Global Environmental Issues

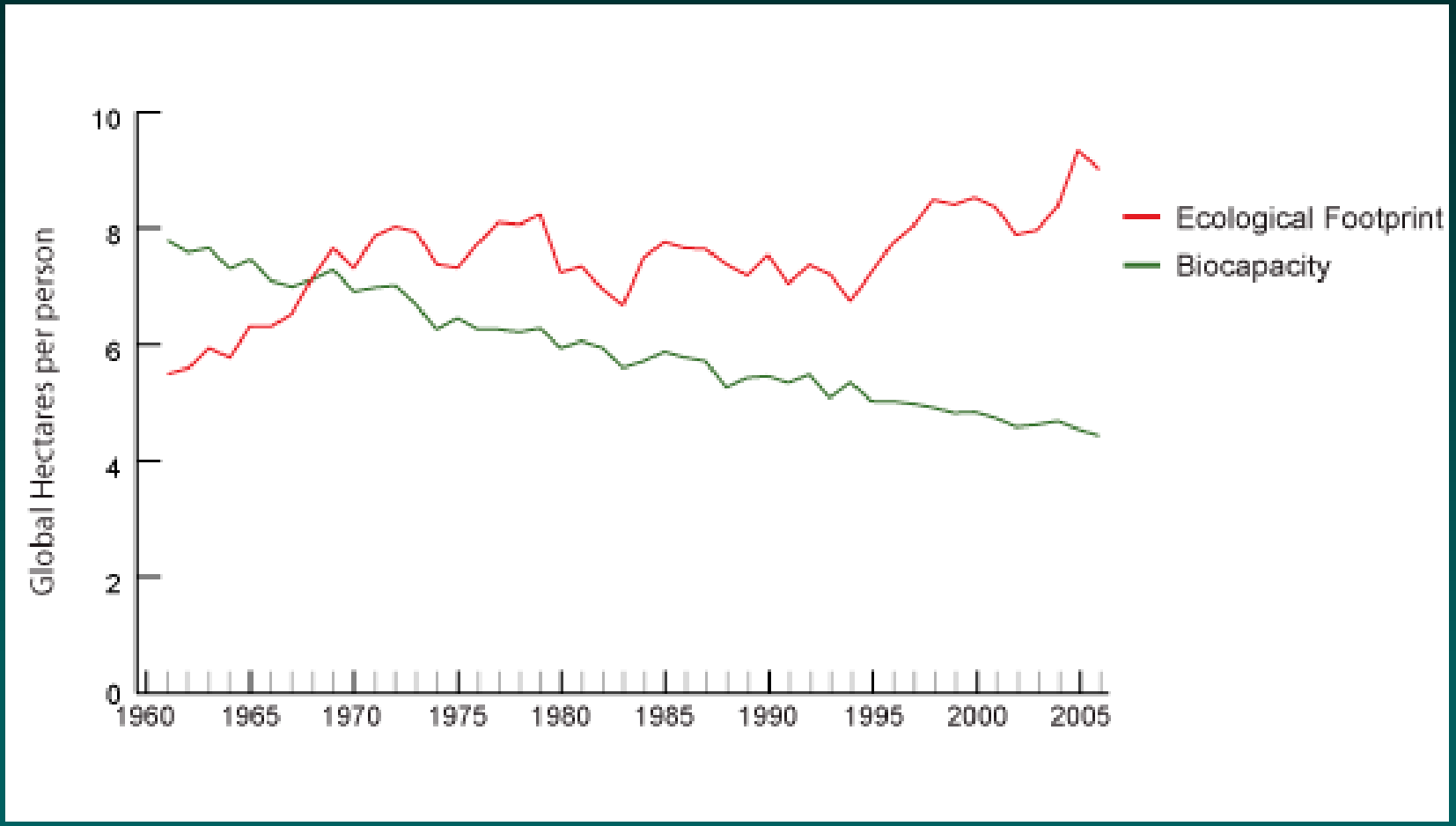
Special lecture – Indian Forest Service

The Limits to Growth

- **First published in 1972 by the Club of Rome**
- **Update published in 1992 "*Beyond the Limits*"**
- **2004: "*Limits to Growth – The 30-Year Update*"**

1972 *Limits to Growth*

- **Global ecological constraints will have significant influence on global developments in the 21st century**
- **Capital and manpower might have to be diverted – possibly to the extent that the average quality of life will decline in the 21st century**
- **Argued for a decrease in the "ecological footprint" of humanity**



Ecological footprint of the USA

1987 World Commission on Environment and Development

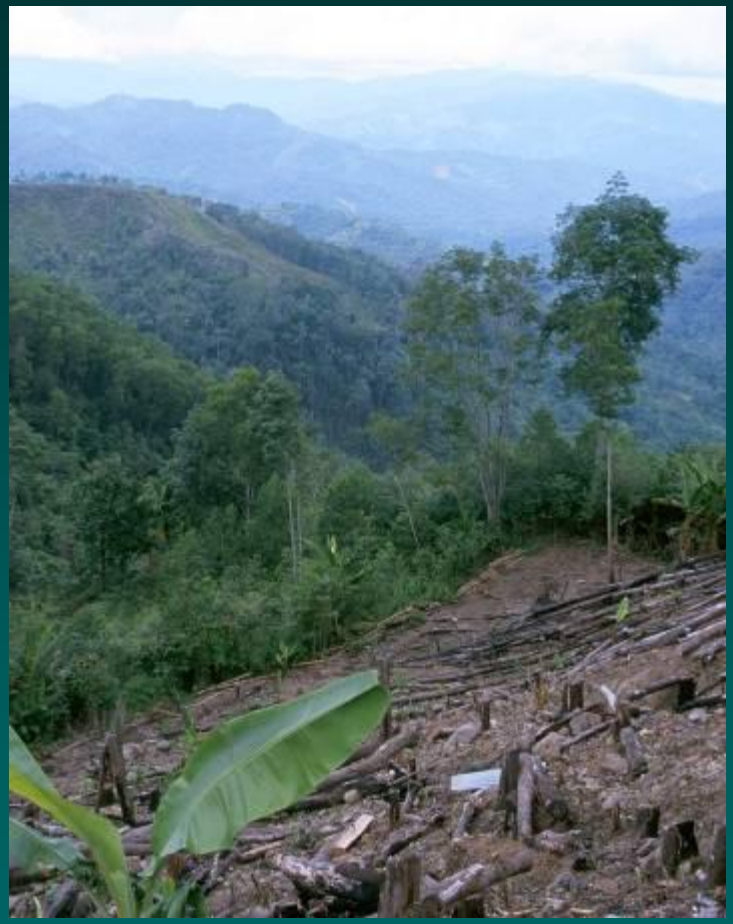
- Also known as the Brundtland Commission
- Landmark report “Our Common Future”
- Had political leverage
- “Humanity has the ability to make development sustainable”
- “A new era of environmentally sound economic development”

1992 United Nations Conference on Environment and Development

Known as the "Earth Summit"

- **100 World Leaders**
- **500 NGOs**
- **8,000 Accredited journalists**
- **30,000 Private citizens**

Two main themes:



Sustainable development

Global environmental change

Sustainable development

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs

Brundtland Commission, 1987.

Requirements:

- More and better international cooperation
- A shift in benefits from the rich and powerful to the poor and weak
- Political decision-making that involves effective public participation
- Community empowerment and active democracy

Concerns in 1992

Northern countries

- Loss of biodiversity
- Climate change
- The ozone layer
- UV-B and skin cancer
- Rising sea levels

Southern countries

- Poverty alleviation
- Food
- Economic growth

Millennium Summit 2000

- Part of the UN General Assembly
- Established the Millennium Development Goals
- Initiated the Millennium Ecosystem Assessment, which reported in 2005: “the ability of the planet’s ecosystems to sustain future generations can no longer be taken for granted”
- The MEA also noted that turning the observed trends would require significant changes in policies, institutions and practices, and that these changes are not currently underway

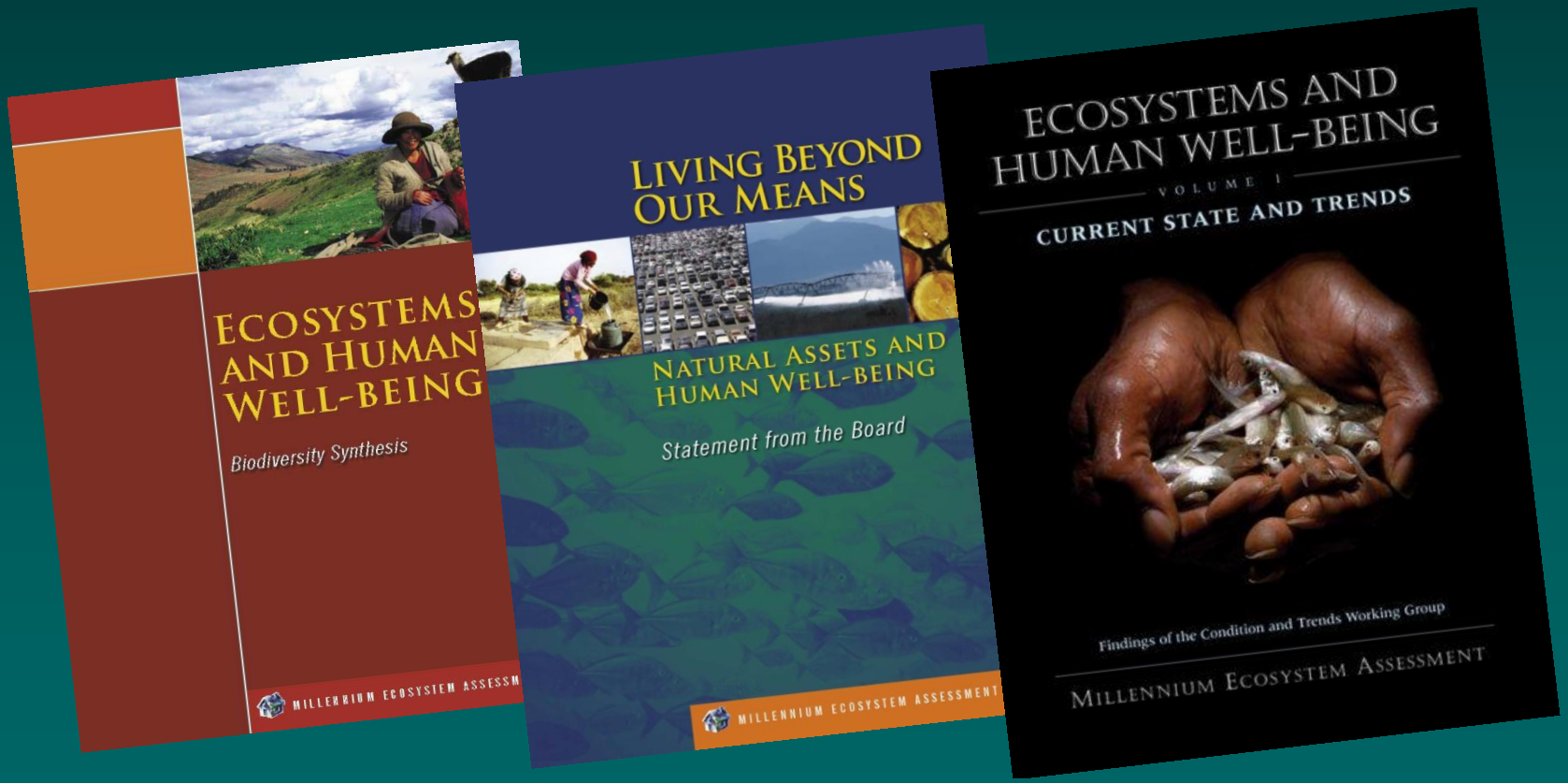
Some serious problems

- Grain production per person peaked in 1980s (but note substitutions)
- Now no prospect for a significant growth in the harvest of marine fish
- Costs of natural disasters is increasing
- Growing conflicts over water and fossil fuel allocations
- Persistent economic declines in some areas: 54 nations had declining per capita GDP between 1990 and 2001.

Millennium Ecosystem Assessment

- Called for by UN Secretary-General Kofi Annan in 2000
- Initiated under UN Environment Program in 2001
- Objective: to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being

Ecosystems and Human Well-Being

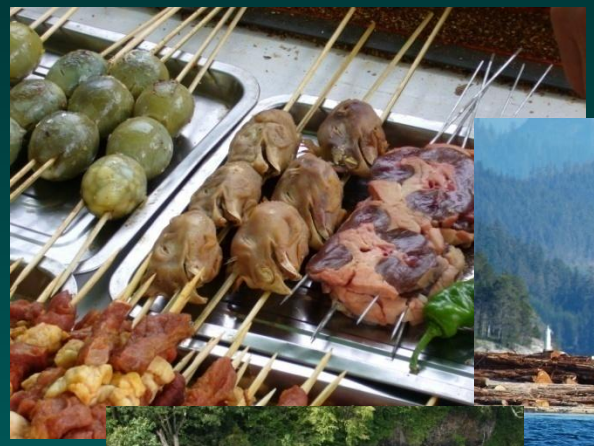


What was unique?
Focus on Ecosystem Services

Provisioning Services

Goods produced or provided by ecosystems

- Food
  - Crops
  - Livestock
  - Capture Fisheries
  - Aquaculture
  - Wild Foods
- Fibre
  - Timber
  - Cotton, hemp, silk
  - Wood Fuel
- Genetic resources
- Biochemicals
- Freshwater



Regulating Services

Benefits obtained from regulation of ecosystem processes

- Air Quality Regulation
- Climate Regulation
  - Global (CO_2 sequestration)
  - Regional and local
- Erosion regulation
- Water purification
- Disease regulation
- Pest regulation
- Pollination
- Natural Hazard regulation

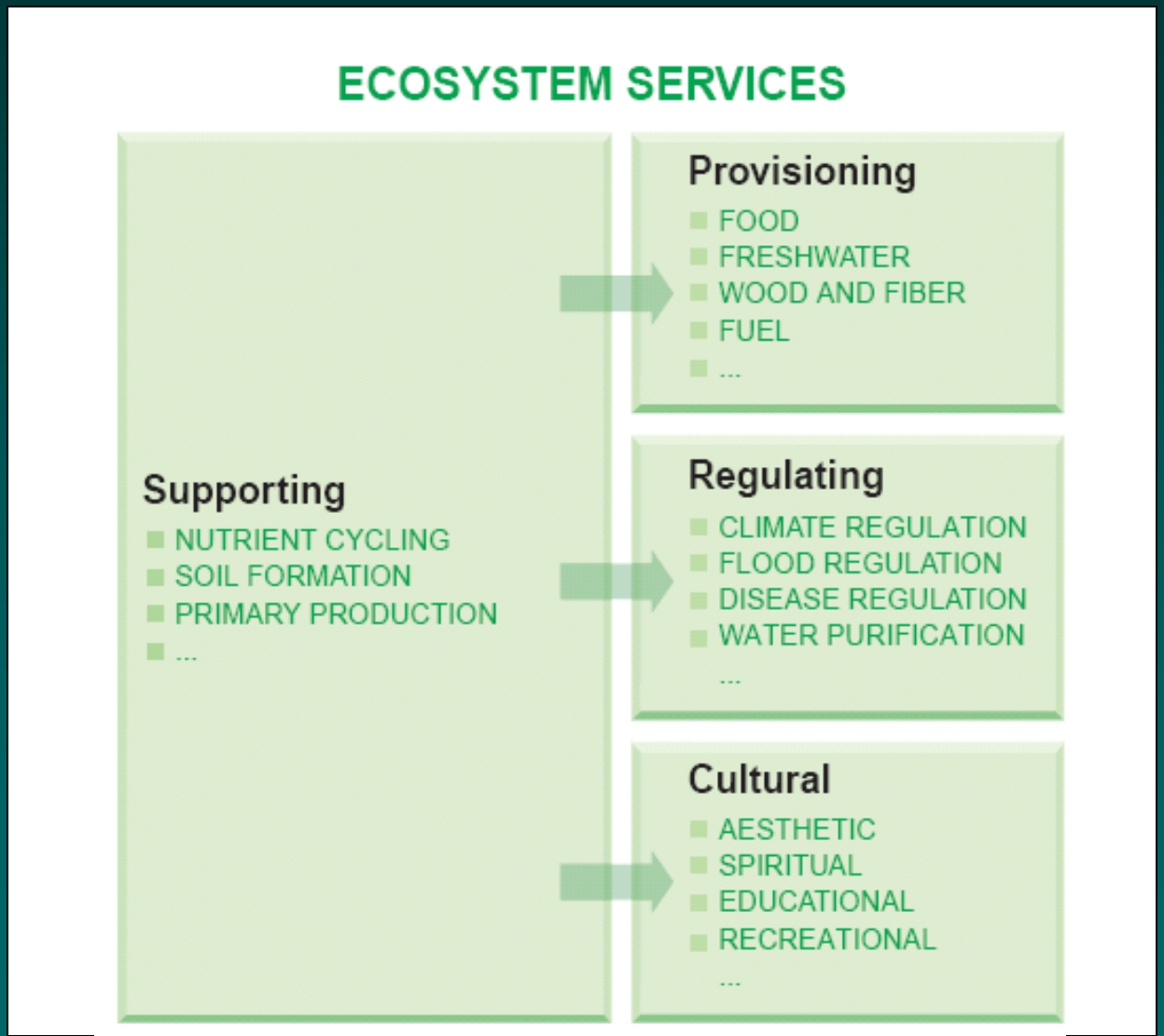
Cultural Services

Non-material benefits obtained from ecosystems

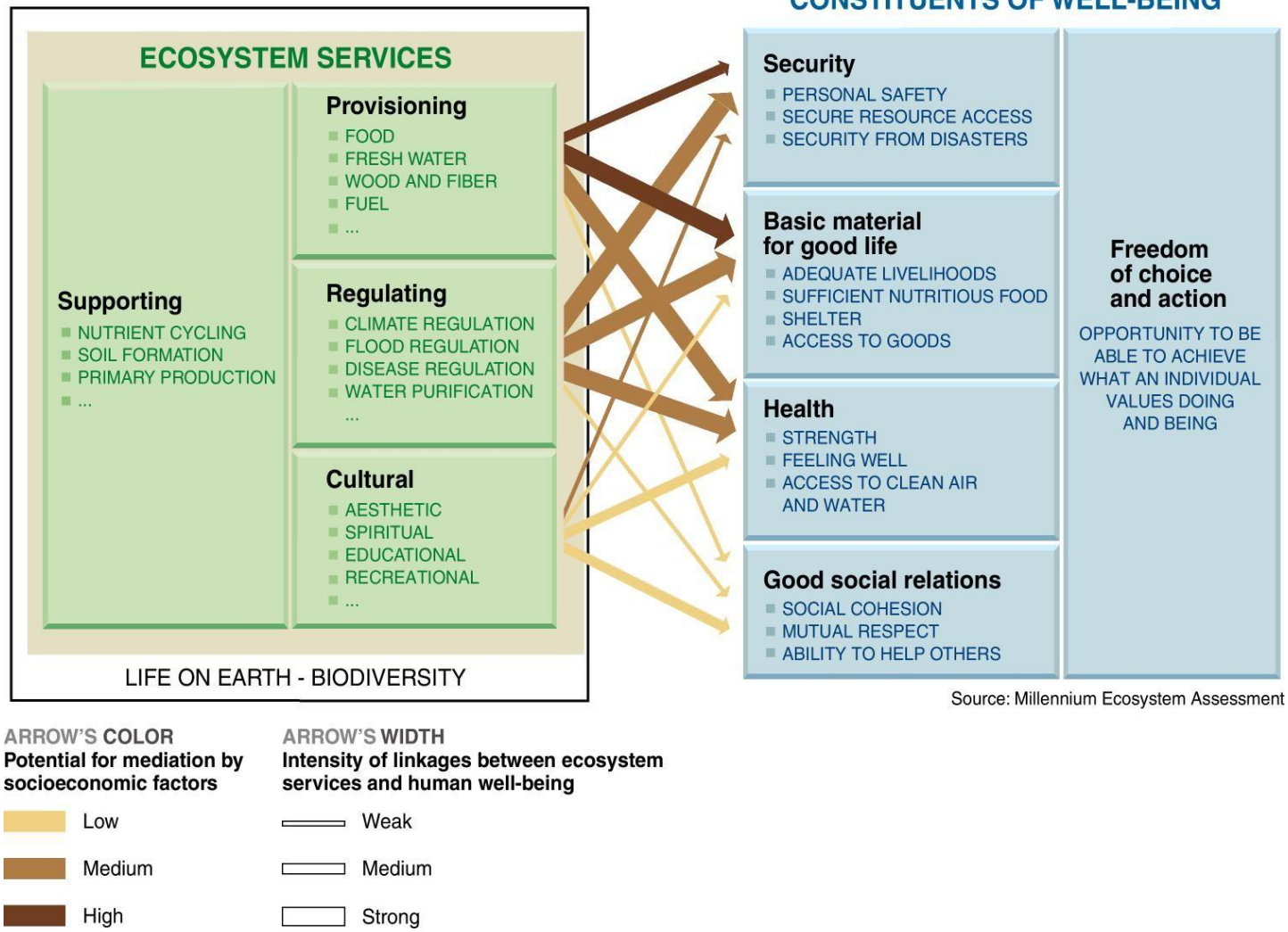
- Spiritual and Religious Values
- Knowledge Systems
- Educational values
- Inspiration
- Aesthetic Values
- Social Relations
- Sense of Place
- Recreation and Ecotourism

Focus: Ecosystem Services

The benefits people obtain from ecosystems

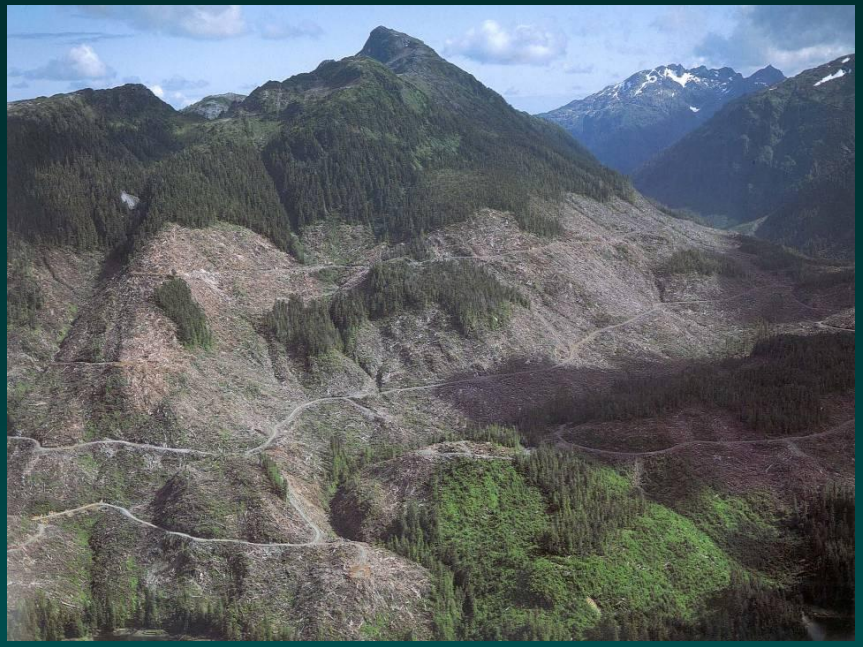


Focus: Consequences of Ecosystem Change for Human Well-being

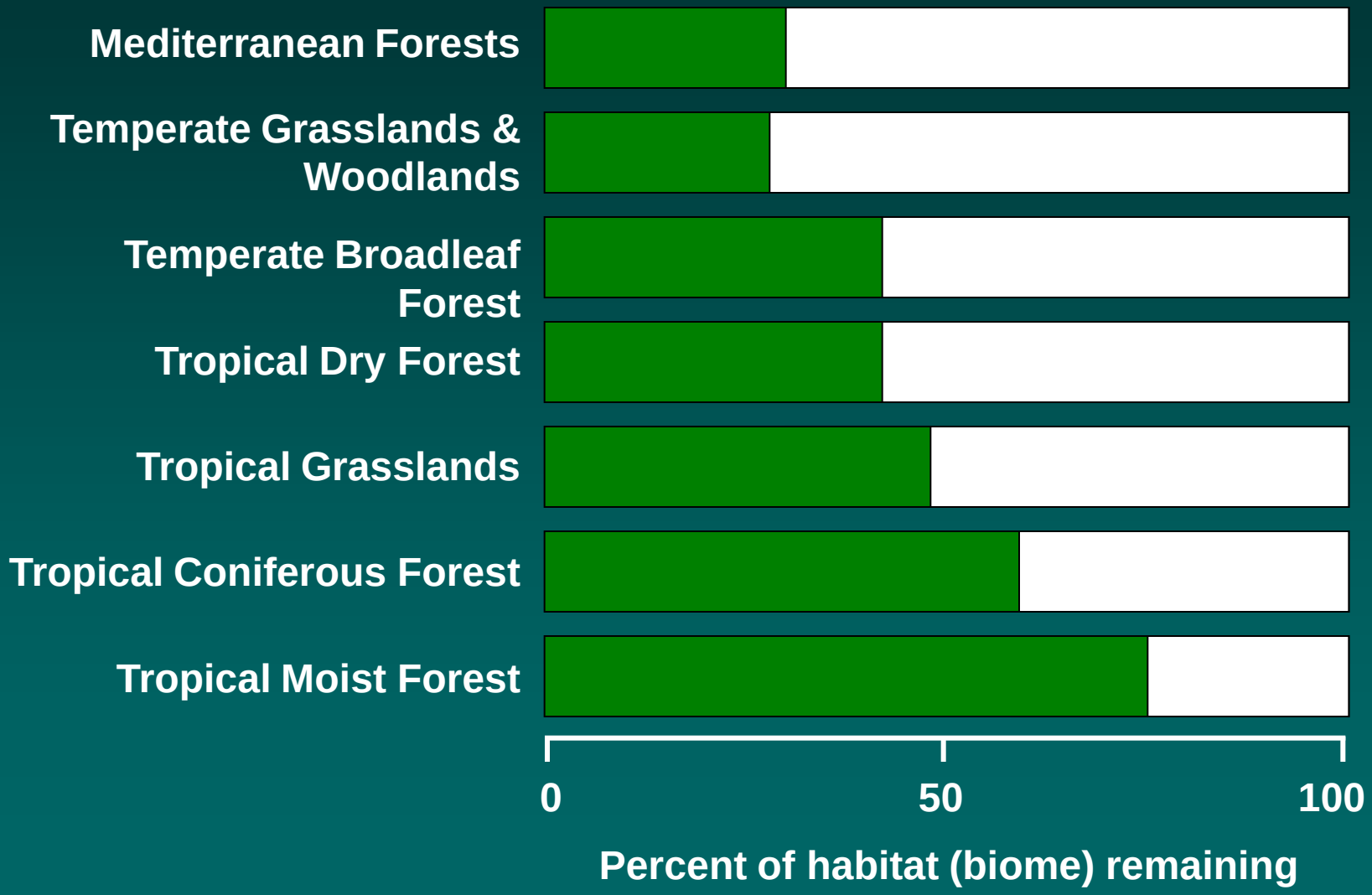


Finding #1

- Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history
- This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth

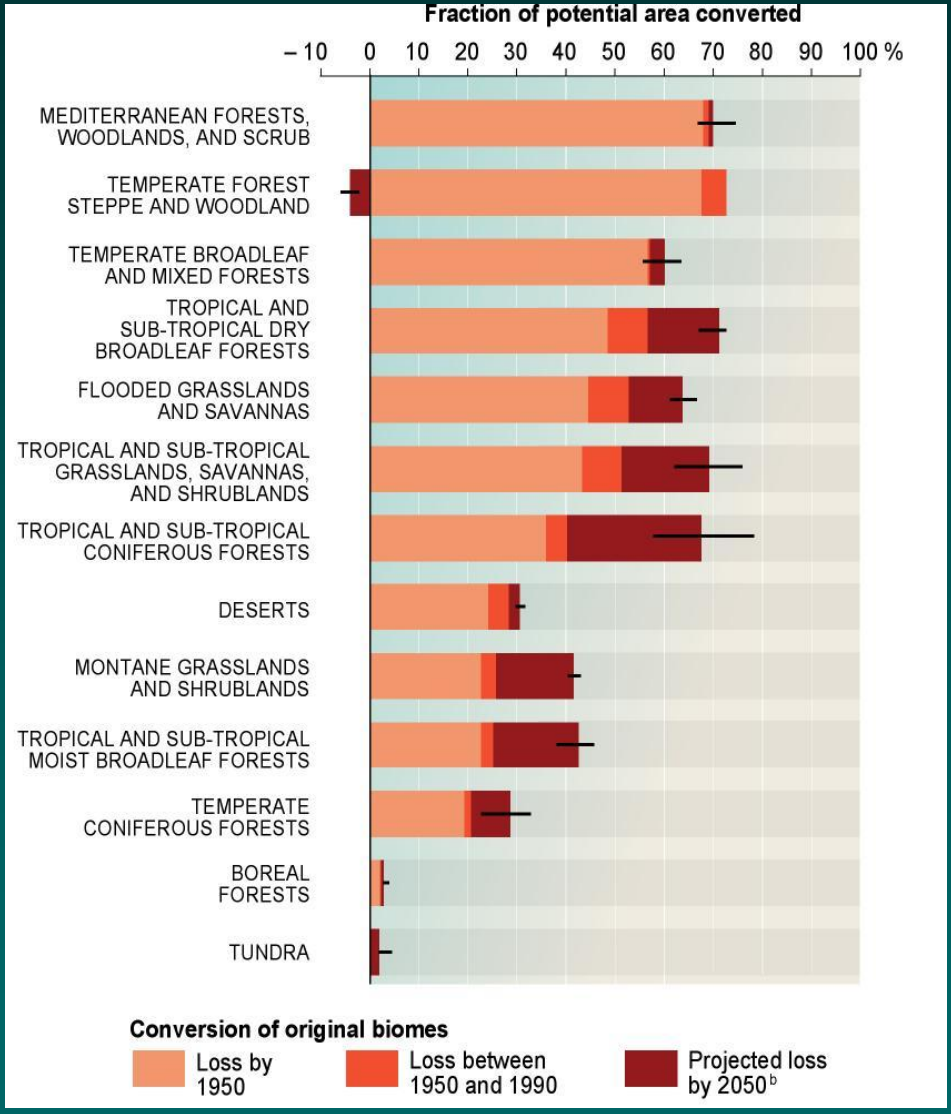


Habitat Loss to 1990



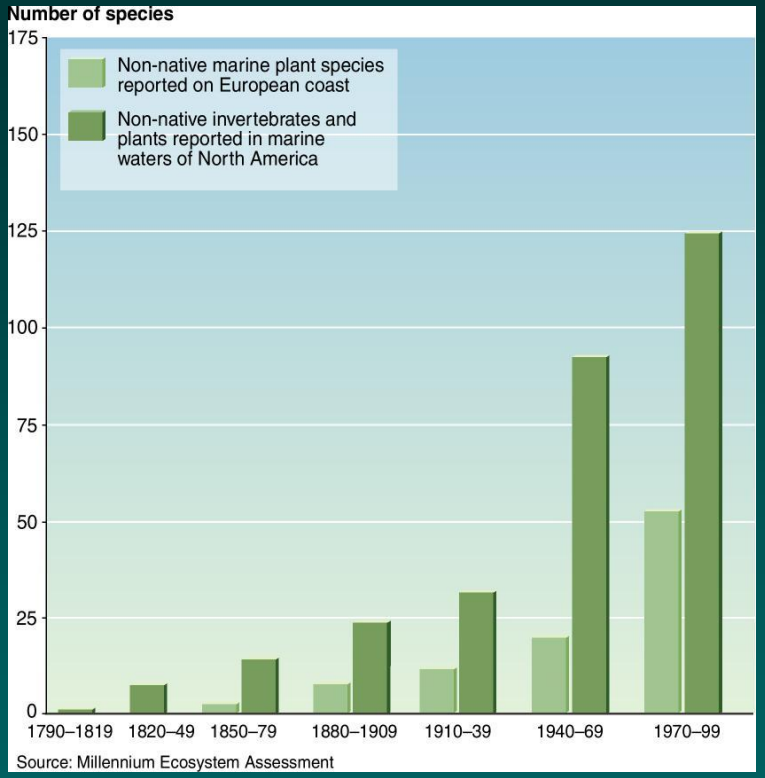
Unprecedented change: Ecosystems

- 5-10% of the area of five biomes was converted between 1950 and 1990
- More than two thirds of the area of two biomes and more than half of the area of four others had been converted by 1990



Significant and largely irreversible changes to species diversity

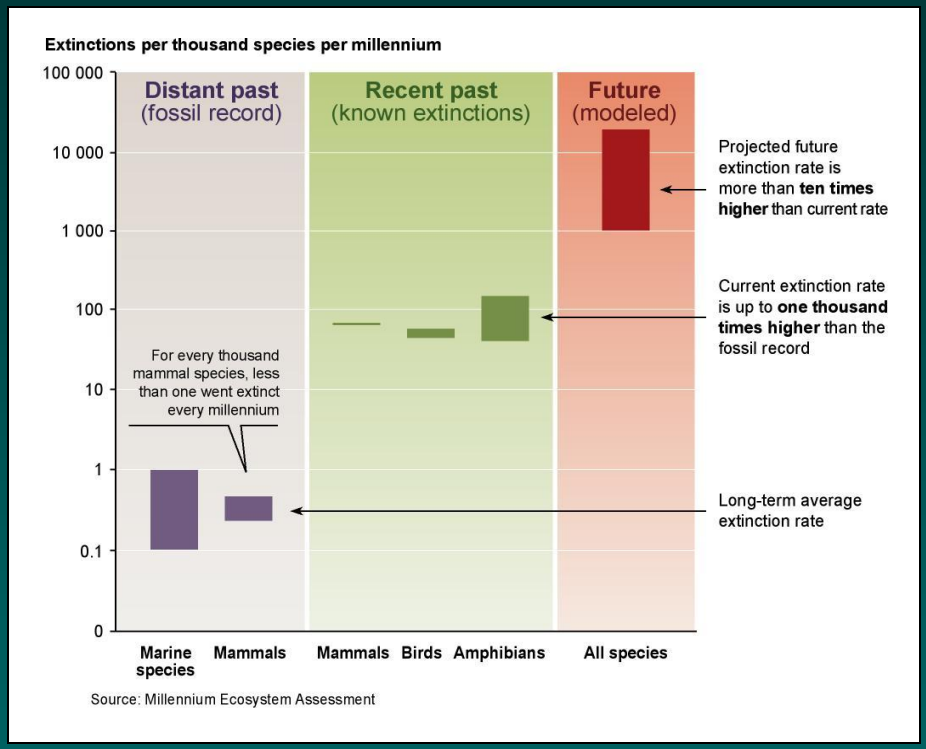
- The distribution of species on Earth is becoming more homogenous
- The population size or range (or both) of the majority of species across a range of taxonomic groups is declining



Growth in number of marine species introductions in North America and Europe

Significant and largely irreversible changes to species diversity

- Humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet's history (*medium certainty)*
- 10–30% of mammal, bird, and amphibian species are currently threatened with extinction (*medium to high certainty)*



Finding #2

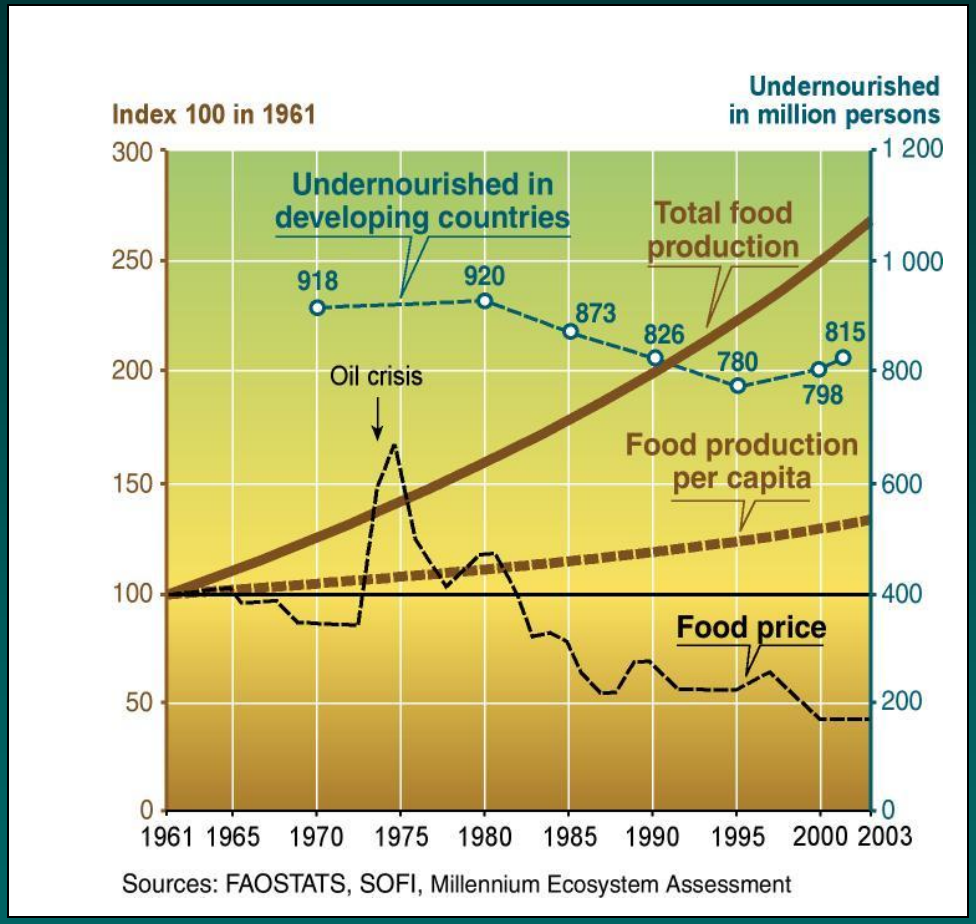
- The changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs
- These problems, unless addressed, will substantially diminish the benefits that future generations obtain from ecosystems

Changes to ecosystems have provided substantial benefits

- Rapid growth in demand for ecosystem services between 1960 and 2000:
  - world population doubled from 3 to 6 billion people
  - global economy increased more than sixfold
- To meet this demand:
  - food production increased 2 ½ times
  - water use doubled
  - wood harvests for pulp and paper production tripled
  - timber production increased by more than half
  - installed hydropower capacity doubled

Changes to ecosystems have provided substantial benefits

- Food production has more than doubled since 1960
- Food production per capita has grown
- Food price has fallen



Industries based on ecosystem services still the mainstay of many economies

- Contributions of agriculture
  - Agricultural labour force accounts for 22% of the world's population and half the world's total labour force
  - Agriculture accounts for 24% of GDP in low-income developing countries
- Market value of ecosystem-service industries
  - Food production: $980 billion per year
  - Timber industry: $400 billion per year
  - Marine fisheries: $80 billion per year
  - Marine aquaculture: $57 billion per year
  - Recreational hunting and fishing: >$75 billion per year in USA
  - Wildlife watching: $32 billion annually in USA

Degradation and unsustainable use of ecosystem services

- Approximately 60% (15 out of 24) of the ecosystem services evaluated in the assessment are being degraded or used unsustainably
- The degradation of ecosystem services often causes significant harm to human well-being and represents a loss of a natural asset or wealth of a country

Status of Provisioning Services

Service		Status
Food	crops	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fibre	timber	+/–
	cotton, silk	+/–
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Fresh water		↓

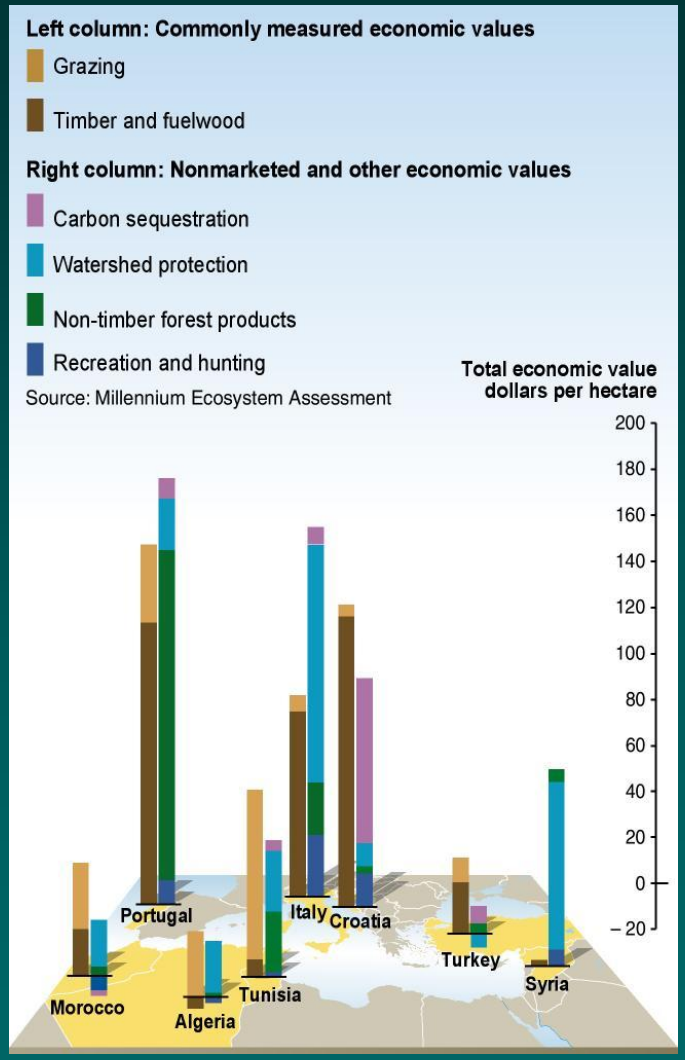
Status of Regulating and Cultural Services

	Status
Regulating Services	
Air quality regulation	↓
Climate regulation – global	↑
Climate regulation – regional and local	↓
Water regulation	+/–
Erosion regulation	↓
Water purification and waste treatment	↓
Disease regulation	+/–
Pest regulation	↓
Pollination	↓
Natural hazard regulation	↓
Cultural Services	
Spiritual and religious values	↓
Aesthetic values	↓
Recreation and ecotourism	+/–

Degradation of ecosystem services often causes significant harm to human well-being

- Degradation tends to lead to the loss of non-marketed benefits from ecosystems
- The economic value of these benefits is often high and sometimes higher than the marketed benefits

Timber and fuelwood generally accounted for less than a third of total economic value of forests in eight Mediterranean countries.



Some degradation is still unrecognized

- Major changes are occurring in the oceans
  - Ocean acidification
  - Loss of oxygen in deeper areas, creating dead zones

Trade-offs among ecosystem services

Mangrove Services:

- nursery and adult fishery habitat
- fuelwood & timber
- carbon sequestration
- traps sediment
- detoxifies pollutants
- protection from erosion & disaster

Mangrove ecosystem

Impact on Poor and Marginalized People

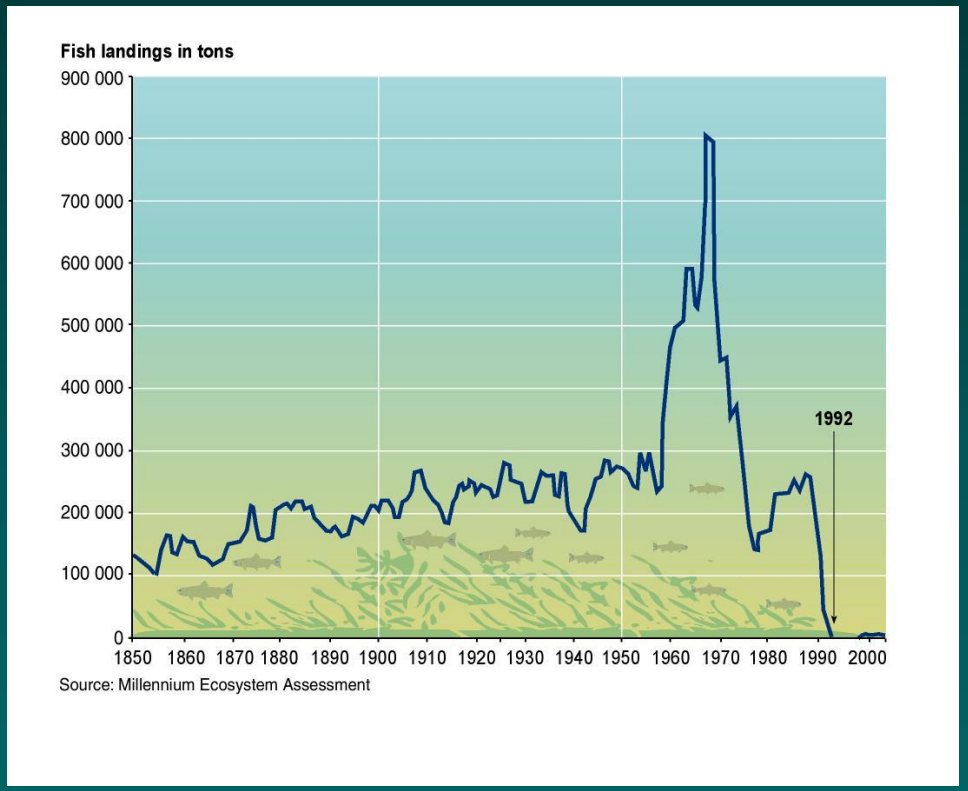
Poor people are most dependent on ecosystem services and most vulnerable to degradation of the services

Increased likelihood of nonlinear changes

- There is *established but incomplete* evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes in ecosystems (including accelerating, abrupt, and potentially irreversible changes), with important consequences for human well-being

Examples of nonlinear change

- **Fisheries collapse**
  - **The Atlantic cod stocks off the east coast of Newfoundland collapsed in 1992, forcing the closure of the fishery**
  - **Depleted stocks may not recover even if harvesting is significantly reduced or eliminated entirely**



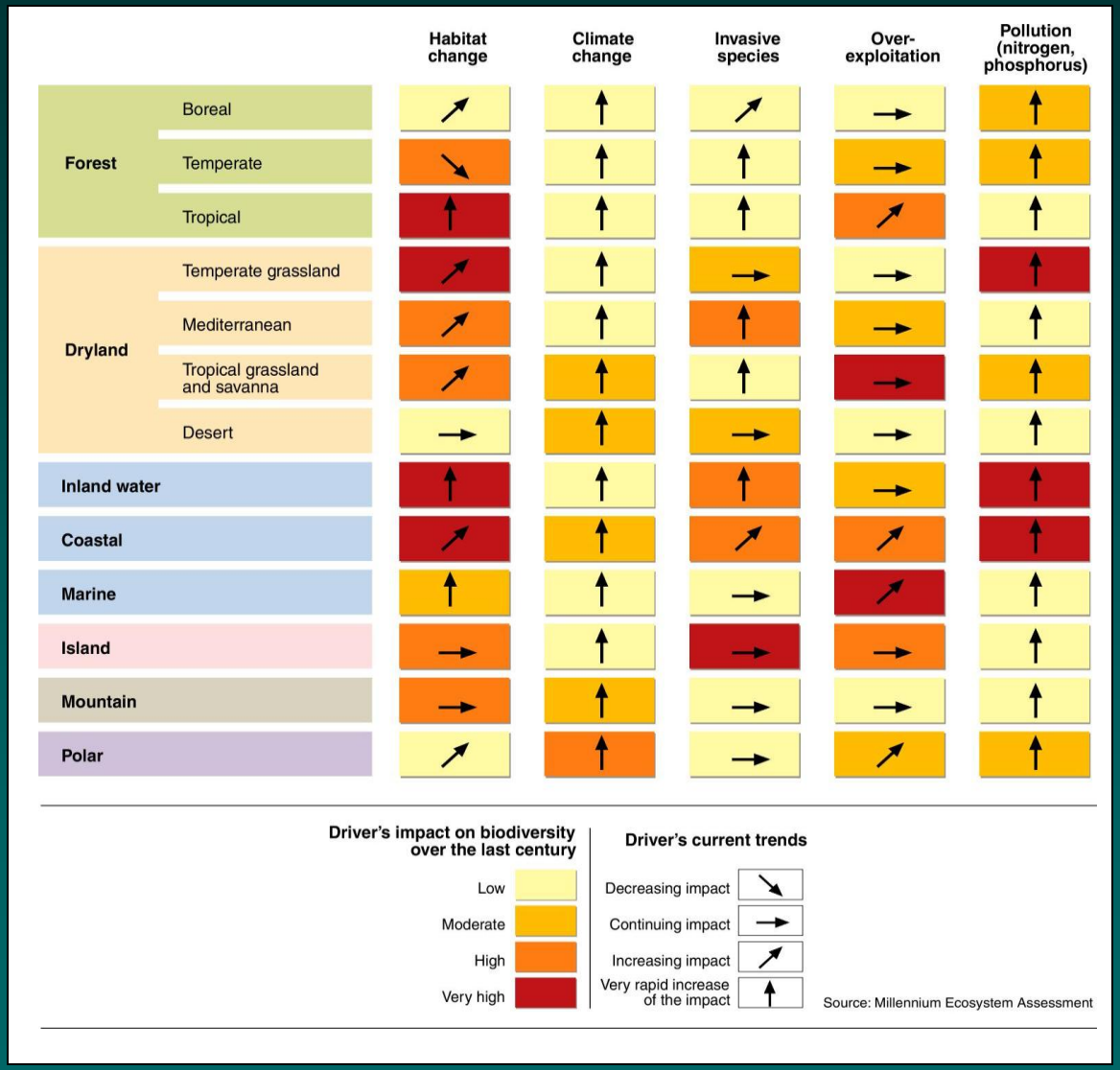
Level of poverty remains high and inequities are growing

- **Economics and Human Development**
  - 1.1 billion people surviving on less than $1 per day of income. 70% in rural areas where they are highly dependent on ecosystem services
  - Inequality has increased over the past decade. During the 1990s, 21 countries experienced declines in their rankings in the Human Development Index
- **Access to Ecosystem Services**
  - An estimated 852 million people were undernourished in 2000–02, up 37 million from the period 1997–99
  - Per capita food production has declined in sub-Saharan Africa
  - Some 1.1 billion people still lack access to improved water supply, and more than 2.6 billion lack access to improved sanitation
  - Water scarcity affects roughly 1–2 billion people worldwide

Finding #3:

– The degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals

Direct drivers growing in intensity



Most direct drivers of degradation in ecosystem services remain constant or are growing in intensity in most ecosystems

Finding #4:

- The challenge of reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met under some scenarios that the MA considered but these involve significant changes in policies, institutions and practices, that are not currently under way
- Many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or that provide positive synergies with other ecosystem services

Responses – Key Barriers

- Inappropriate institutional and governance arrangements, including the presence of corruption and weak systems of regulation and accountability.
- Market failures and the misalignment of economic incentives.
- Social and behavioral factors, including the lack of political and economic power of some groups particularly dependent on ecosystem services or harmed by their degradation.
- Underinvestment in the development and diffusion of technologies
- Insufficient knowledge (as well as the poor use of existing knowledge) concerning ecosystem services and responses that could enhance benefits from these services while conserving resources.
- Weak human and institutional capacity related to the assessment and management of ecosystem services.

The Issue:
Loss and Degradation of Forests

Why is it important?

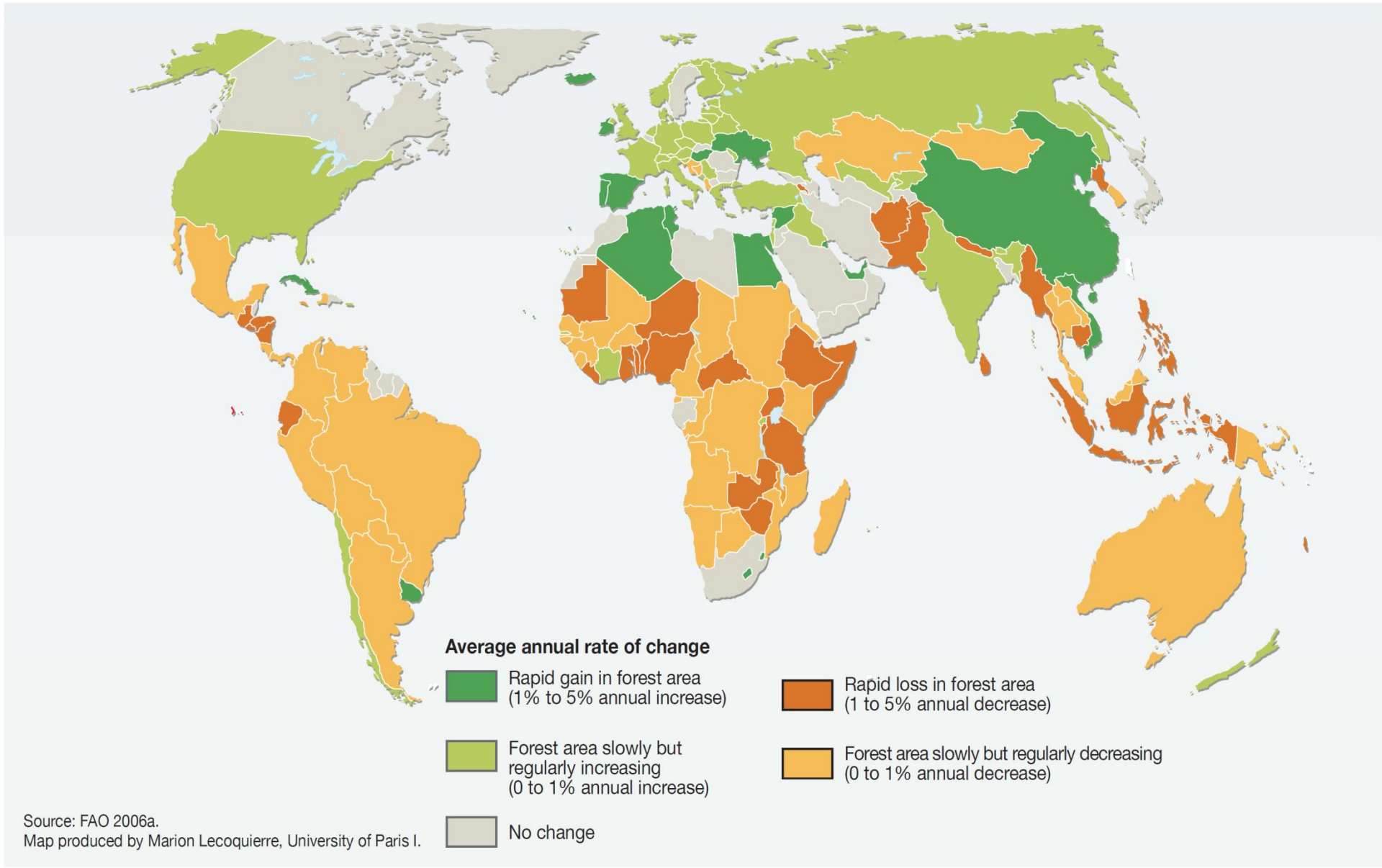
- Loss of biodiversity
- Carbon emissions and sequestration
- Loss of livelihoods
- Ecosystem services (such as climate regulation, prevention of erosion, mitigation of floods)

Deforestation

- Deforestation rate in the 1990s was 16 million ha annually
- Deforestation rate in the 2000s was 13 million ha annually
- Tropical countries are generally losing forest cover, while developed countries generally gaining. Of the annual tropical timber production, 85% is for fuel, 10% is for local timber and 5% for export.
- Net loss of forest is ca. 7 million ha annually


EVILS OF DEFORESTATION
वन विनाश के दुष्परिणाम

Changes in area covered by forest, 1990-2005



Source: FAO 2006a.
Map produced by Marion Lecoquierre, University of Paris I.

Major causes of forest loss

- Expansion of subsistence agriculture in Africa and Asia
- Large economic development programmes involving resettlement, agriculture and infrastructure in Latin America and Asia.
- Unsustainable logging
- Natural disturbances (drought, forest fire, pests and disease)


Sabah, Malaysia

Forest conversion

- Intensive agriculture
- Ranching
- Industrial agriculture
- Plantation forestry
- Dams


Villa Blanca, Costa Rica

Tea, Amani, Tanzania


Turrialba, Costa Rica

Bans on logging

- Philippines – ban on all logging in "old growth and virgin forests"
- China – ban on all logging in natural forests since July 1998.
- Suriname – 10% of the country's land area was set aside as Wilderness areas in 1998.

Logging

Bans on logging

- In December 1996, Cambodia banned log exports.
- In 1997 and 1998, Vietnam imported at least 260,000 m^3 of logs, worth US$130 million, from Cambodia
- Documents authorizing illegal exports were signed by the co- prime ministers, and funds were diverted to the Military Region 1.

Poor regulation of logging

- Favourable deals and policies
- Ambiguous laws
- Bribes, enforcement and loopholes
- Tax evasion
- Illegal logging

Russia and China

Suifenhe, Heilongjiang, PRC


A solution?
Sustainable Forestry

Available alternatives

- Improved management of natural forests (e.g., British Columbia)
- Replacement of wood supply from natural forests by intensive plantations (e.g., New Zealand)
- Improved management of secondary forests (e.g., Europe)

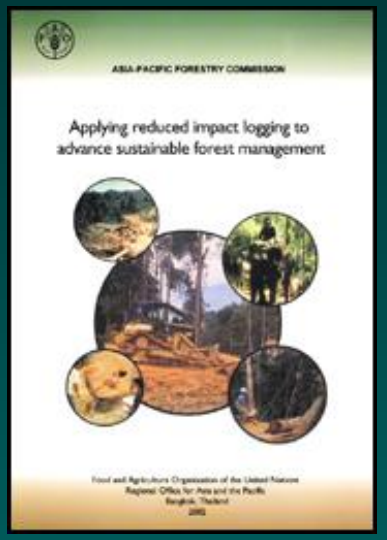
Management of natural forests

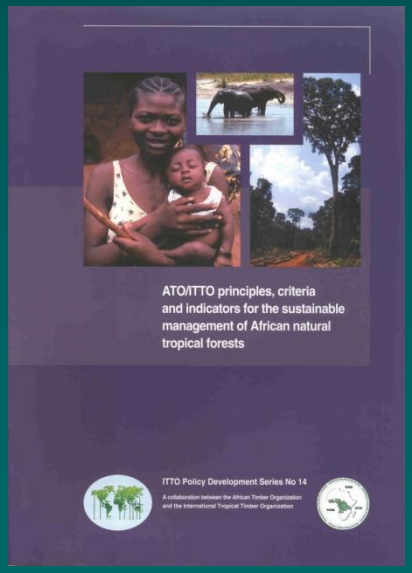
- Sustainable forest management
- Reduced Impact Logging

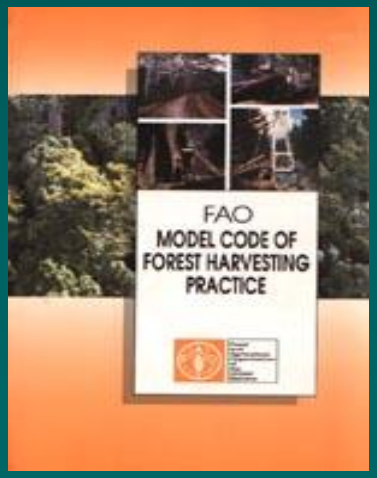
Although these seem different, they are essentially the same, with RIL being applied primarily in the Tropics

The move towards sustainable forest management

A number of attempts have been made to define best management practices for tropical forests internationally







Is this Chir Pine (*Pinus roxburghii*) forest being managed sustainably?

Is this sustainable forest management?

Closely linked to sustainable forest management elsewhere

- Montréal Process
- European Process
- Certification

SFI
CERTIFIED
PARTICIPANT

FIBER USED IN THIS PRODUCT LINE
MEETS THE SOURCING REQUIREMENTS
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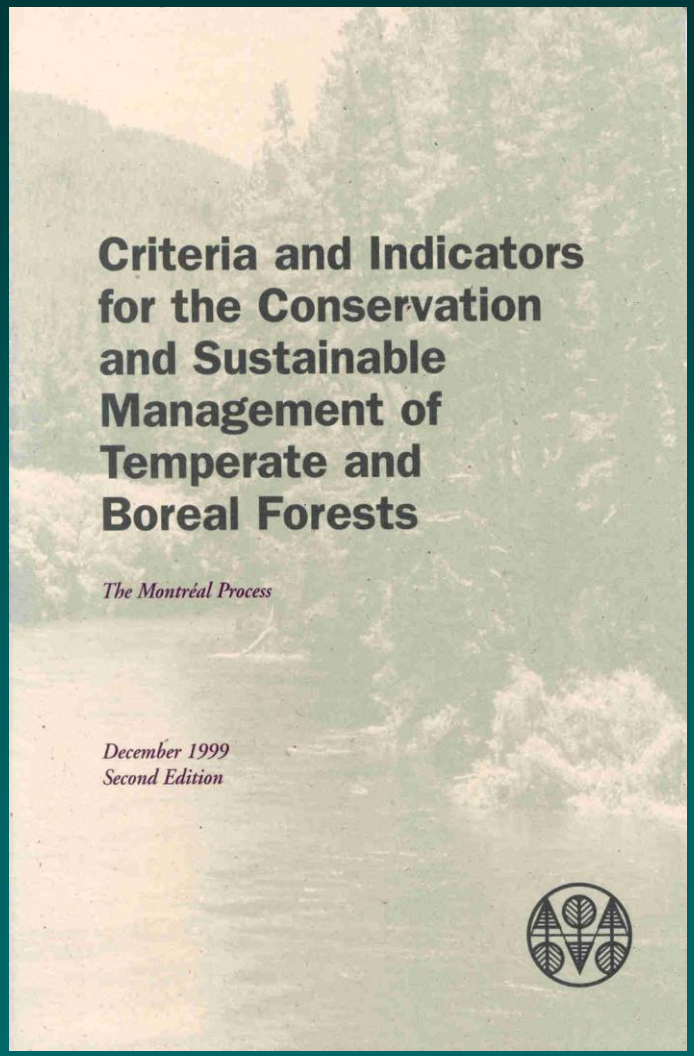


Structure of a selectively logged forest

- Reduced density of trees
- More open environment
- Increased spatial heterogeneity

Loss of species

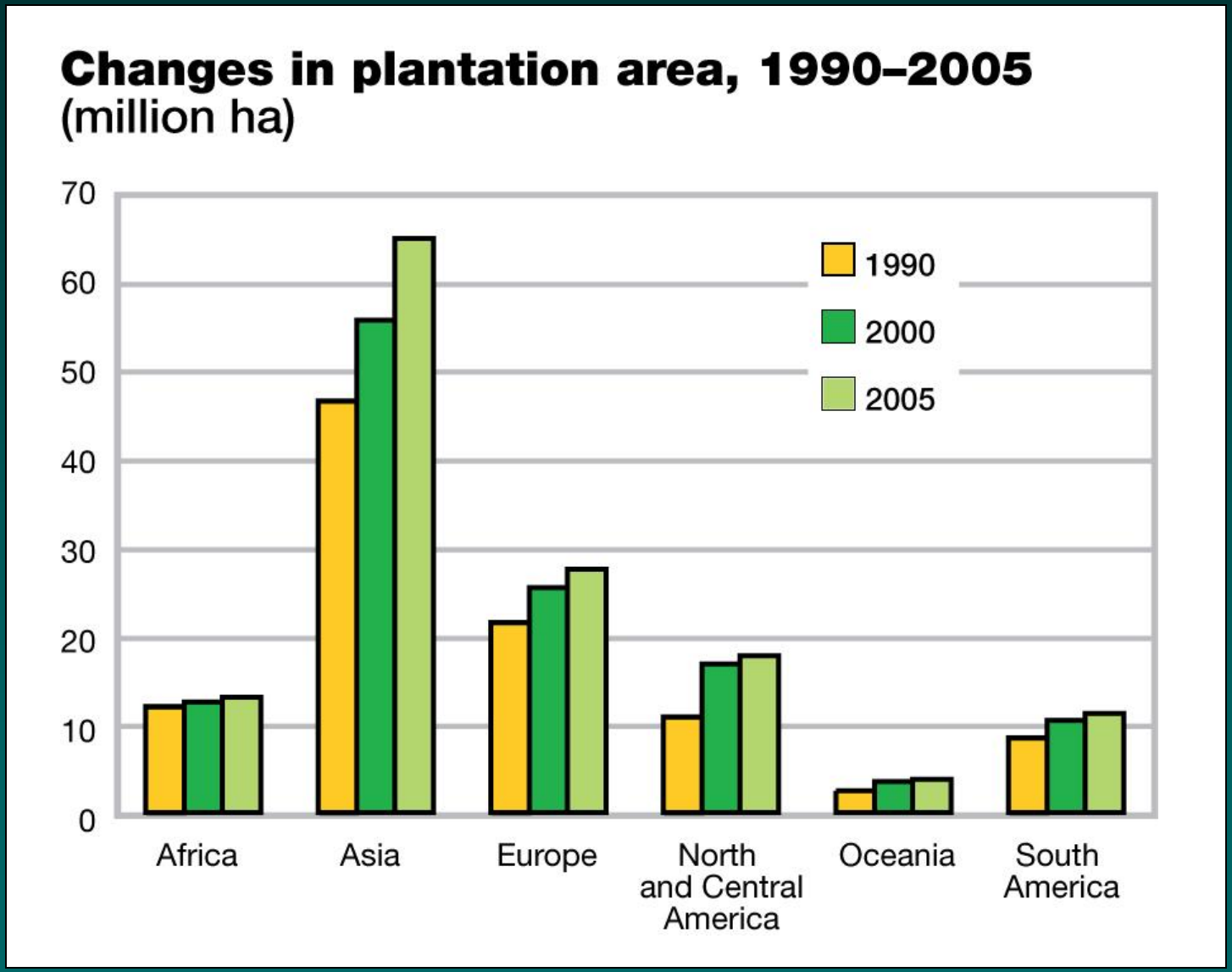
- Selective logging rarely results in the local extinction of a species, as younger trees of logged species are usually present.
- An exception is Brasilwood (*Caesalpinia echinata*) which has been logged out over large areas of Amazonia.
- 1500 species are classed as threatened by felling or forest management by the World Conservation Monitoring Centre.
- 250 dipterocarp species are classed as “critically endangered”
- Trade in such species regulated through CITES

Changing practices: Clayoquot, BC

Helicopter logging

- Done commercially in the Pacific Northwest, parts of Europe and in South Africa
- Major reductions in environmental damage offset by much higher costs
- New techniques (cut and lift) can avoid felling damage altogether

Plantations



Certification and labelling provides a potential means of restoring public confidence

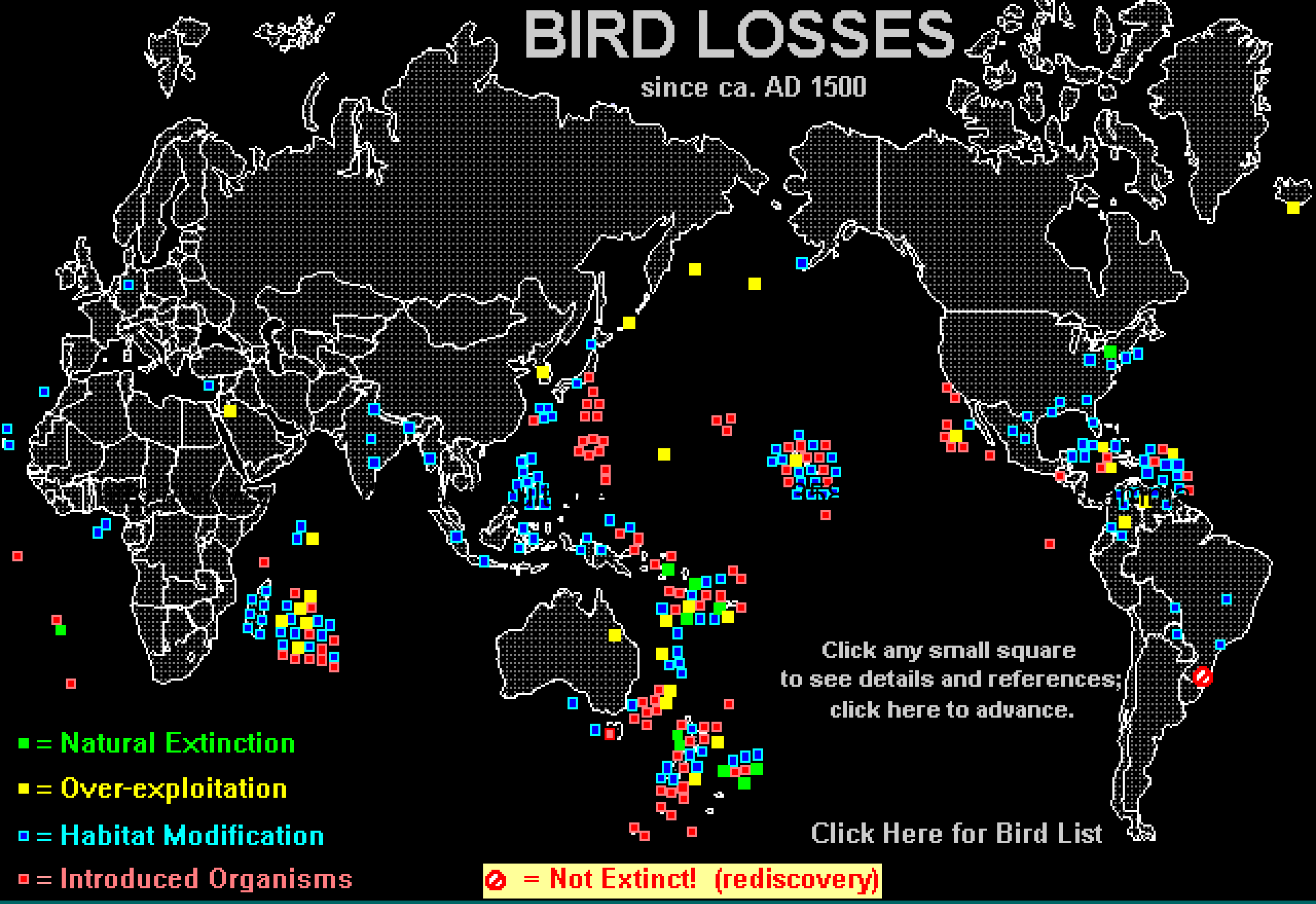
Loss of Biodiversity

Current rates of species loss

- Estimates vary widely
- All estimates are guesses, based on models
- At the rate of tropical moist forest loss in 1981-1990, 5-11% of species would have been lost by 2015. Mostly unknown and undescribed insects.

Is the current extinction rate normal?

- Average lifespan of a fossil species seems to be about 4 million years
- If 10 million species existed at any one time, then the extinction rate should be 2.5 species annually
- Applying this to current bird and mammal numbers would yield rates of one species every 400 and 800 years, respectively
- Known rates are 100 and 200 times higher than background for birds and mammals



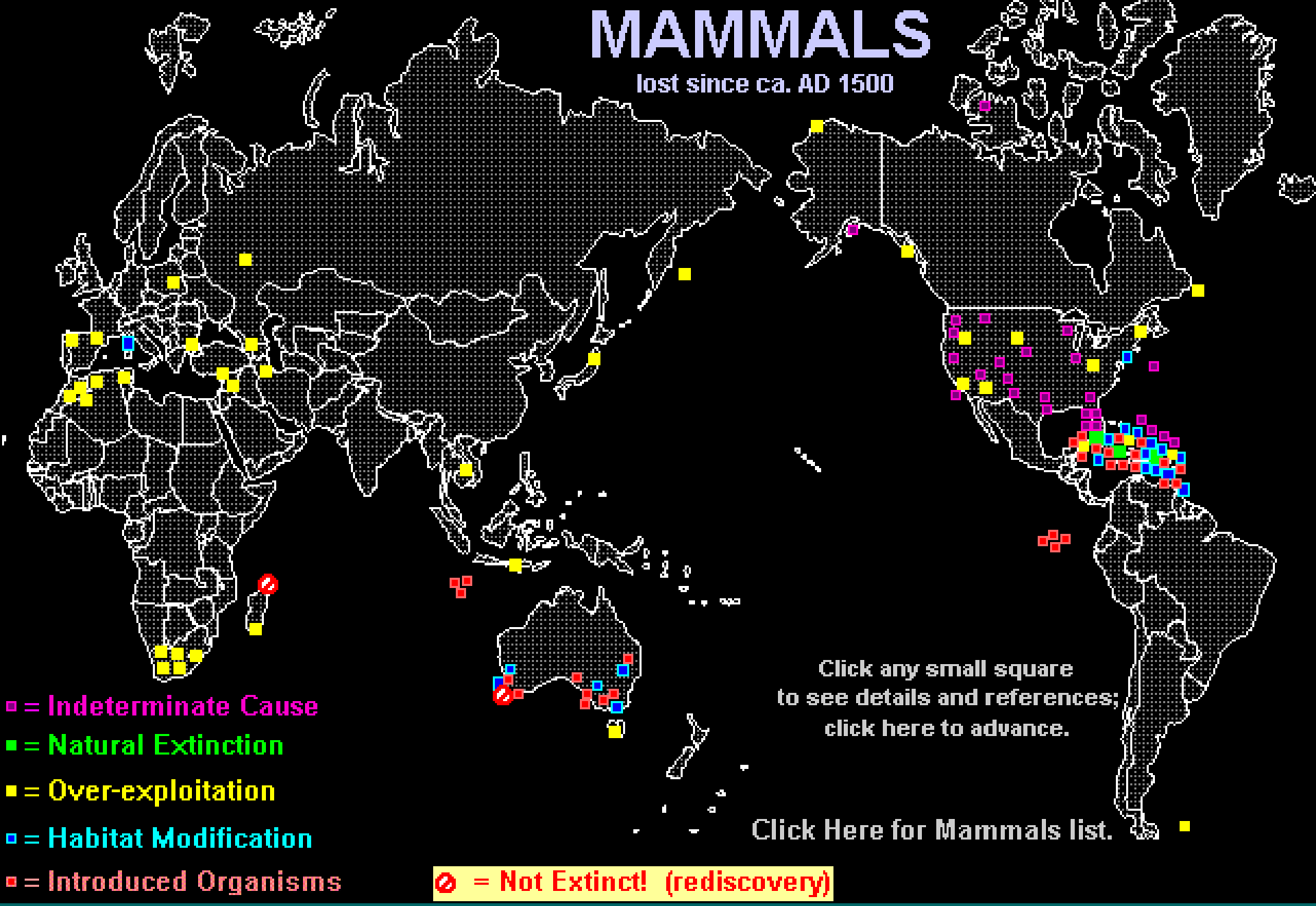
http://www.uwsp.edu/geo/faculty/heywood/geog358/endanger.htm#birds

Pink-headed Duck (*Rhodonessa caryophyllacea*) – From east India, Bangladesh and Myanmar. Maybe extinct.

Himalayan Quail *(Ophrysia superciliosa)* – From north India, Believed to be extinct.

Introduced pests - mosquitoes

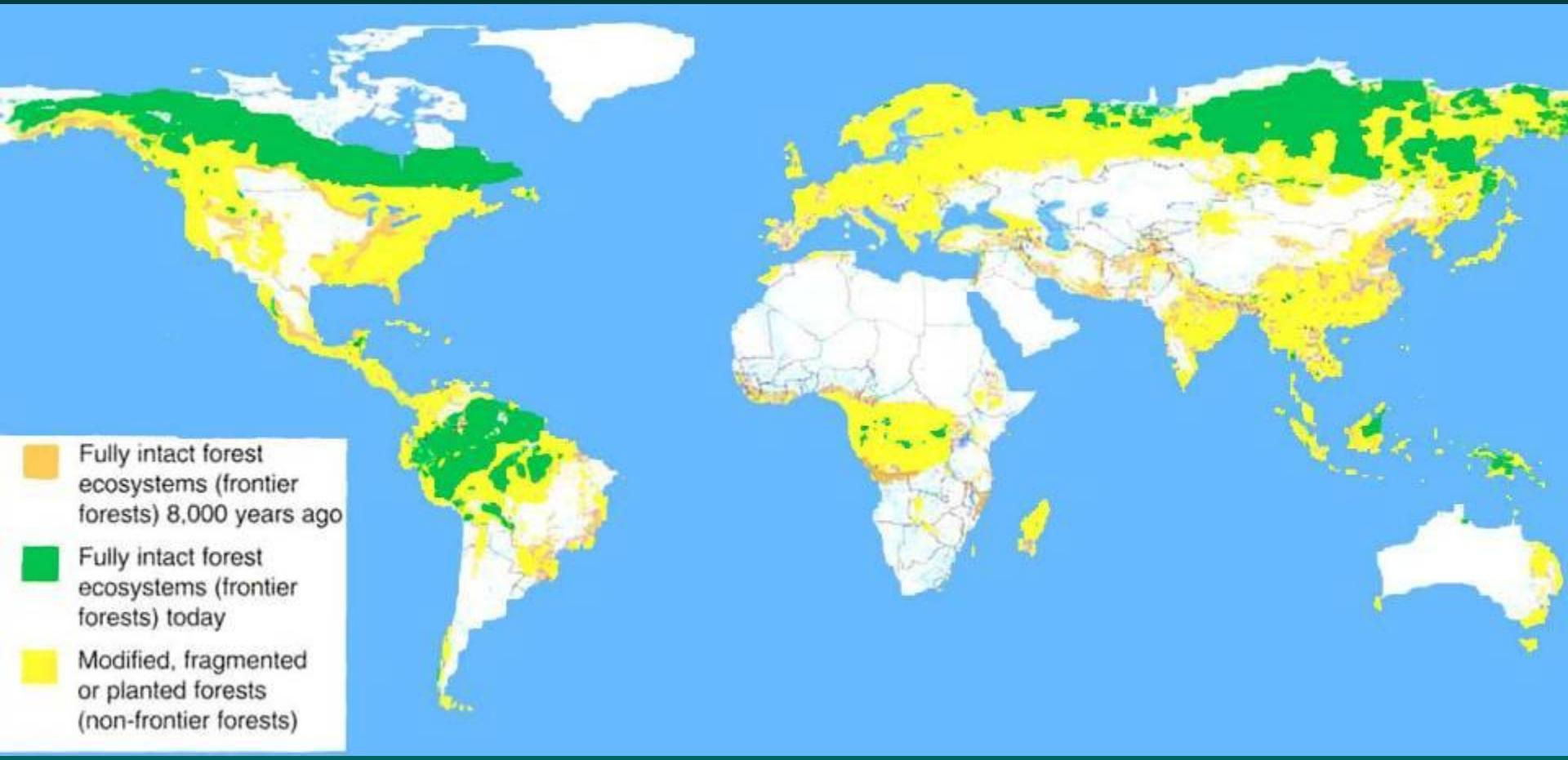
'Apapane



http://www.uwsp.edu/geo/faculty/heywood/geog358/endanger.htm#mammals

Problems with foxes

Forest change and forest loss



Major areas at risk

- Mato Grosso and Para States of southeastern Brazilian Amazonia
- Atlantic coastal rain forest of Brazil
- Philippines
- Madagascar

Species loss

- Loss of habitat
- Loss of food supply
- Hunting
- Fragmentation
- Introduced species
- Climate change

Loss of habitat

Loss of food supply

Sun Bittern

Hunting

Fragmentation

A single road may constitute a major impediment for some animals. Three-toed sloths are almost exclusively arboreal.

Lion-tailed Macaque (*Macaca silenus*), Western Ghats – what is its future?

Introduced species

Introduced species can have devastating effects on native species, particularly on islands. The kakapo (a native flightless parrot) of New Zealand is now restricted to a few offshore islands.

The cost of conservation

- Globally, $6.5 billion is spent annually on protected areas, with $5.5 billion going to the developed world
- US$ 300 million annually would cover the minimum costs of managing all of Africa's 1,200 national parks and reserves

The cost of conservation

In comparison, annually

- **$51 billion goes to EU farm subsidies**
- **$450 million to UK arms subsidies**
- **Worldwide, $26 billion is spent on dog and cat food**
- **In Europe alone, $11 billion is spent on ice cream**

Ecotourism has grown in demand rapidly

‘Up-market’ ecotourism funding reserves (Okonjima, Namibia)

travel & workshops

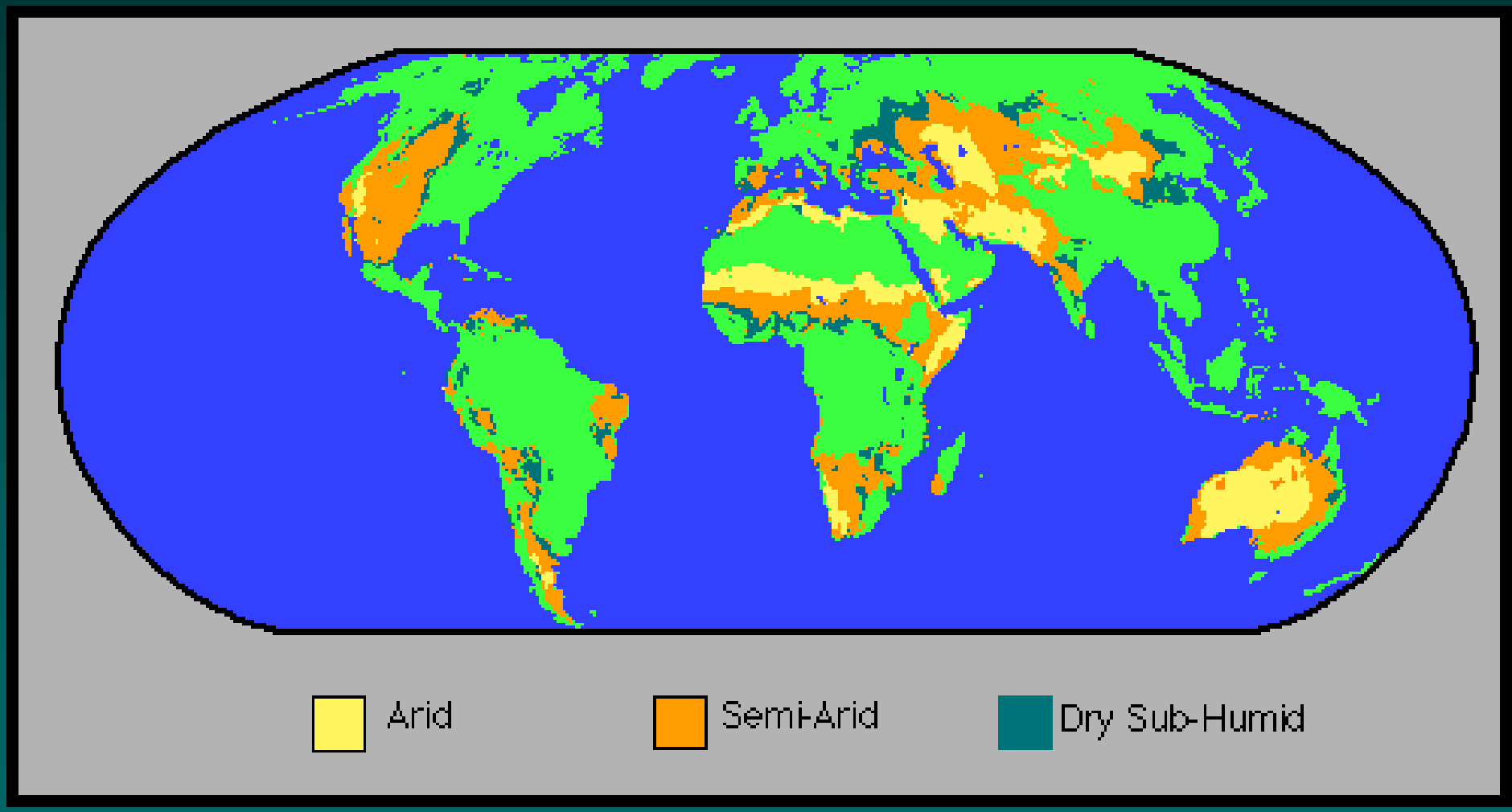
Some uses may be incompatible with the objectives

$650 per person for a half-day trip. Bears guaranteed.

Careful control of those participating may be needed

Desertification

Drylands



Drylands

- 47 percent of the global land mass, or approximately 5.2 billion ha.
- 10-20% have undergone some level of degradation
- 64% of all drylands are found in Africa and Asia (32% each)
- 12% are found in North America, 11% in Australia, and 9% in South America.
- Over 75% of the Australian continent is dryland

Drylands

- About 2 billion people live in the World's drylands
- 90% of the people in dryland areas are in developing countries
- All development indicators indicate that drylands are consistently behind the rest of the world
- Average water availability is 1300 m^3 per person per year (basic human standard is 2000 m^3)

Desertification in India

- 2.4% of the World's land area
- 16.7% of the World's population
- 18% of the World's livestock
- Highly dependent on monsoon (which has failed in some years recently)

Particularly prone to desertification

Reasons for resource degradation in dryland areas

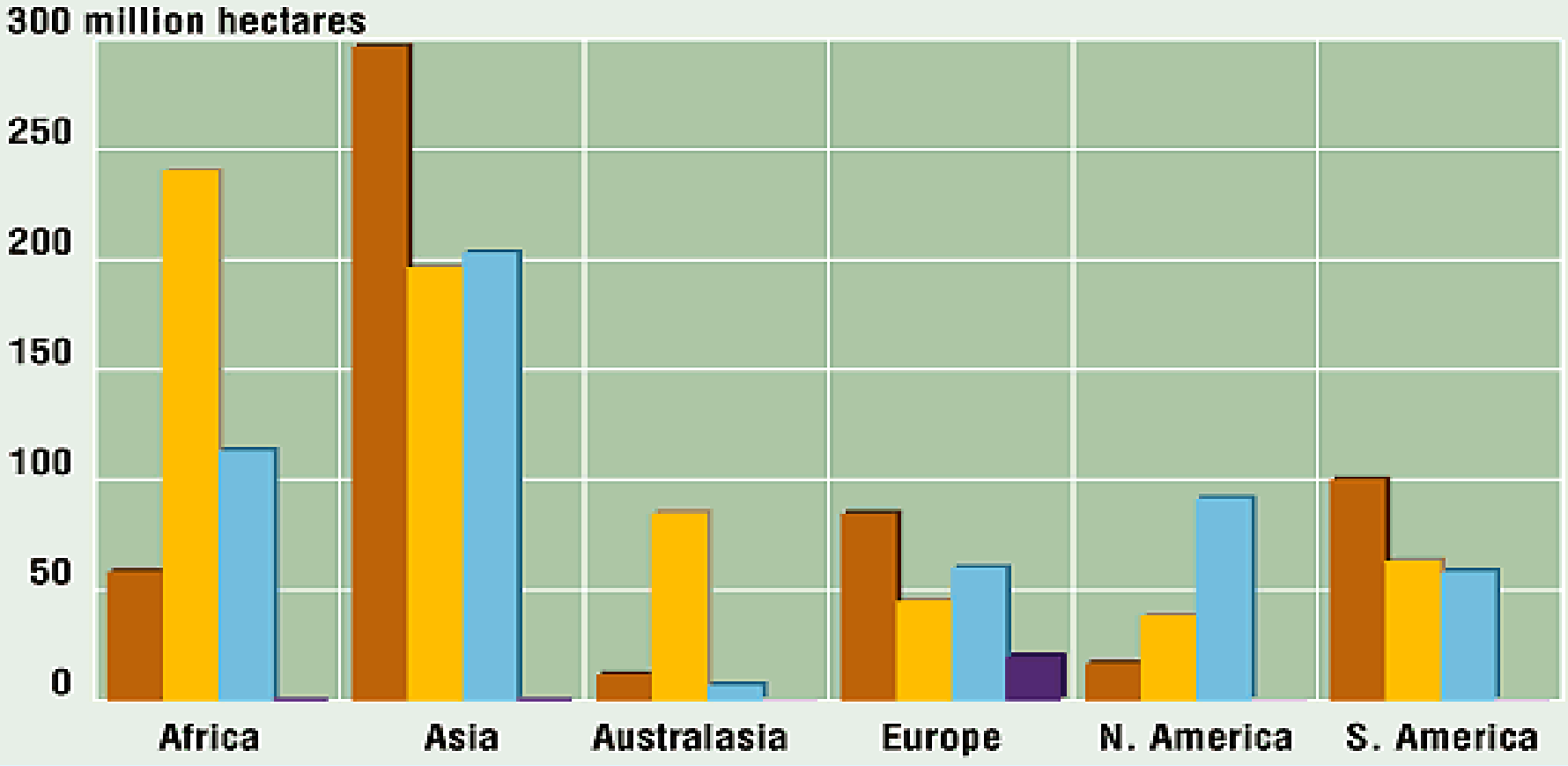
- Repeated drought and human intervention
  - erroneous use of fire as a management tool,
  - conversion to agricultural land,
  - overgrazing
  - over-harvesting of forest resources

Soil erosion caused by over-grazing, St. Lucia, South Africa

Erosion of grazing land, KwaZulu-Natal, South Africa

Kruger National Park, South Africa

MAIN CAUSES OF DRYLAND SOIL DEGRADATION BY REGION



Desertification does not refer to the moving forward of existing deserts but to the formation, expansion or intensification of degraded patches of soil and vegetation cover.

Dryland degradation

Progressive process:

- **Reduction in forest cover**
- **Reduction in soil fertility and soil structure, increase in soil erosion and susceptibility to fire**
- **Replacement, partially or totally, of forest ecosystems by grasses, shrubs and other invasive species**
- **Desertification**

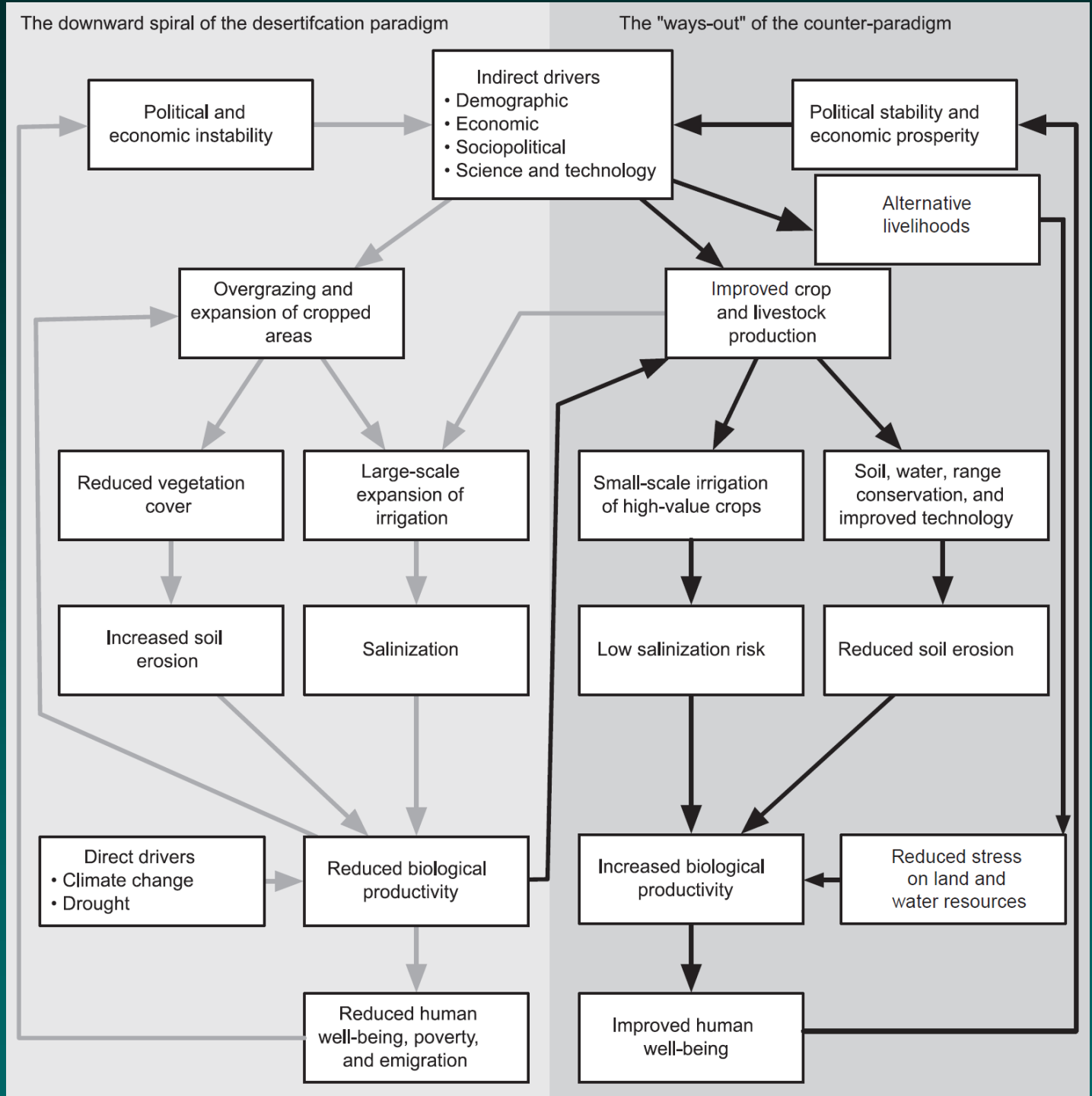
Firewood

- Fuelwood considered as a free resource, with the only price being the cost (usually in terms of time) of harvesting it.
- Open access to resources (land, forest and rangeland) and the absence of land security have contributed to the destruction of this resource.
- Unrestricted forest clearance and fuelwood collection has far exceeded the ecosystem's capacity to regenerate naturally.

Soil degradation in dryland areas

- **Physical: decline in soil structure, leading to reduced infiltration, increase in rainfall runoff, exacerbation of erosion**
- **Chemical: salinization, alkalinization, leaching, acidification**
- **Biological: reduction in humus quality and quantity, declines in soil biodiversity**

South Australia


The downward spiral of the desertifcation paradigm
The "ways-out" of the counter-paradigm
Political and economic instability
Indirect drivers
• Demographic
• Economic
• Sociopolitical
• Science and technology
Political stability and economic prosperity
Alternative livelihoods
Overgrazing and expansion of cropped areas
Improved crop and livestock production
Reduced vegetation cover
Large-scale expansion of irrigation
Small-scale irrigation of high-value crops
Soil, water, range conservation, and improved technology
Increased soil erosion
Salinization
Low salinization risk
Reduced soil erosion
Direct drivers
• Climate change
• Drought
Reduced biological productivity
Increased biological productivity
Reduced stress on land and water resources
Reduced human well-being, poverty, and emigration
Improved human well-being

Past policy failures

- **Forest plantations**
  - **excessively high costs of most schemes**
  - **rejection of many schemes by the general public**
- **Many other re-greening activities failed because they were not effectively linked to the implementation of other policies (e.g. agricultural and pastoral policies)**


Casuarina plantation
Egypt

Institutional problems

- complex relationships between stakeholders and the land
- contradictions between land law and customary law (e.g., with respect to ownership of resources and user rights)
- difficulties in replacing current agricultural and livestock production methods with new forms of rural land organisation and natural resource use

Food security and poverty

- Improvement of food security is an absolute prerequisite to sustainable development
- Main constraint to the implementation of sustainable resource management plans is the intensity of land use
- Even in heavily degraded areas people still depend, to a great extent, on what remains of any forest to meet their basic needs

Climate change

Flooding vs drought

Causes of climatic change

External forcing
- Sunspot cycles
- Variations in the earth's orbit around the Sun

Internal forcing
- Volcanoes
- Orogeny and epeirogeny
- Ocean circulation
- Atmosphere

Human-induced changes
- Pollution
- Deforestation
- Burning of fossil fuels

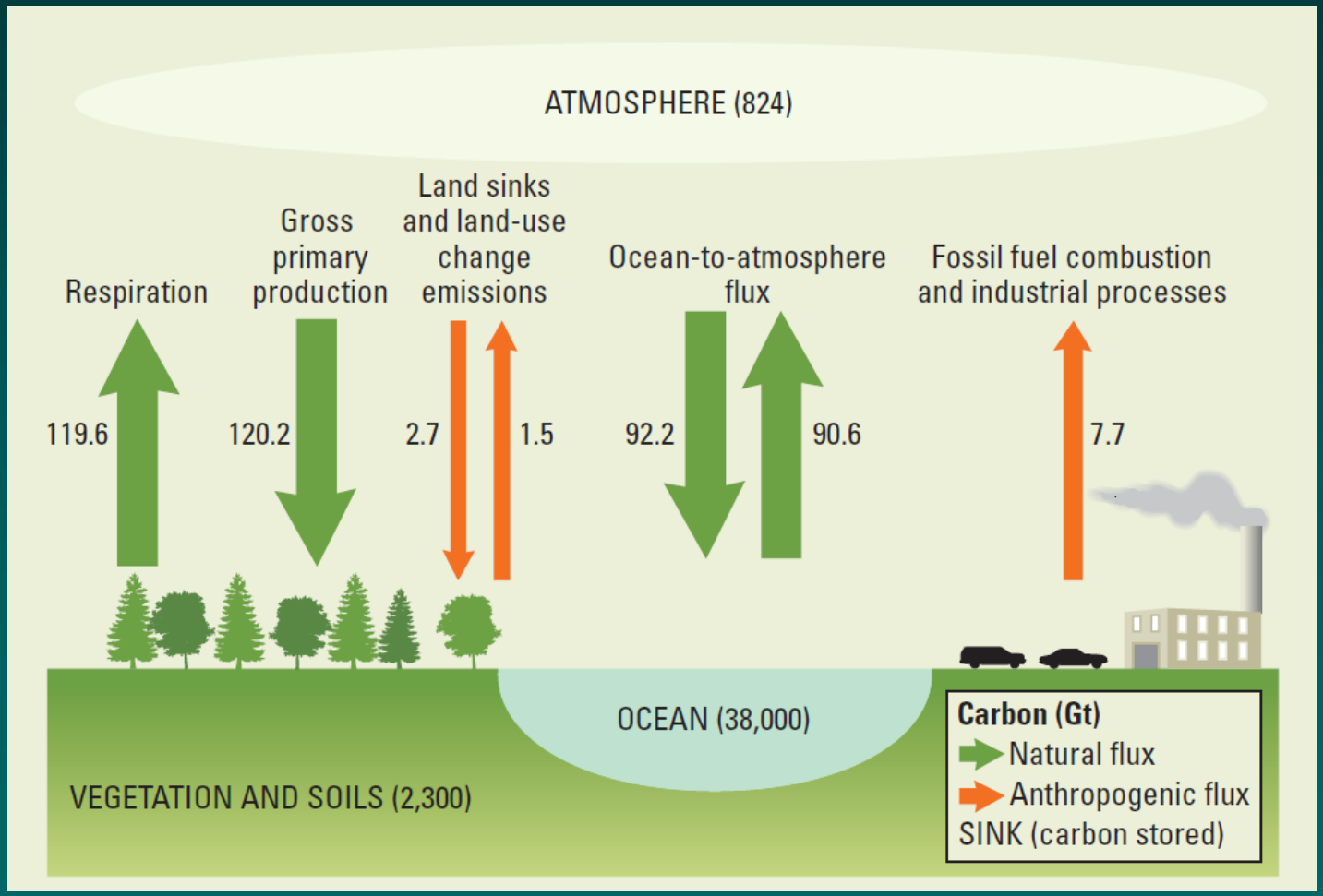
Causes of climatic change

Human-induced changes

- Pollution
- Deforestation
- Burning of fossil fuels

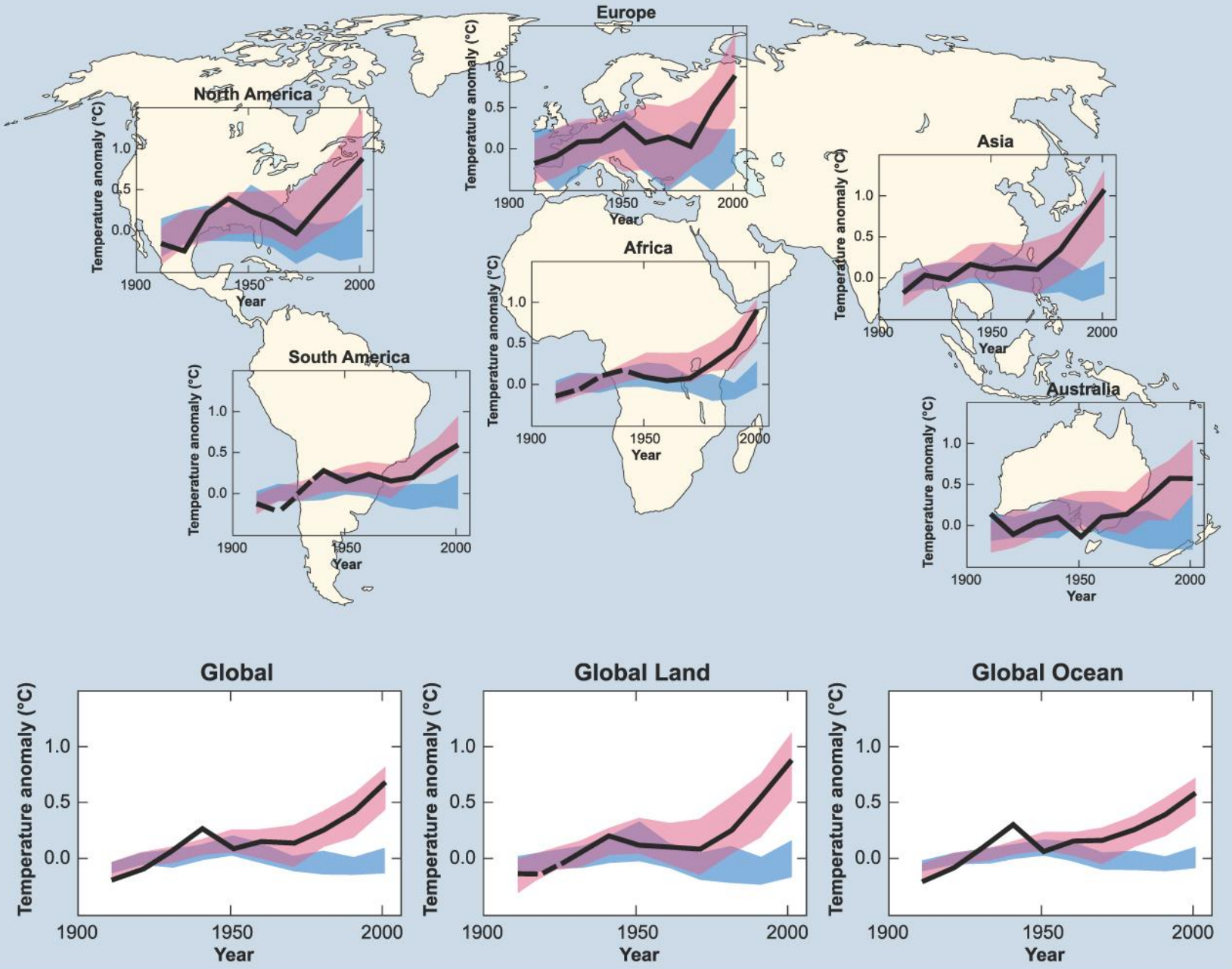
The greenhouse effect

The radiation balance is very sensitive to perturbation, which is what has happened over the last 150 years



Anthropogenic forcing?

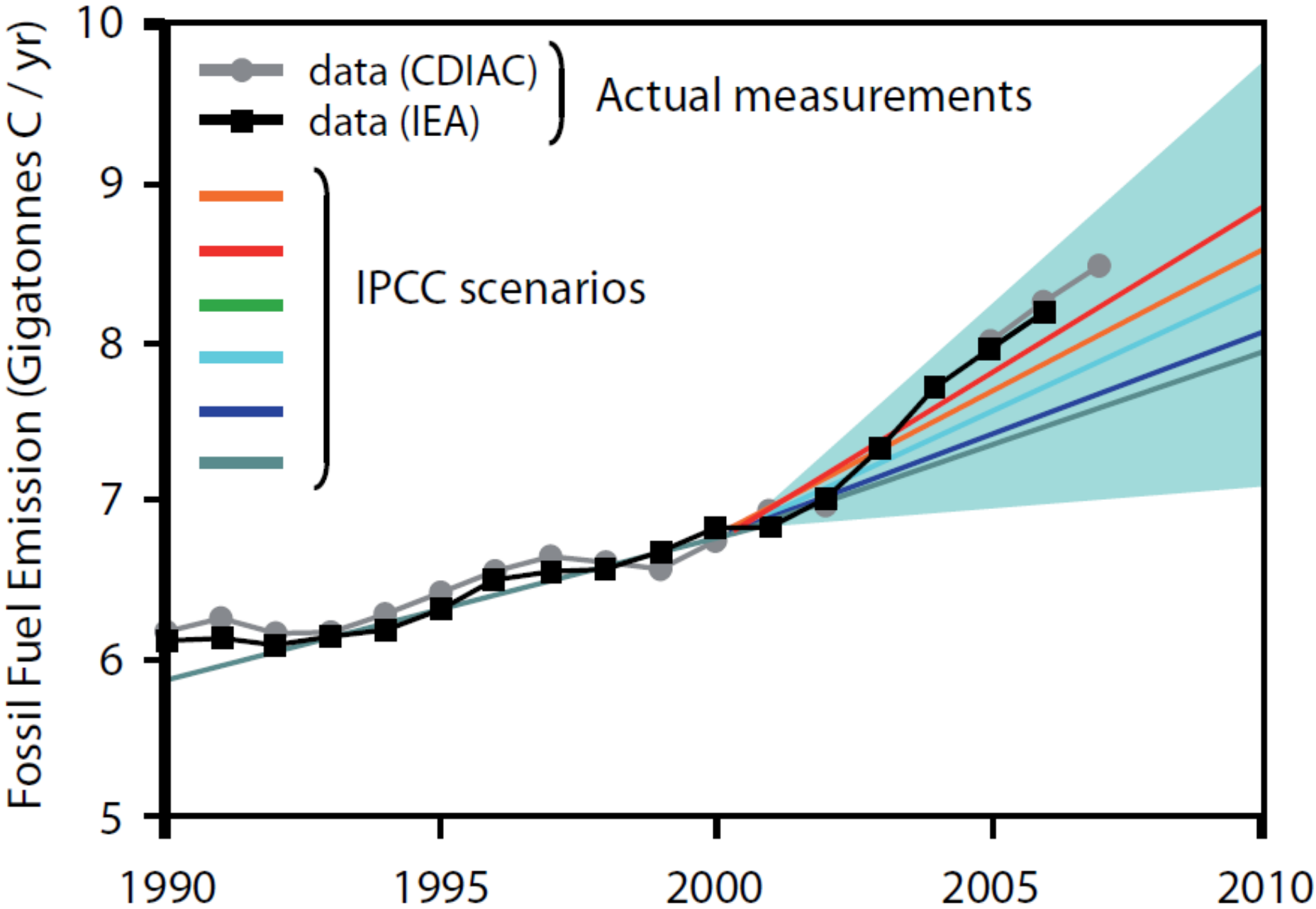
- The big argument in climate change is not whether climate is changing, but what is causing that change
- The whole premise is based on modelling – can we predict what the earth's climate would be like in the absence of climate change? Modelers say 'yes'. Climate skeptics say 'no'.



Future Climate

- Estimates of future climate depend on which scenario is used, and which model is used.
- The scenarios take into account different possible paths for human development
- It is currently impossible to say which path will be closest to reality

Figure 1.4: Fossil fuel emissions: Actual vs IPCC scenarios



Chukrasia tabularis

Cupressus cashmeriana

Eugenia arnottiana

In order to model future forests, a detailed knowledge of the ecology of the species present is required. In many countries, this is simply absent.

Hill towns such as Shimla will come under increasing pressure

Wildfires in Russia in 2010 emphasized the need for greater vigilance: current mortality rates in Moscow are twice the normal rate (caused by smoke and excessive temperatures)

On 6 August, a 40 million m^3 mudslide was triggered by a melting glacier near Pemberton, British Columbia

On 7 August 2010, a landslide may have killed ca. 2000 people in Gansu Province, China

- 132 people killed in Indian-controlled Kashmir, 500 missing
- >1600 people killed by floods in Pakistan, 4 million facing food shortages, 400,000 ha of farmland flooded

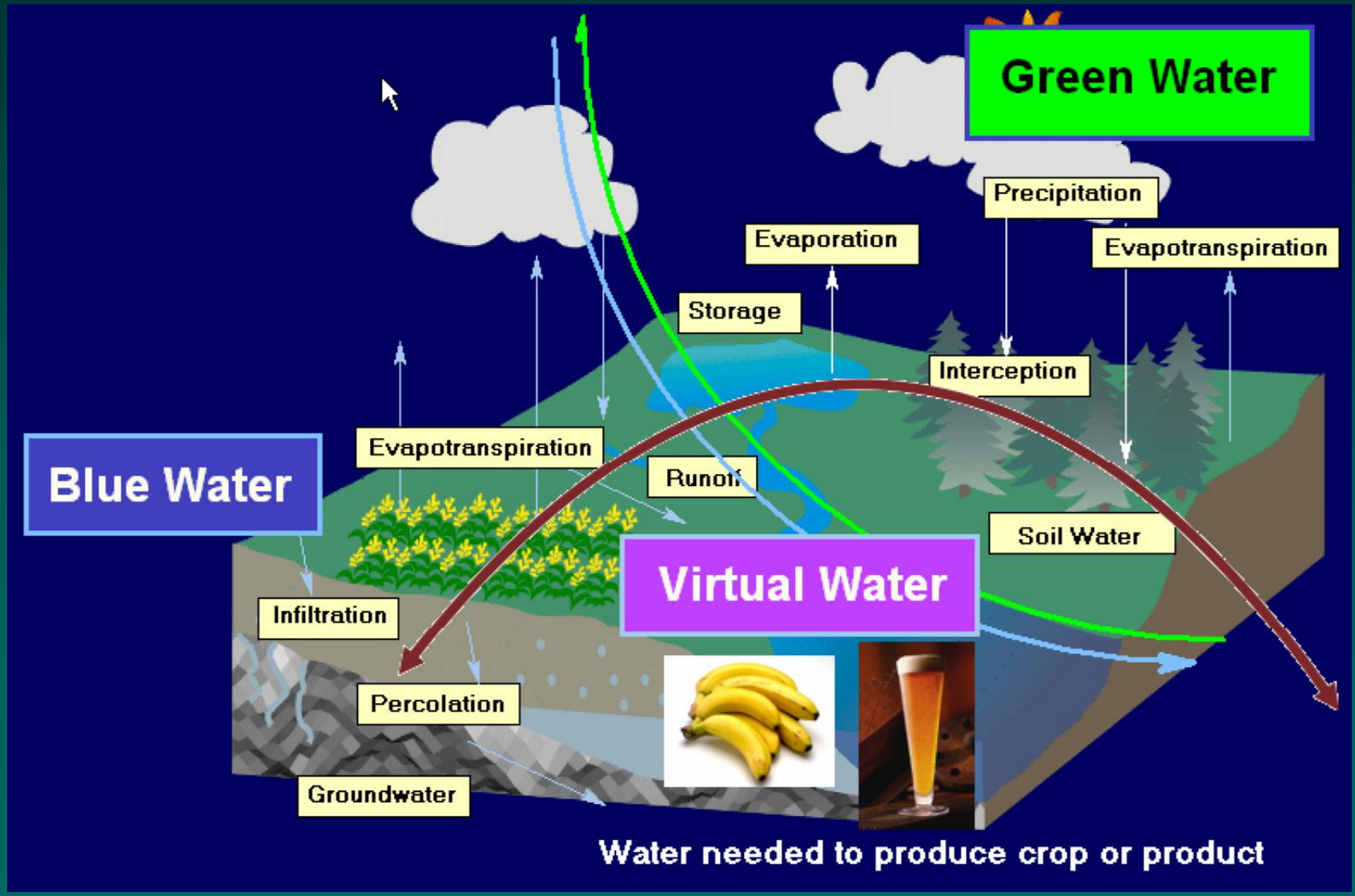
Widespread flood damage is visible in this aerial handout photograph taken over Khyber Pakhtunkhwa August 5, 2010 and released on August 7

Water

Water

- 96.54% of the Earth's water is in oceans
- Of the remainder:
  - 0.76% in ground water (fresh)
  - 0.93% in ground water (salt)
  - 1.76% in glaciers, permanent snow and permafrost
  - 0.016% freshwaters
- About 0.00974% of Earth's total water is available for human use

Virtual Water



Water: Are we heading for a crisis?

Projections:
50 % increase in food production needed in next 30 years

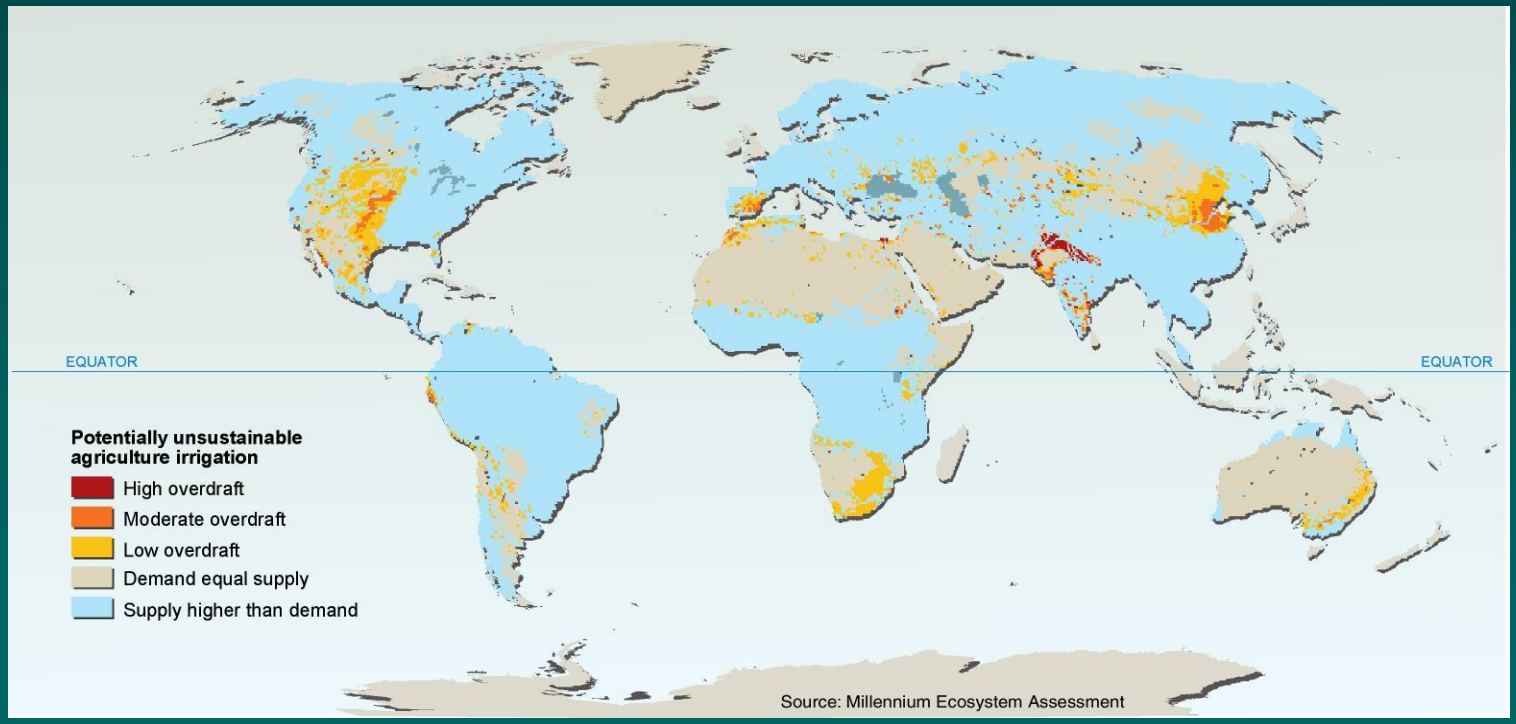
Why?
2 billion new people
0.8 billion with shortage
1 billion changing their diet
10-20% of food biomass being diverted to ethanol or biodiesel

Agriculture uses 70% of all freshwater consumption

40% of food today comes from irrigated land

Water

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

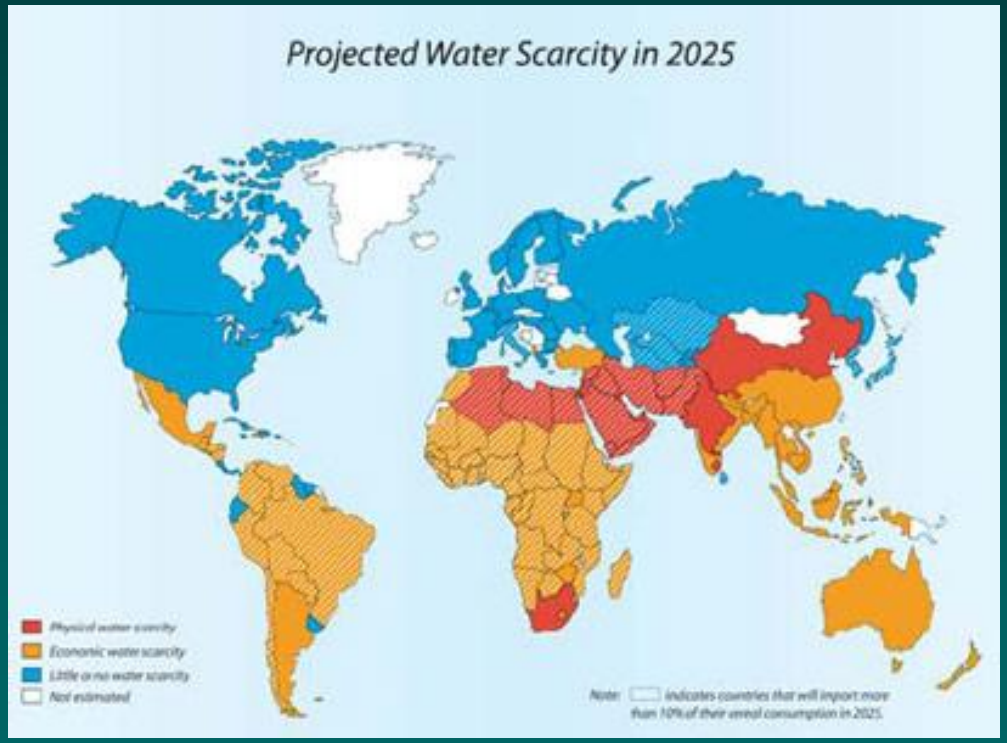


Sonoran Desert, California (Palm Desert)

Water scarcity

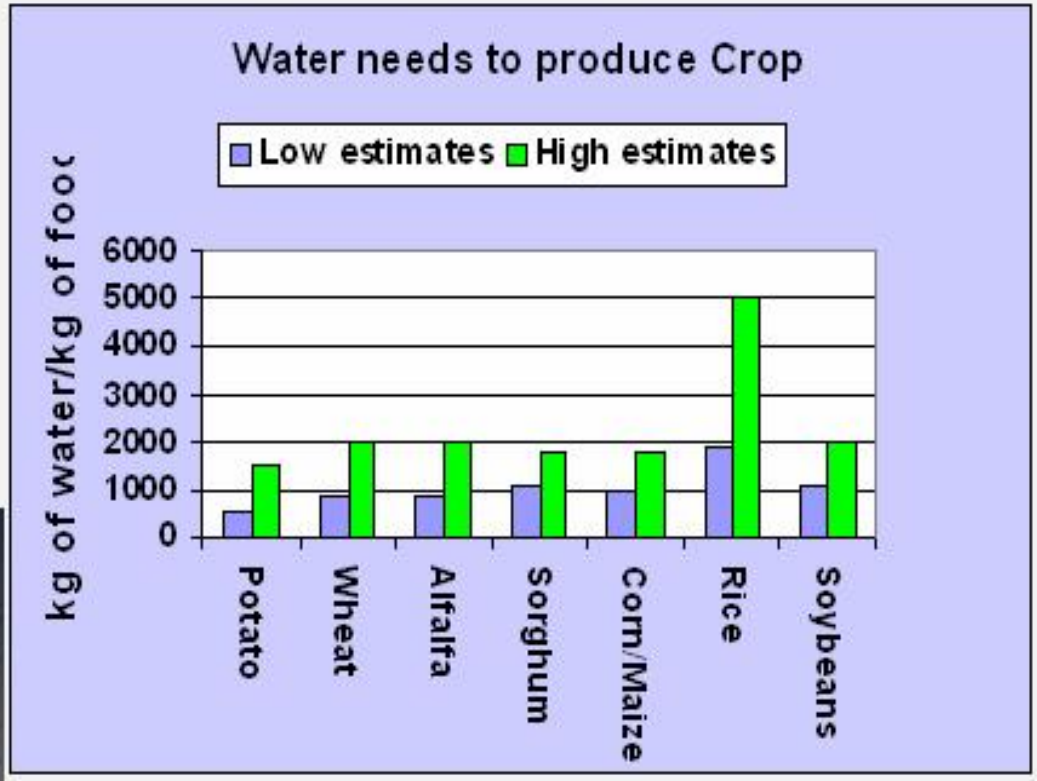
- Physical water scarcity (resources cannot meet demands)
- Economic water scarcity (lack of infrastructure is more important than lack of resources)
- Institutional water scarcity (certain people do not have rights to land or water)

Many parts of the world are predicted to have significant water shortages by 2025



Water Needs for Food

- Water Needs for Grain
- Water Needs for Meat
- Water Needs for Different Diets



As a general estimate we can state that we need about 1200 L of water to produce 1 kg of basic staple food.

Based on Seckler et al. 1998, Alcamo, 1997, and Gleick 1997


Fujian, China

Water Needs for Grain
Water Needs for Meat
Water Needs for Different Diets

Water Needs for Meat Production

Water requirements to produce 1 kg of meat

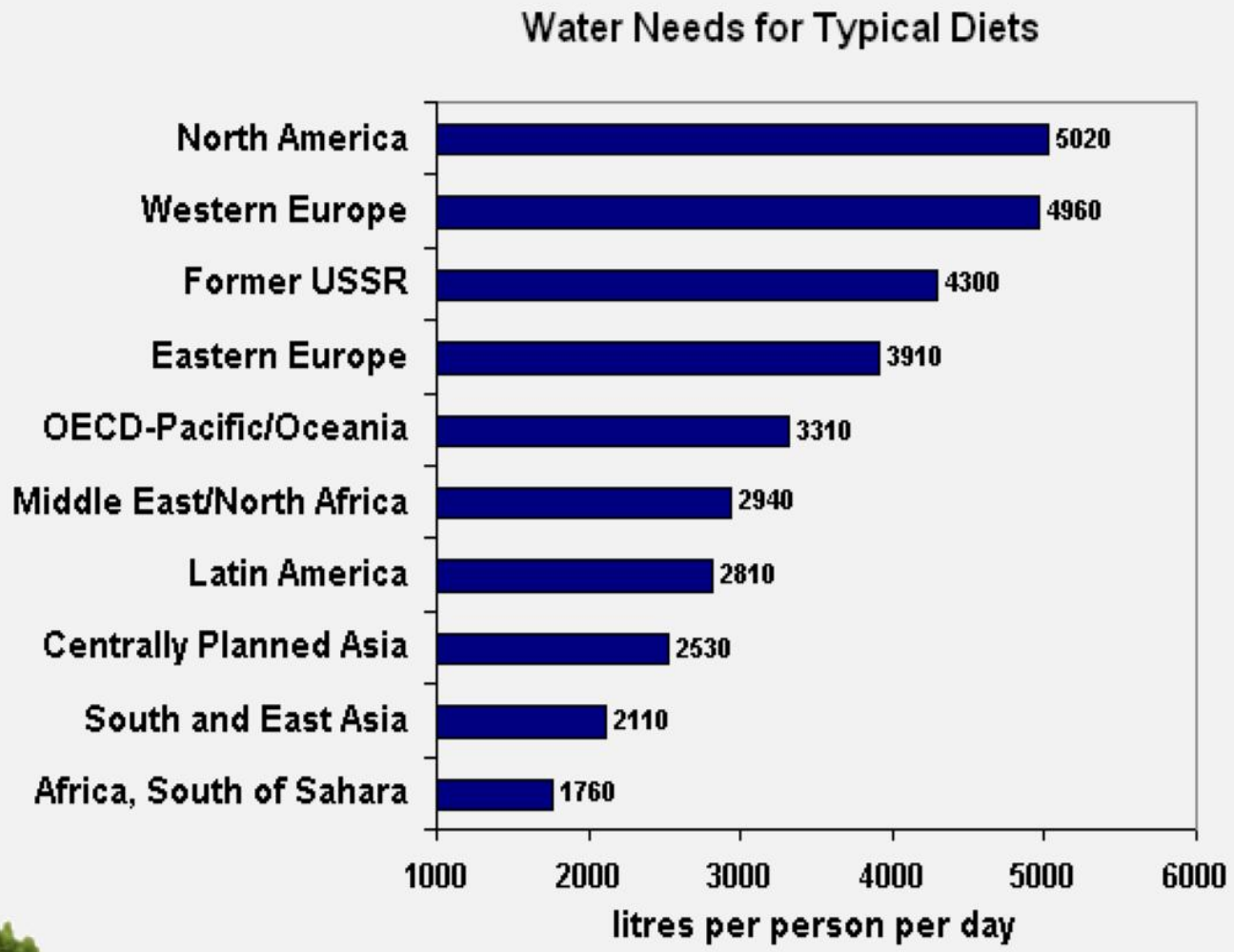
Chicken: 3500 - 5,700 kg of water / kg of meat
Beef: 15,000 -70,000 kg of water / kg of meat

As a general estimate we can state that we need about 3 times as much water to produce 1 kg of chicken meat or 20-30 times as as much water to produce 1 kg of beef than to produce 1 kg of basic staple food (grain).


Northern Territory
Australia

Water Needs for Food

- Water Needs for Grain
- Water Needs for Meat
- Water Needs for Different Diets



Please note: This does not include water needs for industrial use.

Global average virtual water contents

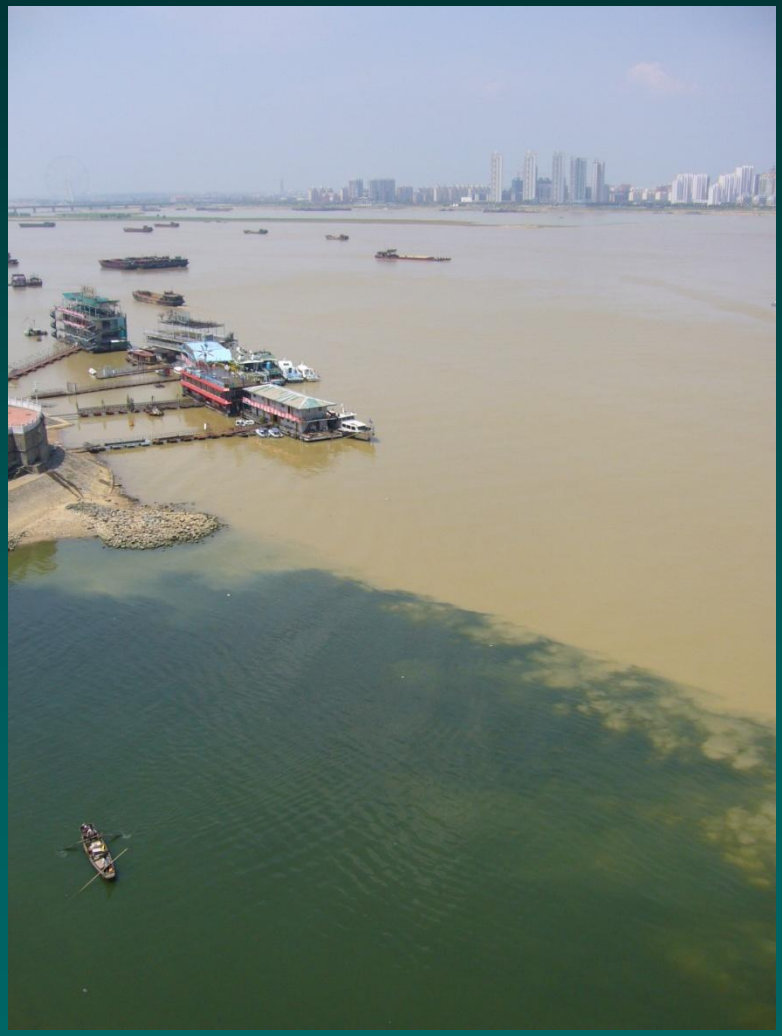
1 glass of beer (250 ml)	75 l
1 glass of milk (200 ml)	200
1 cup of coffee (125 ml)	140
1 apple (100 g)	70
1 cotton T-shirt	2000
1 beefburger	2400
1 pair of leather shoes	8000
1 sheet of A4 paper	10


Sabie, South Africa

China

Ministry of Water Resources, Jan 2005:

- 53% of water in major river systems is undrinkable
- Half the water in 52 lakes surveyed undrinkable
- 35% of groundwater too polluted to drink



Gan River, Nanchang

Water Pollution

- **Cuyohoga River, Ohio – caught fire a number of times, with the June 22, 1969, fire capturing the attention of Time Magazine, and thus the nation**

Water Pollution

- Songhua River, China – 13 November 2005
- Chemical plant explosion in Jilin contaminated the river with 91 tonnes of benzene-related pollution
- Temporary suspension of water supply to nearly 4 million people in Harbin
- Contamination problems in Khabarovsk, Russia, further downstream

Songhua River, Harbin

Water Pollution

- Eutrophication (nitrogen enrichment) is a serious problem in many freshwater bodies
- As many local people are dependent on fisheries, the risk of transfer of pollutants is very high

Eutrophication, Aixi Lake, Jiangsu, China

Water pollution also has implications for food stocks

Increasing blue water productivity

- Improving irrigation management
- Adapting farming practices to increased water scarcity
- Enhancing the safe and productive use of wastewater in irrigated agriculture
- Multiple use systems: domestic, agriculture, aquaculture, agroforestry and livestock


Egypt

Increasing green water productivity

- Rainwater harvesting
- Supplemental and micro irrigation
- Increased infiltration and reduced runoff through land and water conservation


Air pollution
Changsha, Hunan Province, PRC

Pollution disasters

- Winter months
- Dense population
- Heavy industrialization
- Valley situations
- Temperature inversions
- Accidents, or mixtures from non-accidents

Bhopal, India 1984

- Accident at a Union Carbide pesticide plant
- Methyl isocyanate released, possibly forming hydrogen cyanide
- 2000 killed; 350,000 injured; 100,000 with permanent disabilities

Pollutants

- Physical contaminants
- Chemical contaminants
- Microbial contaminants (mainly associated with water)

Physical contaminants

Particles – PM_{10} and $PM_{2.5}$

- **Asbestos**
- **Silica**
- **Human-made aerosols (e.g., diesel exhaust, wood smoke)**
- **Bioaerosols (e.g., endotoxins, mycotoxins, coccidioidomycosis – Valley Fever)**

Chemical contaminants

- Organic (e.g., petroleum hydrocarbons, chlorinated solvents, pesticides, PCBs, gaseous compounds)
- Inorganic (inorganic salts, including sodium, calcium, nitrate, sulphate, heavy/trace metals, including lead, zinc, cadmium, mercury, arsenic)
- Radioactive (both solid and gaseous)

Environmental toxicology

- **Acute injury: caused by a single exposure to a very high concentration of a chemical**
- **Chronic injury: caused by longer term exposure to lower concentrations**


Chengdu
Sichuan, PRC

Conclusions

- Some environmental issues are truly global (e.g., climate change)
- Some affect particular areas more than others (e.g., deforestation)
- Some are local, but occur widely (e.g., pollution)
- Mechanisms to deal with these vary accordingly