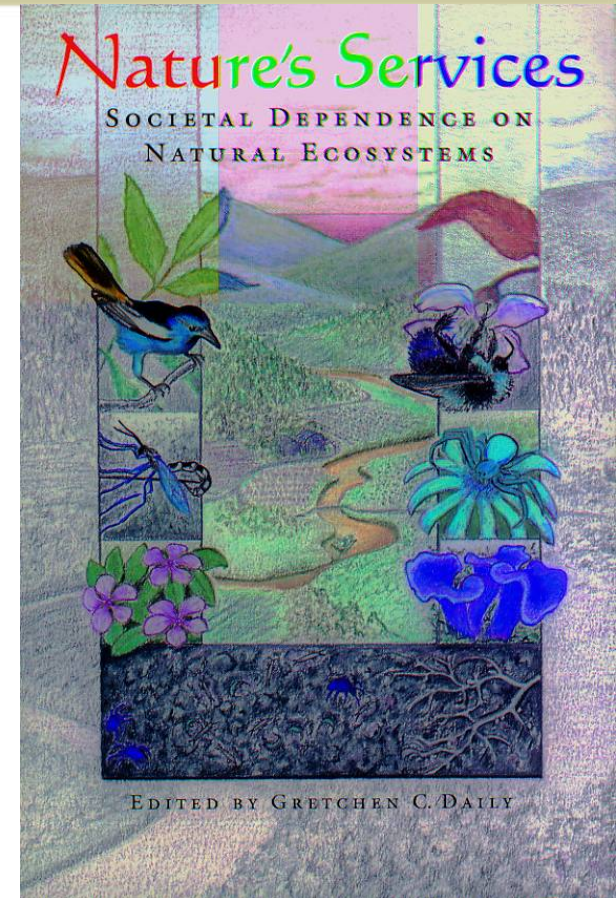


Understanding Global Change: The Millennium Ecosystem Assessment

- **John Harrington, Jr.**
 - Professor, Geography
 - K-State
 - jharrin@ksu.edu
-
- Human Dimensions of Global Change
 - Land Change Science
 - Global Environmental Change
 - Climatology
 - Climate and Vulnerability



The issue of global change is less well known and less political than global warming



Bush's carbon footprints



CARBON FOOTPRINTS

© Ft. Worth Star-Telegram. Dist. by NEA, Inc.



The National Academies Analysis of Global Change Assessments



Analysis of Global Change Assessments: Lessons Learned

Committee on Analysis of Global Change Assessments,
National Research Council

ISBN: 0-309-10545-5, 196 pages, 6 x 9, (2007)

This free PDF was downloaded from:

<http://www.nap.edu/catalog/11868.html>

Salience, Credibility, and Legitimacy

The three essential properties of an effective assessment process are:

- *Salience* relates to the perceived relevance of information: Does the system provide information that decision makers think they need, in a form and at a time that they can use it?
- *Credibility* addresses the perceived technical quality of information. Does the system provide information that is perceived to be valid, accurate, or tested?
- *Legitimacy* concerns the perception that the system has the interests of the user in mind or, at a minimum, is not simply a vehicle for pushing the agenda and interests of other actors. Legitimacy relates to the perceived fairness of the process.

SOURCE: Ravetz 1971; Clark and Majone 1985; Social Learning Group 2001a.

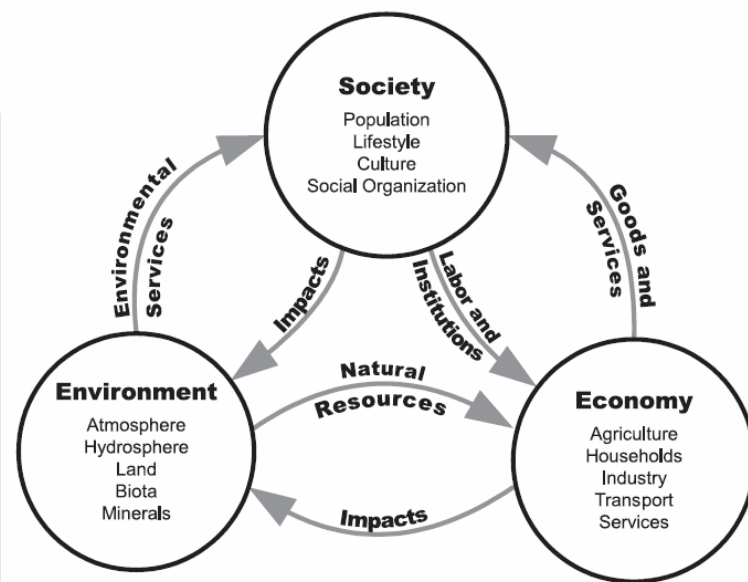


Figure 2.1. The Socioecological System and Its Components

The National Academies Analysis of Global Change Assessments

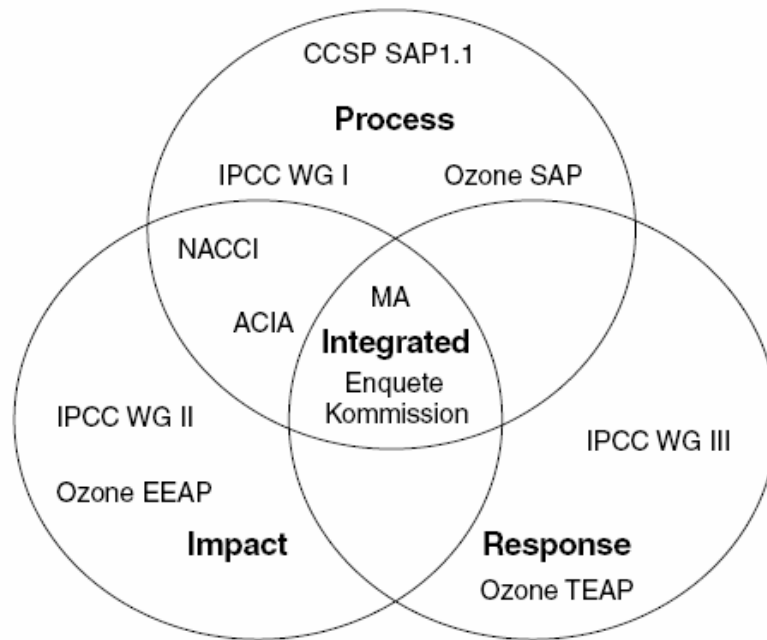
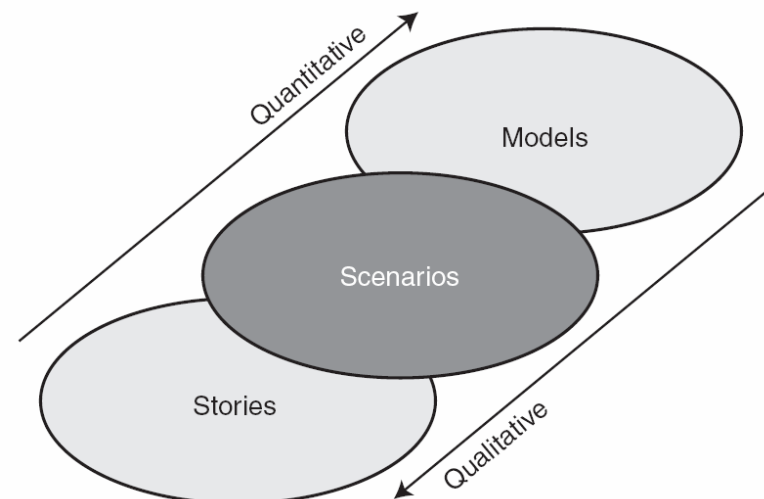


FIGURE 2.1 Three types of global change assessment: process assessment, impact assessment, and response assessment. The fully integrated assessment lies at the intersection of the three types. Examples of assessments are included. ACIA = Arctic Climate Impact Assessment; CCSP SAP 1.1 = U.S. Climate Change Science Program Synthesis and Assessment Product 1.1 on Temperature Trends in the Lower Atmosphere; IPCC WG I, II, and III = Intergovernmental Panel on Climate Change Working Groups I, II, and III; MA = Millennium Ecosystem Assessment; NACCI = U.S. National Assessment of Climate Change Impacts; Ozone EEAP = Environmental Effects Assessment Panel of the stratospheric ozone assessments; Ozone SAP = Scientific Assessment Panel of the stratospheric ozone assessments; Ozone TEAP = Technology and Economical Affects Panel of the stratospheric ozone assessments.



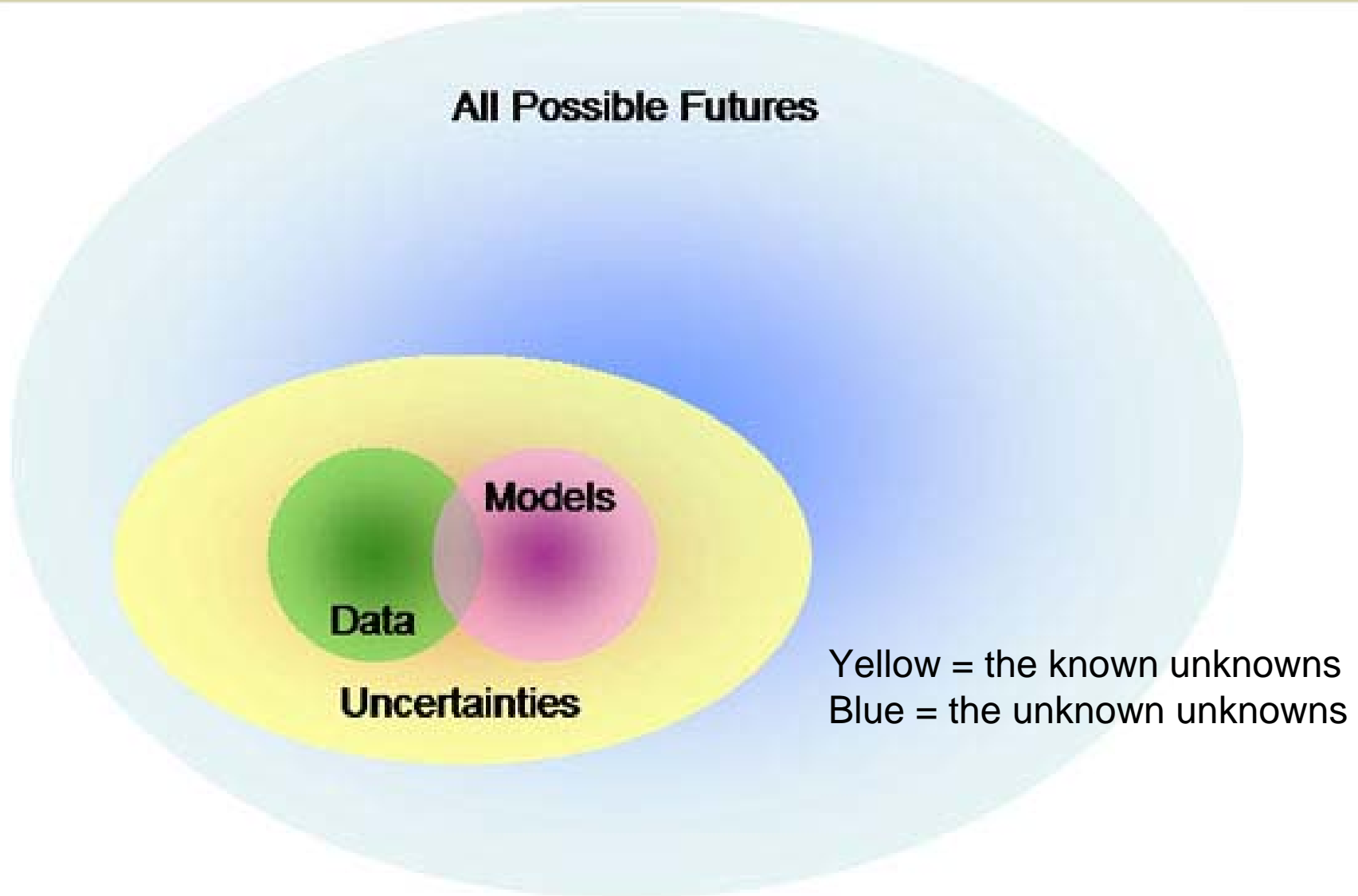
IPCC

WG I = The Science of Climate Change
WG II = Impacts of a Changing Climate
WG III = Climate Change Mitigation

Scenarios for Ecosystem Assessment:

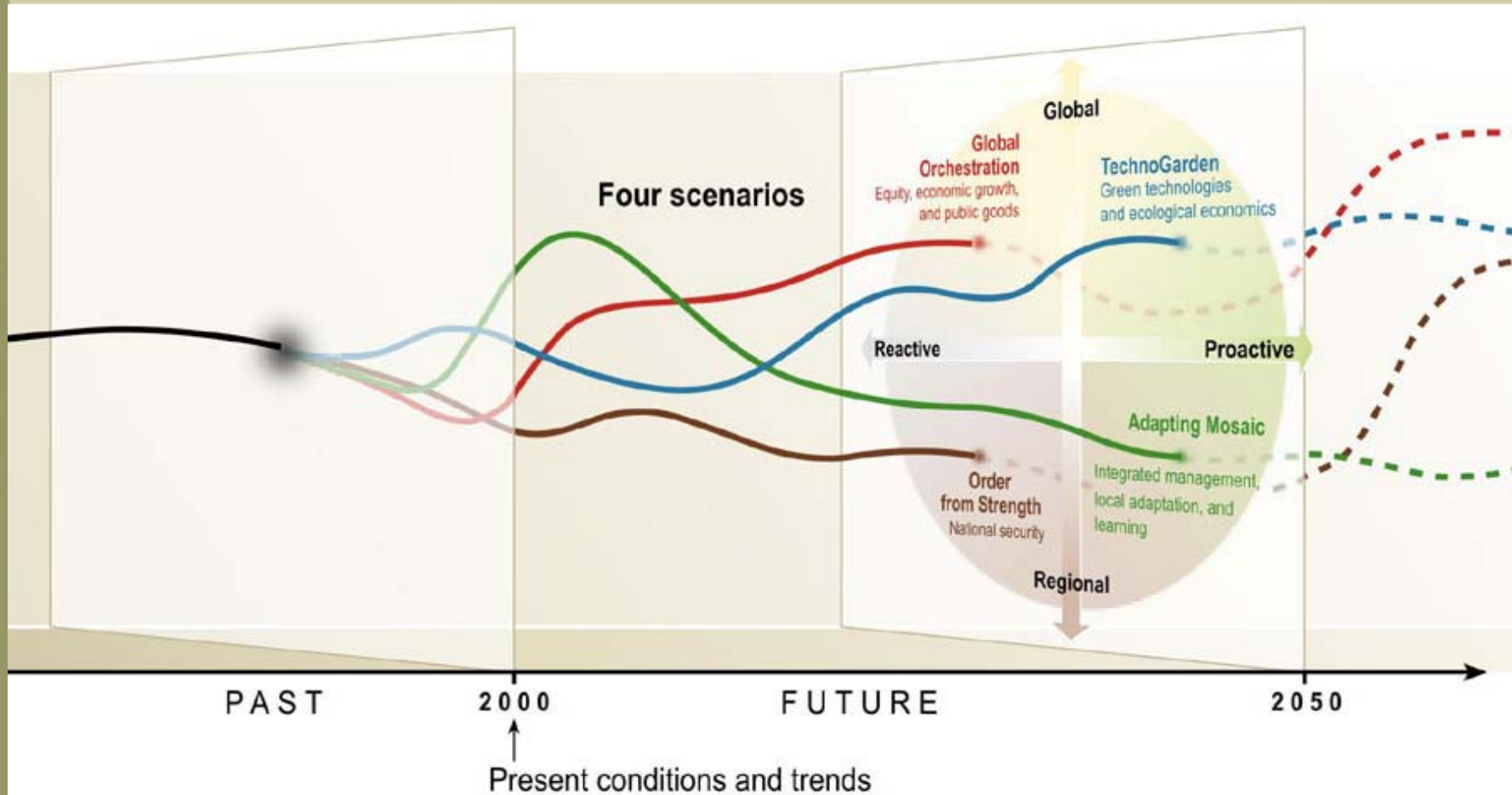
An Overview by Stephen Carpenter, Elena Bennett, and Gary Peterson

<http://www.ecologyandsociety.org/vol11/iss1/art29/>



Scenarios for Ecosystem Assessment: An Overview

<http://www.ecologyandsociety.org/vol11/iss1/art29/>



Order from Strength = a business as usual scenario

Taking the Pulse of Earth's Life-Support Systems

SCIENCE VOL 308
1 APRIL 2005

A massive effort to document the state of ecosystems—and their ability to provide food, comfort, and other services—lays out some grand challenges, but no easy answers



Ecosystem Services

Provisioning, including food, water, fuel, and fiber.

Regulating, such as the prevention of soil erosion and flooding.

Cultural, including recreation, spiritual values, and a "sense of place."

Basic support, including soil formation, nutrient cycling, and oxygen from photosynthesis.

Unpredictable Changes

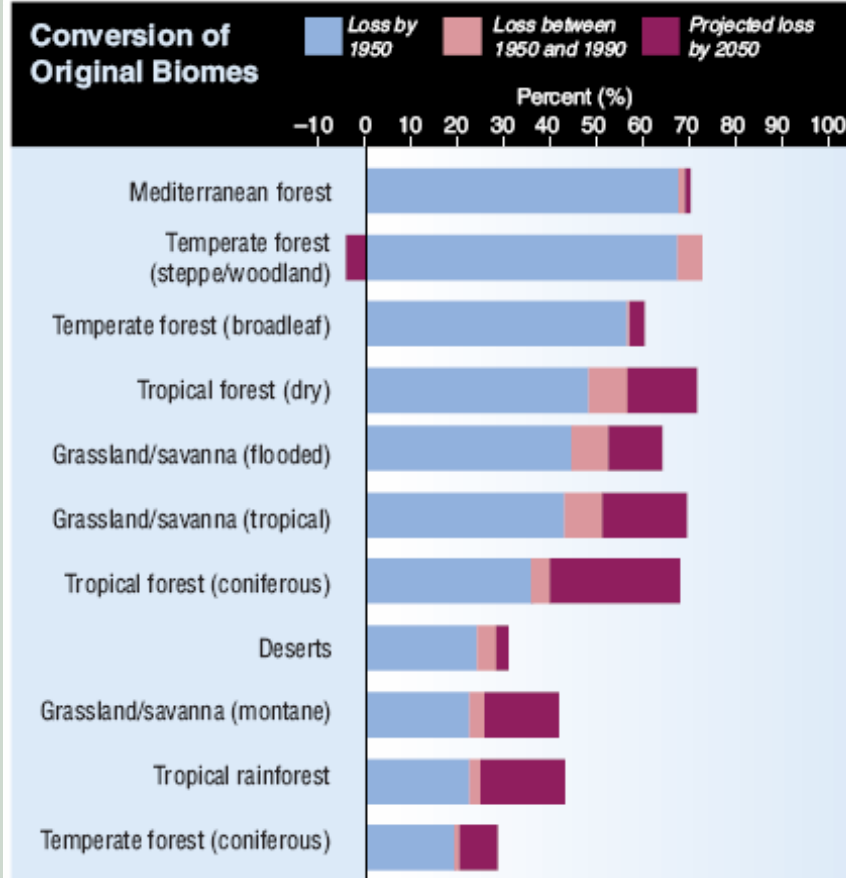
Dead zones. Nutrient loading can cause sudden, widespread algal blooms that suffocate animals.

Fisheries collapse. After centuries of fishing, cod stocks in the Atlantic collapsed in 1992.

Alien invaders. Zebra mussels and other invasive species can be a complete surprise.

Forest feedback. Deforestation dries out a region, which can mean even more forest loss.

Conversion of Original Biomes



Going, going. Major ecological communities, or biomes, will be turned to farms and other purposes over the next 50 years.



Millennium Ecosystem Assessment

Over the past 50 years, **humans have changed ecosystems more rapidly and extensively** than in any comparable period of time in human history, largely **to meet rapidly growing demands** for food, fresh water, timber, fiber and fuel

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** in the form of the **degradation of many ecosystem services**, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people

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

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 has considered but these **involve significant changes in policies, institutions and practices**, that are not currently under way

Overview of Findings

- Over the past 50 years, **humans have changed ecosystems more rapidly and extensively** than in any comparable period of time in human history, largely **to meet rapidly growing demands** for food, fresh water, timber, fiber and fuel
- 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** in the form of the **degradation of many ecosystem services**, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people
- 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
- **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 has considered but these involve significant changes in policies, institutions and practices, that are not currently under way

Largest assessment of the health of Earth's ecosystems

Experts and Review Process

- Prepared by 1360 experts from 95 countries
- 80-person independent board of review editors
- Review comments from 850 experts and governments

Governance

- Called for by UN Secretary General in 2000
- Authorized by governments through 4 conventions
- Partnership of UN agencies, conventions, business, non-governmental organizations with a multi-stakeholder board of directors

Defining Features

Demand-driven

- Providing information requested by governments, business, civil society

Assessment of current state of knowledge

- A critical evaluation of information concerning the consequences of ecosystem changes for human well-being
- Intended to be used to guide decisions on complex public issues

Authoritative information

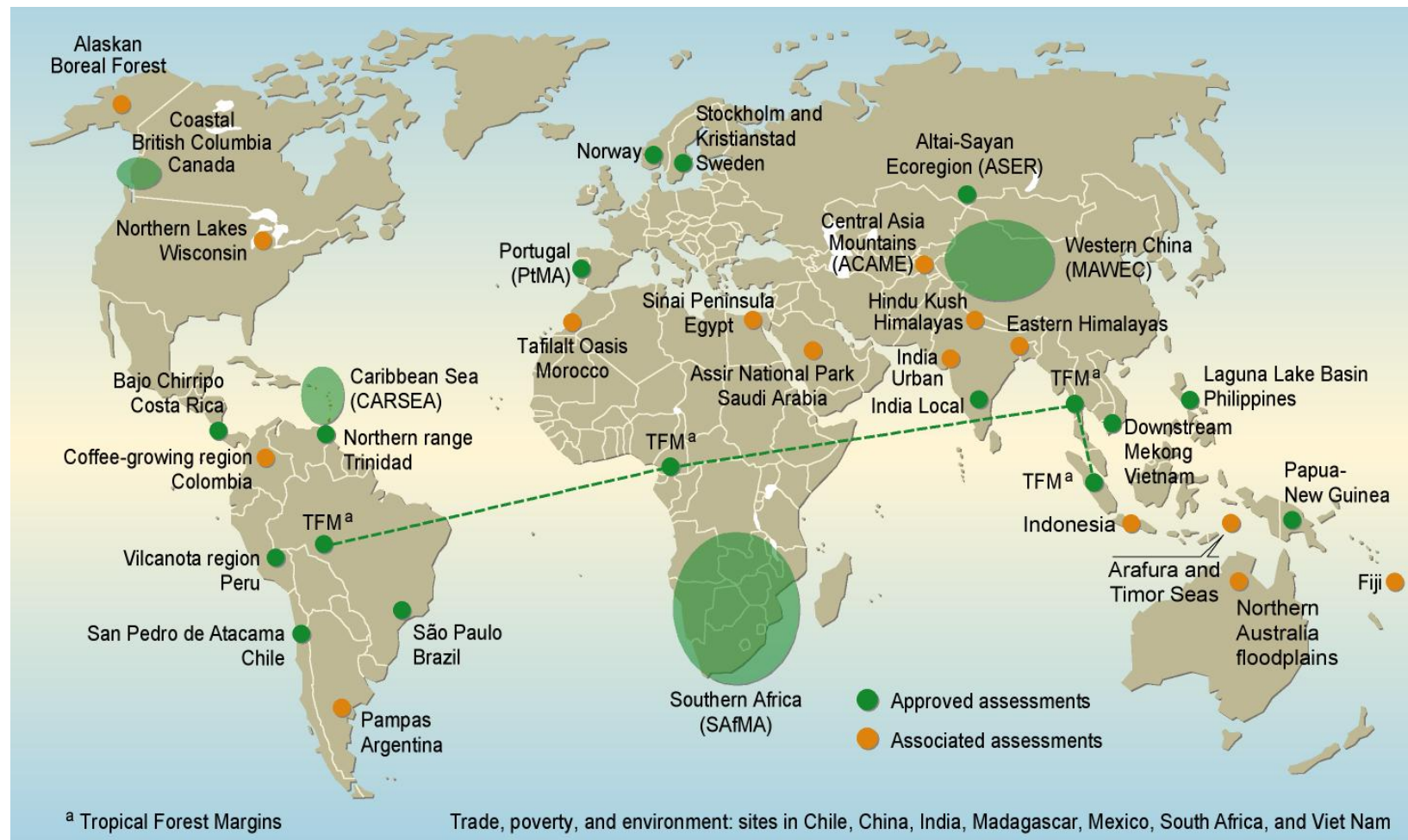
- Clarifies where there is broad consensus within the scientific community and where issues remain unresolved

Policy relevant not policy prescriptive

Defining Features

Multi-scale assessment

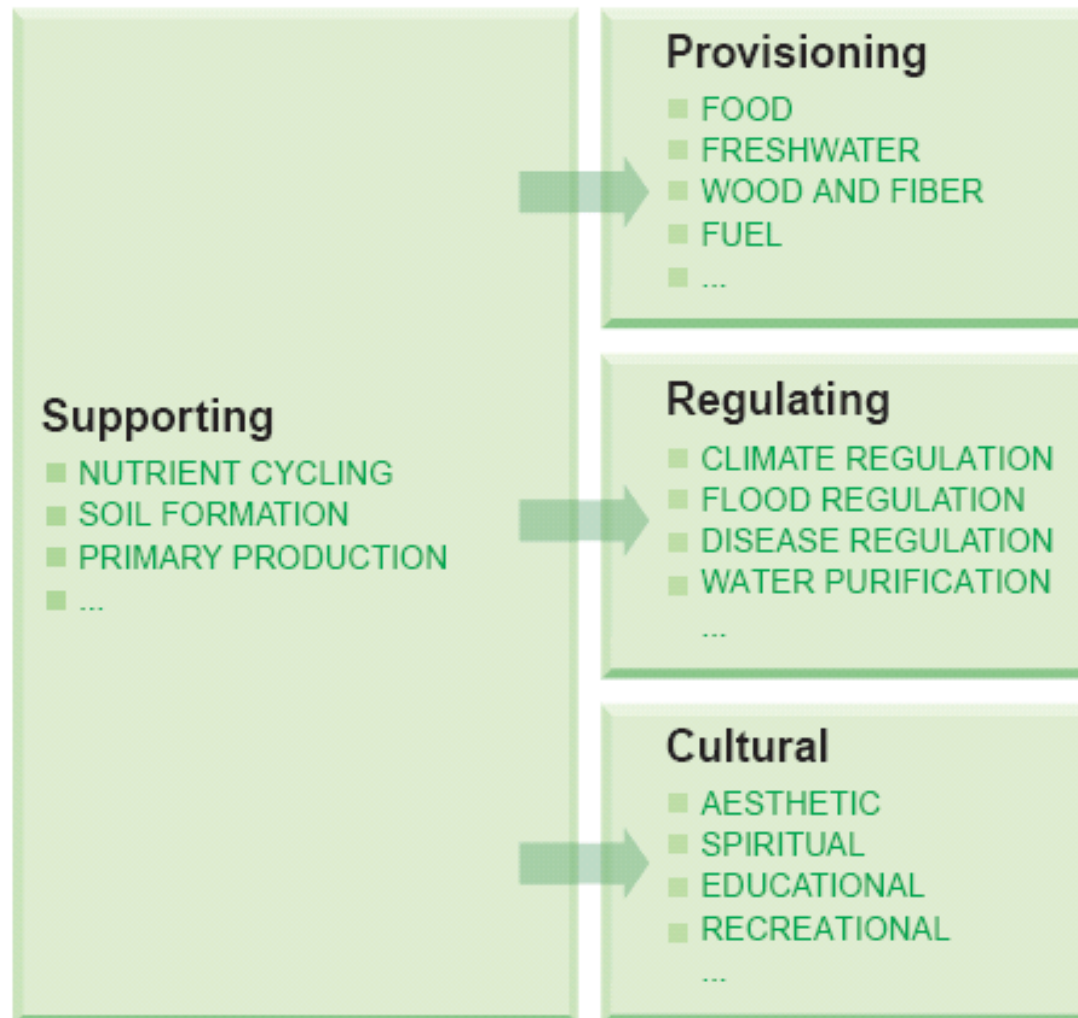
- Includes information from 33 sub-global assessments



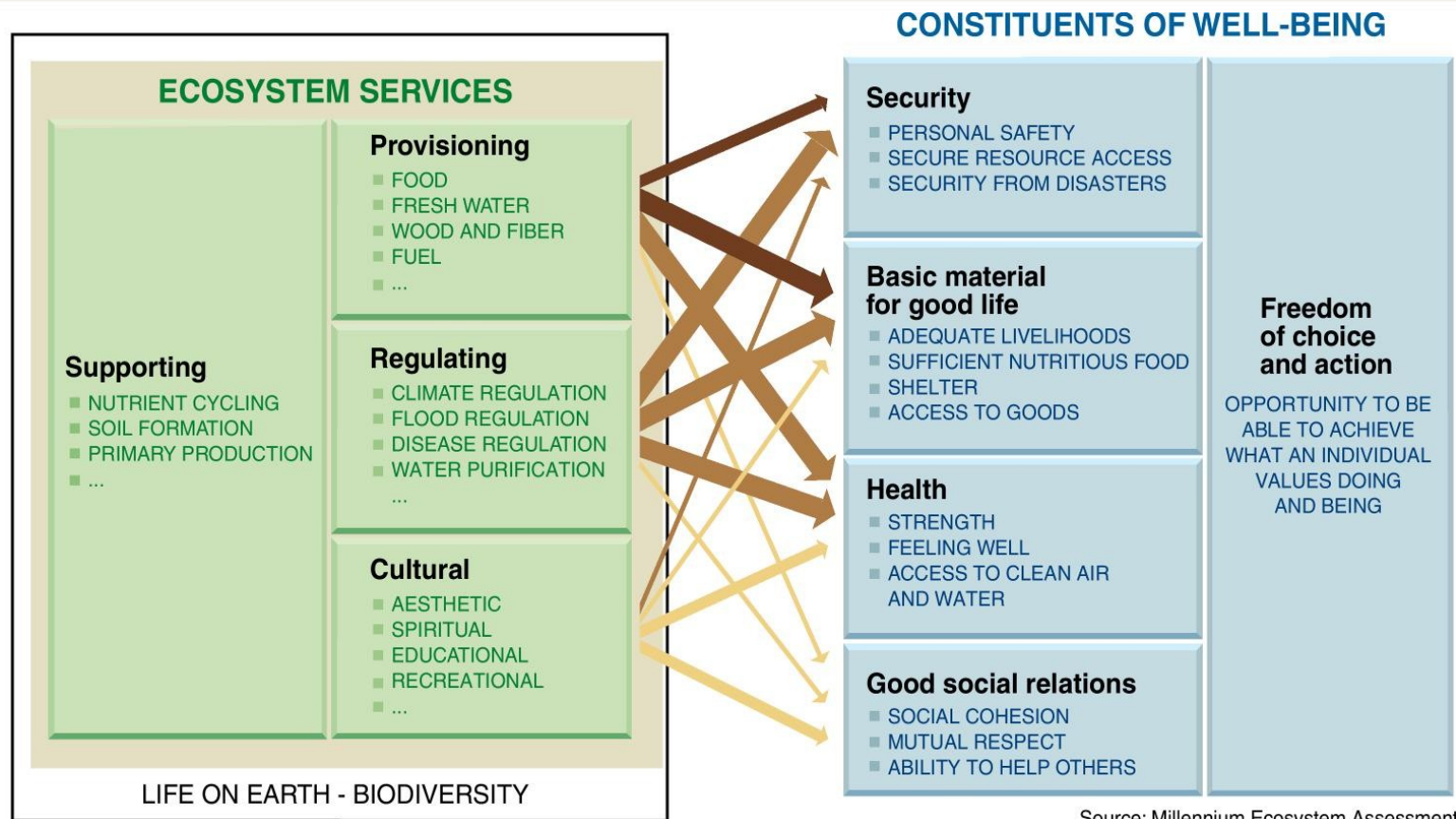
Focus: Ecosystem Services

The benefits people obtain from ecosystems

ECOSYSTEM SERVICES

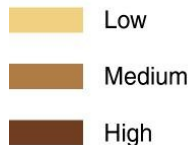


Focus: Consequences of Ecosystem Change for Human Well-being

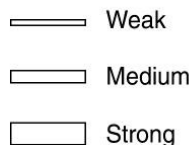


Source: Millennium Ecosystem Assessment

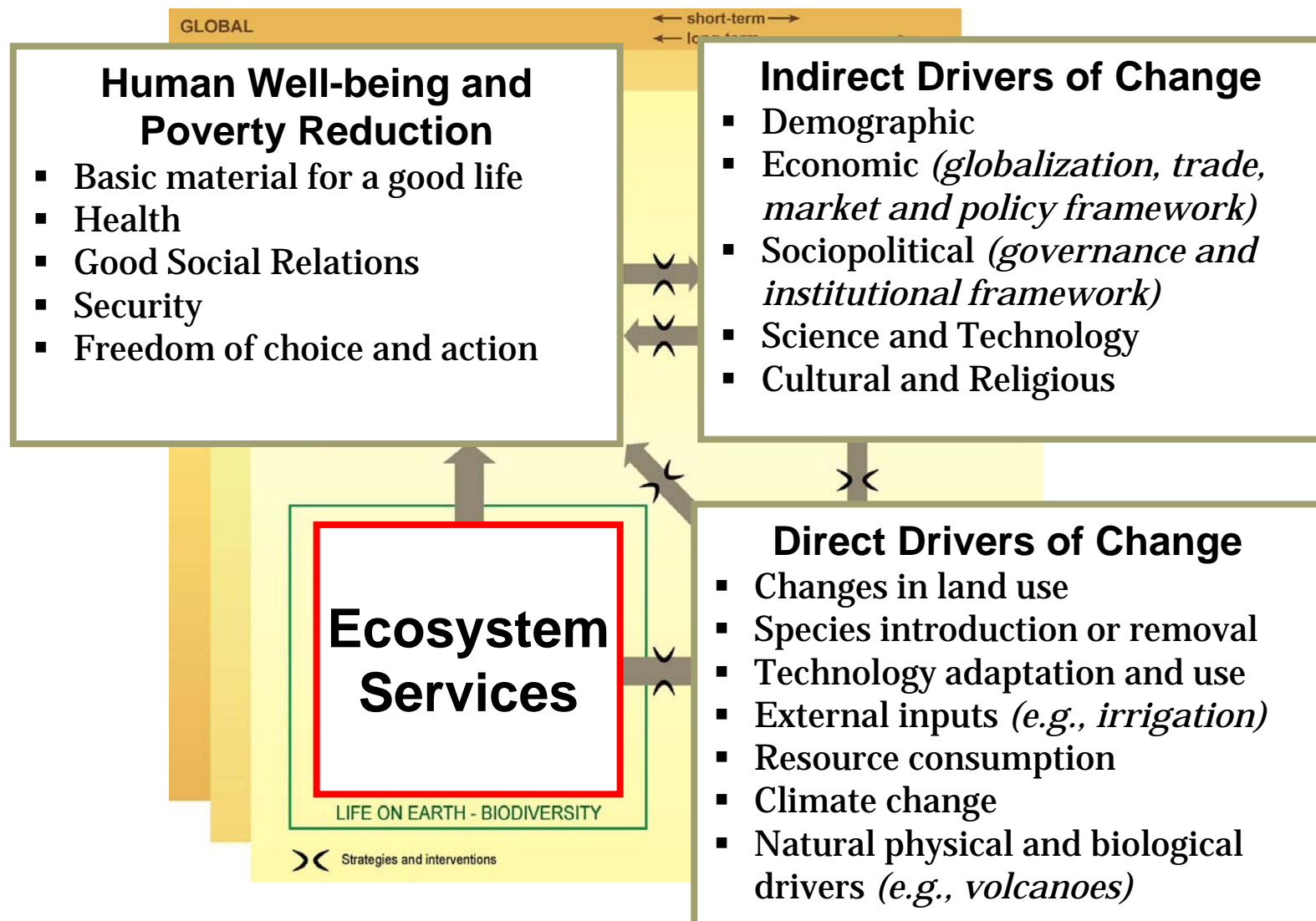
ARROW'S COLOR
Potential for mediation by socioeconomic factors



ARROW'S WIDTH
Intensity of linkages between ecosystem services and human well-being



MA Framework



Four Working Groups

Condition and Trends	Scenarios	Responses
<ul style="list-style-type: none"> ▪ What is the current condition and historical trends of ecosystems and their services? ▪ What have been the consequences of changes in ecosystems for human well-being? 	<ul style="list-style-type: none"> ▪ Given plausible changes in primary drivers, what will be the consequences for ecosystems, their services, and human well-being? 	<ul style="list-style-type: none"> ▪ What can we do to enhance well-being and conserve ecosystems?
Sub-Global	<ul style="list-style-type: none"> ▪ All of the above, at regional, national, local scales 	

MA Findings - Outline

1. Ecosystem Changes in Last 50 Years

2. Gains and Losses from Ecosystem Change

Three major problems may decrease long-term benefits

- Degradation of Ecosystem Services
- Increased Likelihood of Nonlinear Changes
- Exacerbation of Poverty for Some People

3. Ecosystem Prospects for Next 50 Years

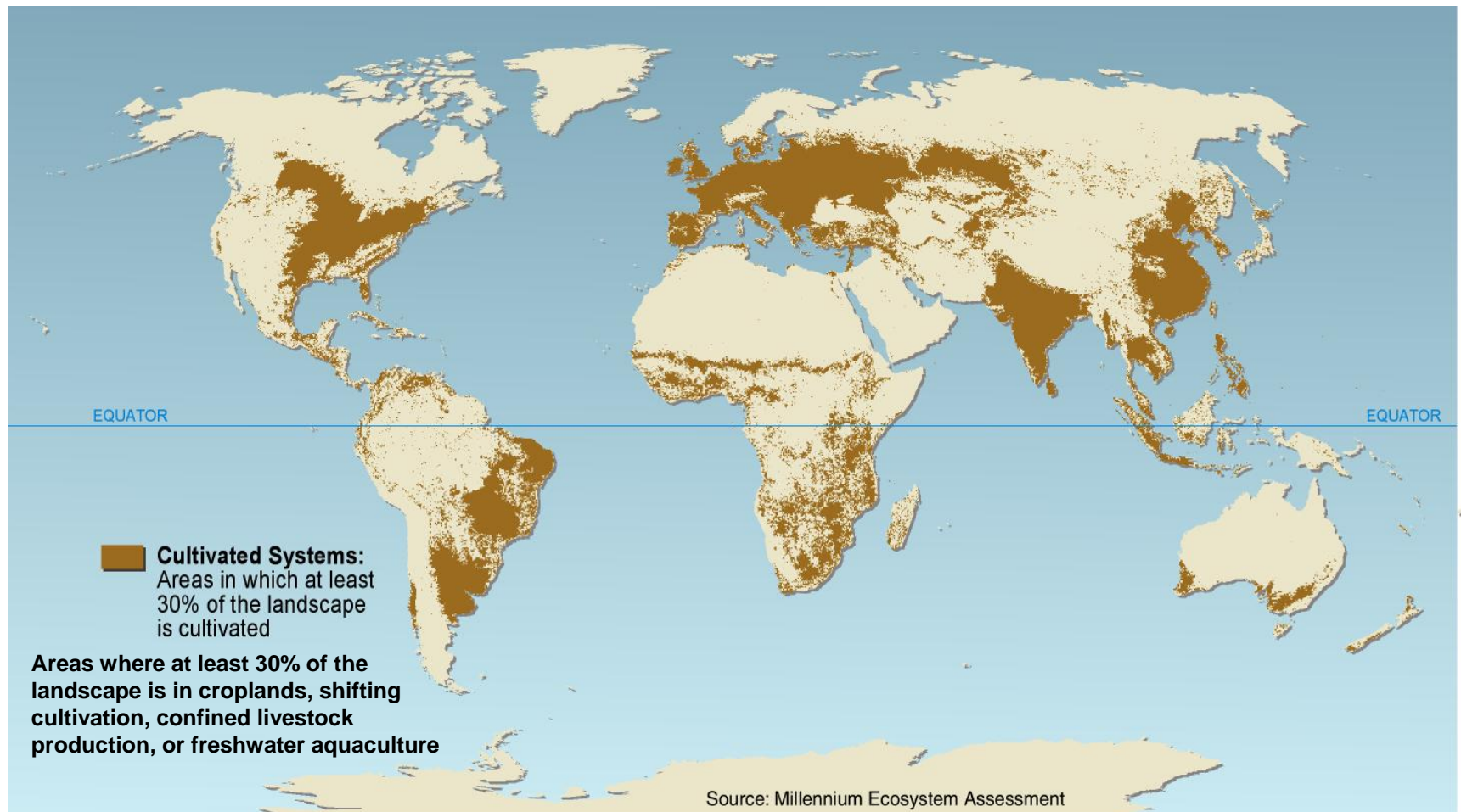
4. Reversing Ecosystem Degradation

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

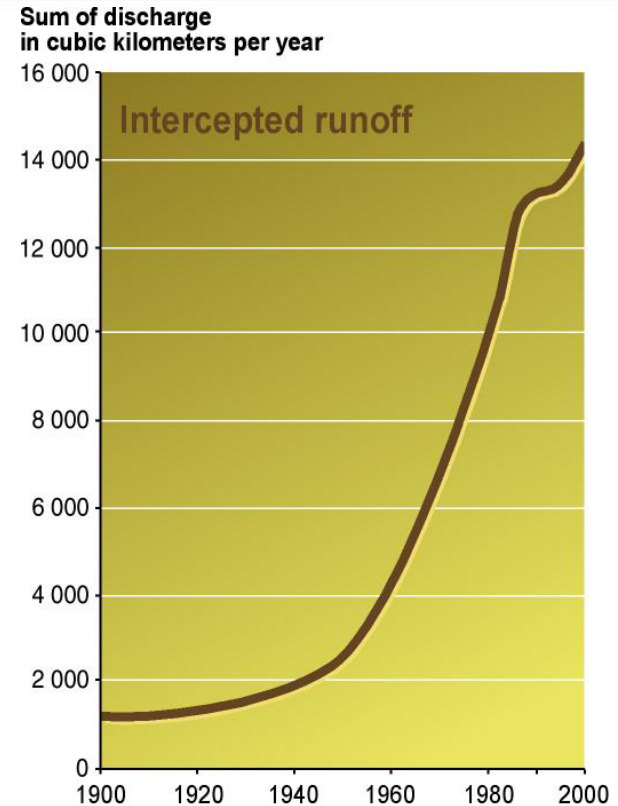
Unprecedented change in structure and function of ecosystems

More land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850. Cultivated Systems in 2000 cover 25% of Earth's terrestrial surface.



Unprecedented change: Aquatic Ecosystems and Hydrology

- 20% of the world's coral reefs were lost and 20% degraded in the last several decades
- 35% of mangrove area has been lost in the last several decades
- Amount of water in reservoirs quadrupled since 1960
- Withdrawals from rivers and lakes doubled since 1960

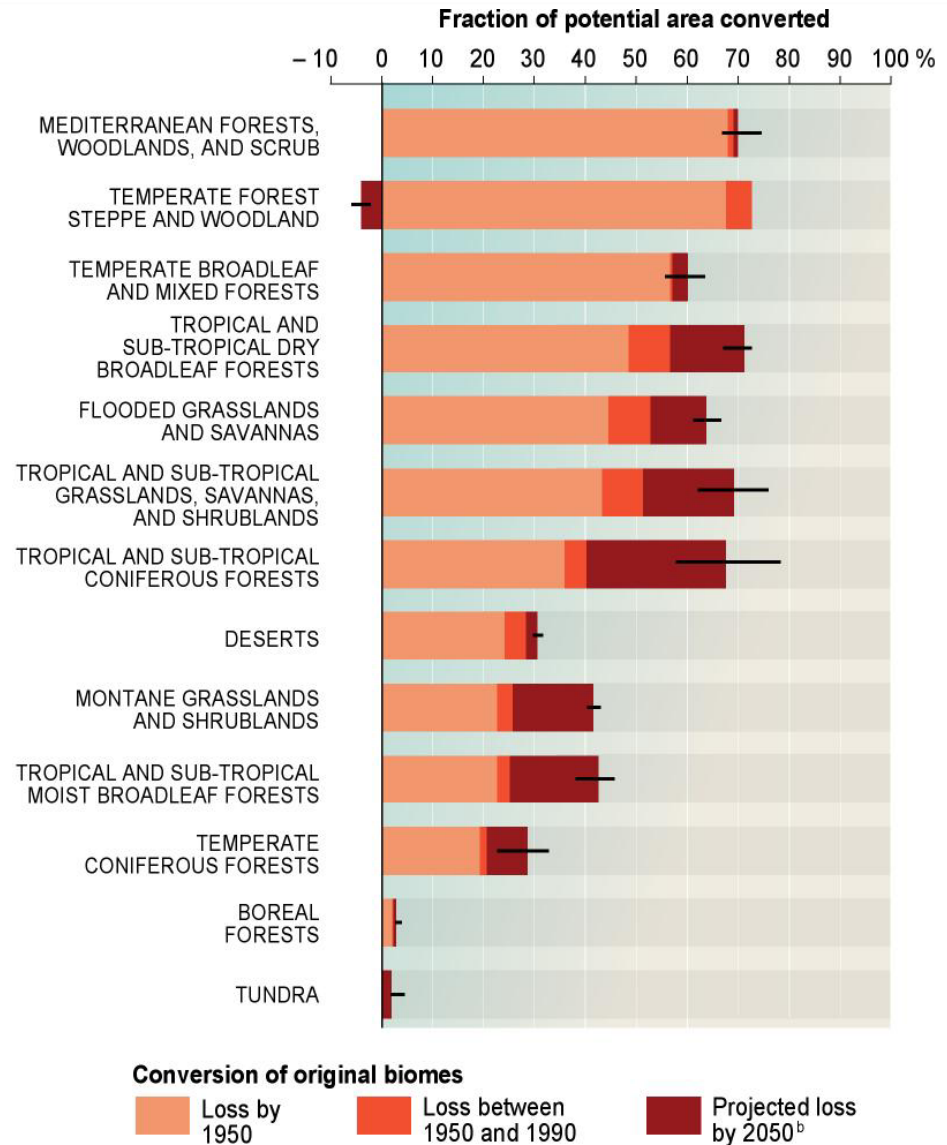


Intercepted Continental Runoff:
3-6 times as much water in reservoirs as in natural rivers

(Data from a subset of large reservoirs totaling ~65% of the global total storage)

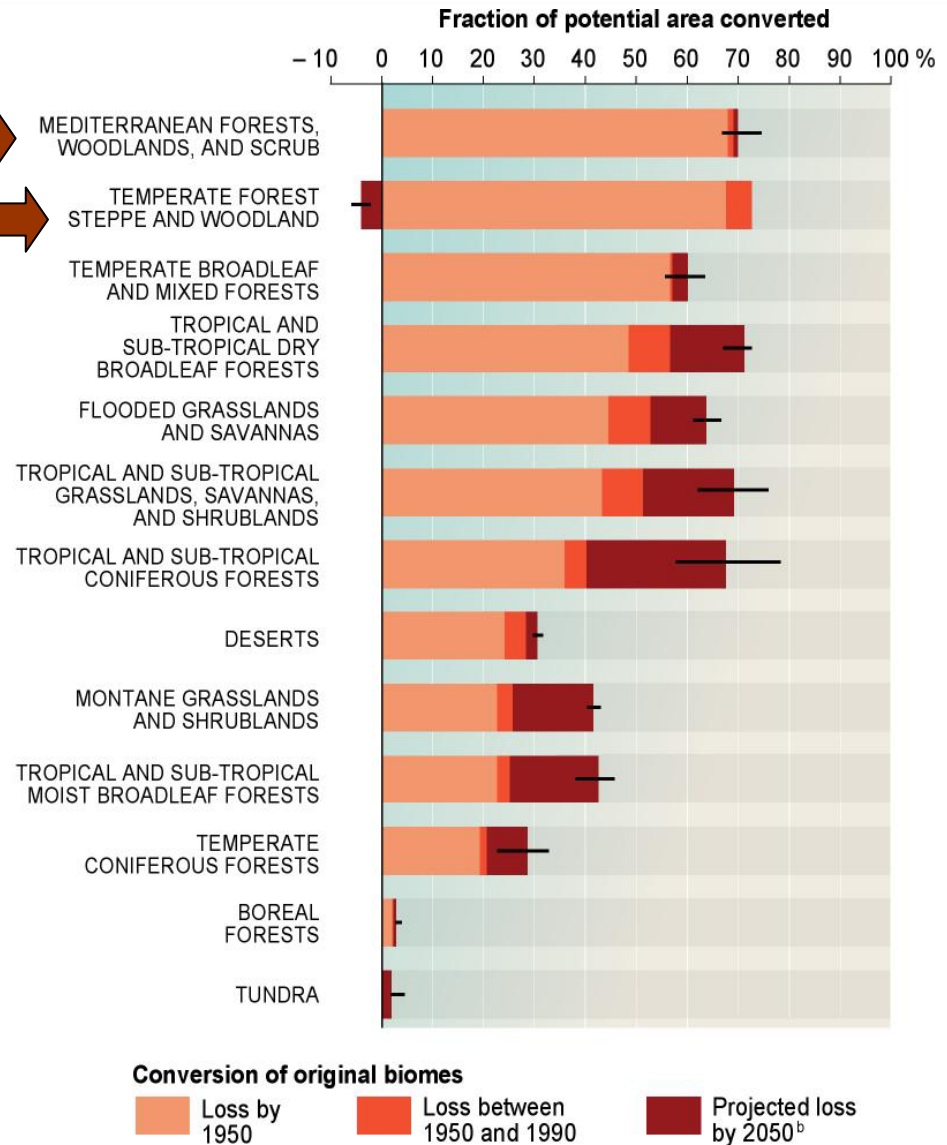
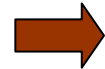
Unprecedented change: Ecosystems

- 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



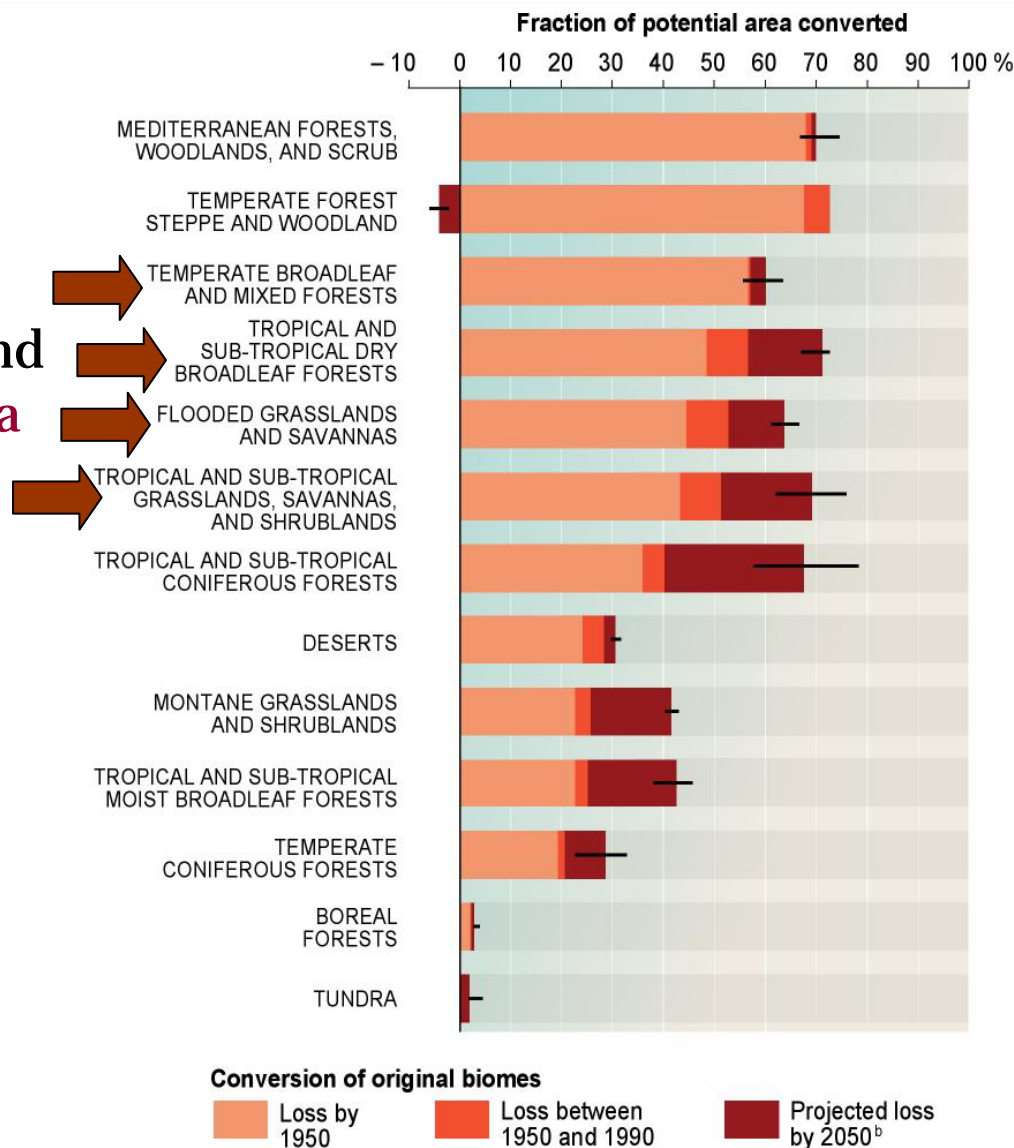
Unprecedented change: Ecosystems

- 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



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



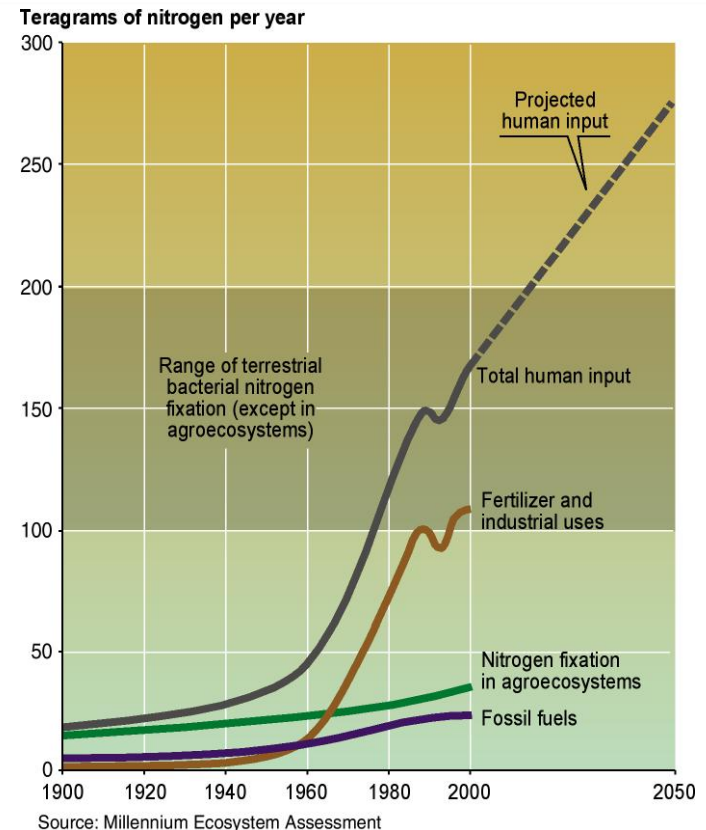
Unprecedented change: Biogeochemical Cycles

Since 1960:

- Flows of biologically available nitrogen in terrestrial ecosystems doubled
- Flows of phosphorus tripled

> 50% of all the synthetic nitrogen fertilizer ever used has been used since 1985

60% of the increase in the atmospheric concentration of CO₂ since 1750 has taken place since 1959

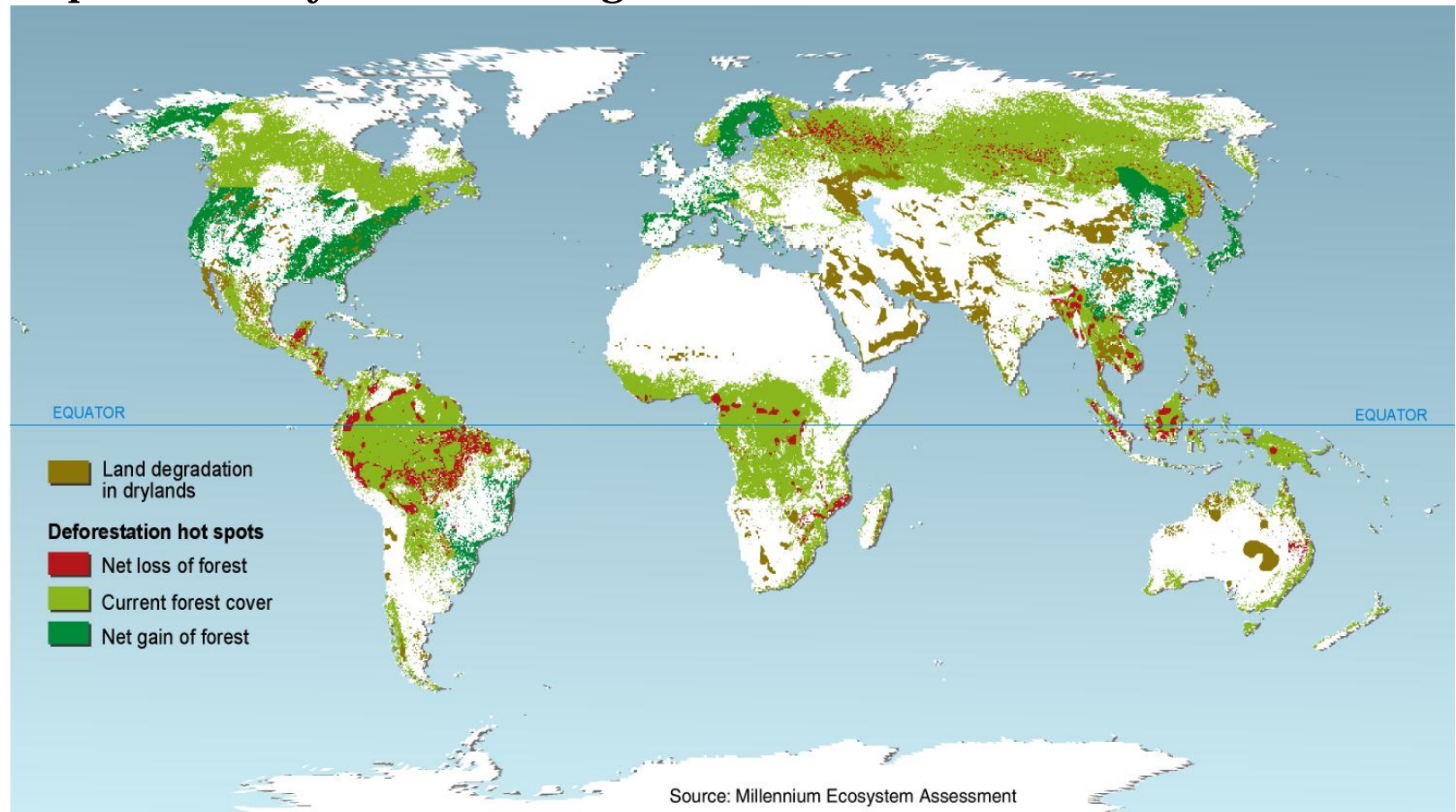


Human-produced Reactive Nitrogen

Humans produce as much biologically available N as all natural pathways and this may grow a further 65% by 2050

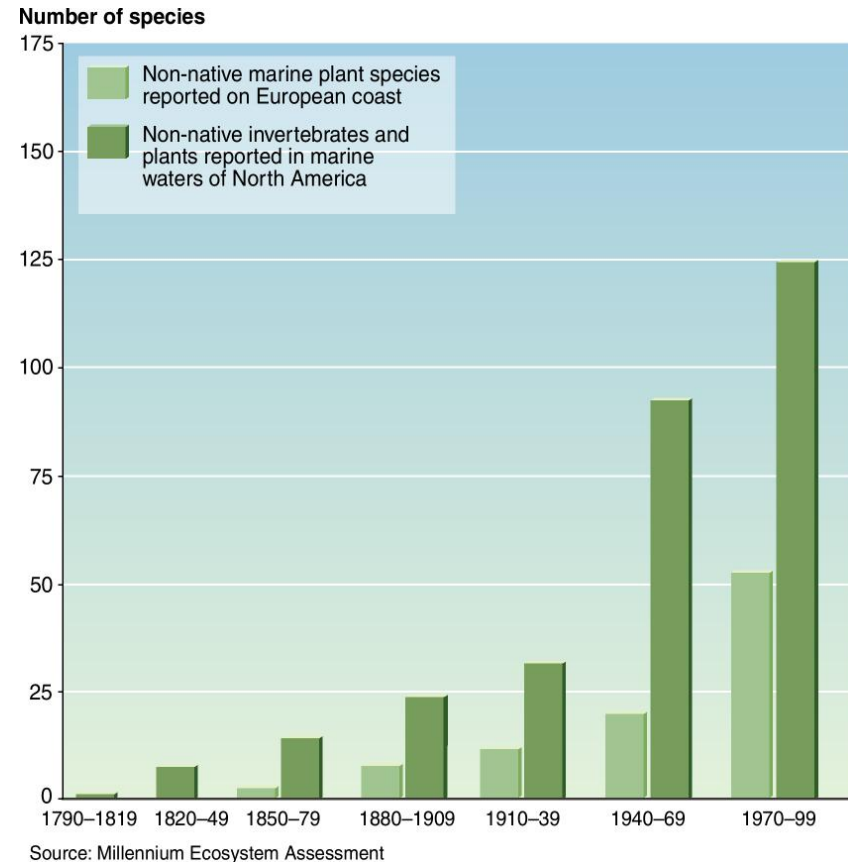
Some ecosystem recovery now underway, but high rates of conversion continue

- **Ecosystems** in some regions are **returning to** conditions similar to their **pre-conversion states**
- **Rates of ecosystem conversion remain high** or are increasing for specific ecosystems and regions



Significant and largely irreversible changes to species diversity

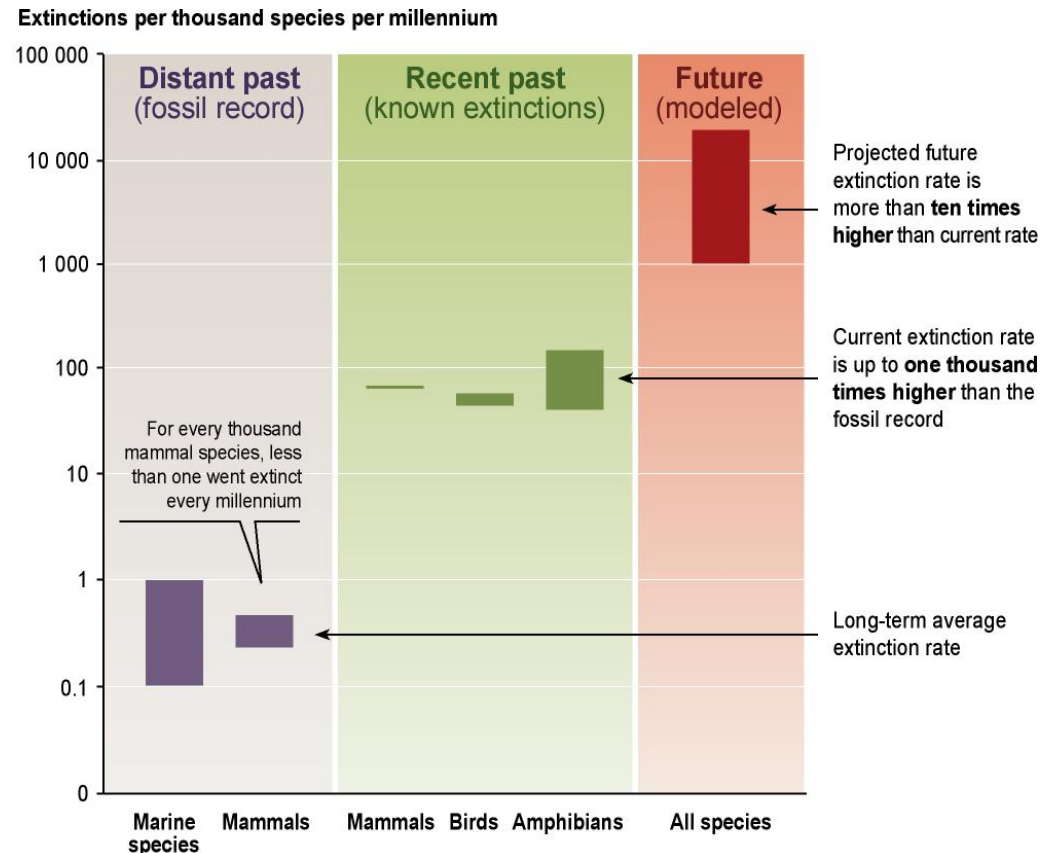
- The **distribution of species** on Earth is **becoming more homogenous**
- The population size or range (or both) of the majority of species across a range of taxonomic groups is declining



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*)



Source: Millennium Ecosystem Assessment

MA Findings - Outline

1. Ecosystem Changes in Last 50 Years

2. Gains and Losses from Ecosystem Change

Three major problems may decrease long-term benefits

- Degradation of Ecosystem Services
- Increased Likelihood of Nonlinear Changes
- Exacerbation of Poverty for Some People

3. Ecosystem Prospects for Next 50 Years

4. Reversing Ecosystem Degradation

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:

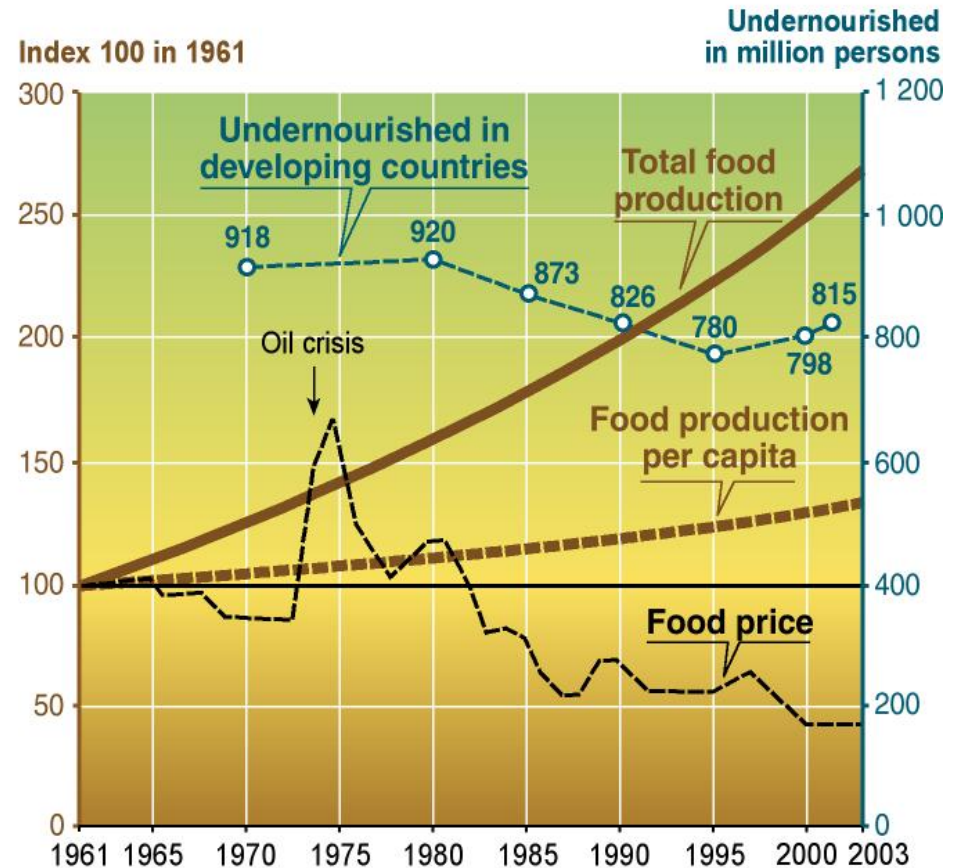
- world population doubled from 3 to 6 billion people
- global economy increased more than sixfold

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



Sources: FAOSTATS, SOFI, Millennium Ecosystem Assessment

Industries based on ecosystem services still the mainstay of many economies

Contributions of agriculture

- Agricultural labor force accounts for 22% of the world's population and half the world's total labor 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 the United States alone

MA Findings - Outline

- 1. Ecosystem Changes in Last 50 Years**
- 2. Gains and Losses from Ecosystem Change**
Three major problems may decrease long-term benefits
 - **Degradation of Ecosystem Services**
 - Increased Likelihood of Nonlinear Changes
 - Exacerbation of Poverty for Some People
- 3. Ecosystem Prospects for Next 50 Years**
- 4. Reversing Ecosystem Degradation**

Degradation and unsustainable use of ecosystem services

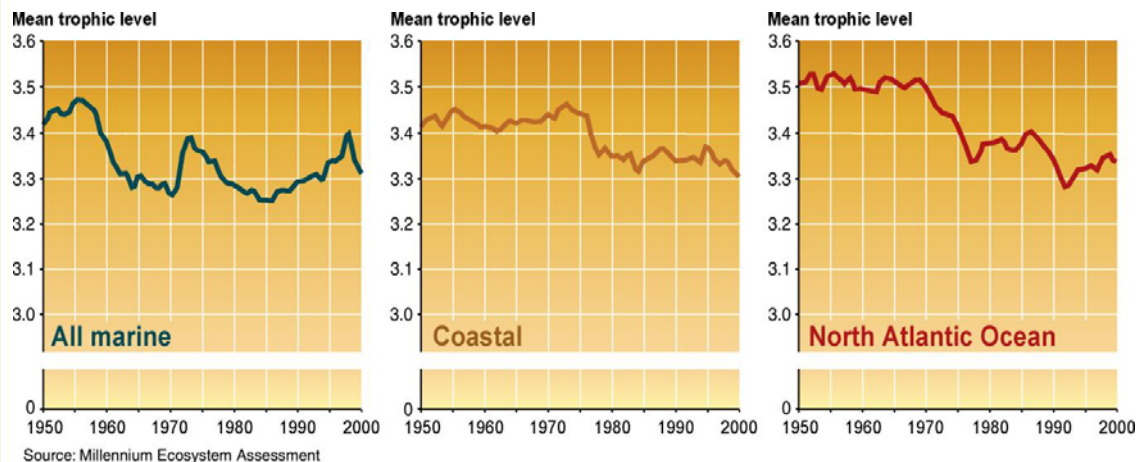
- Approximately 60% (15 out of 24) of the ecosystem services evaluated in this assessment are being degraded or used unsustainably
- The **degradation of ecosystem services** often causes significant harm to human well-being and represents a **loss of a natural asset** or wealth of a country

Status of Provisioning Services

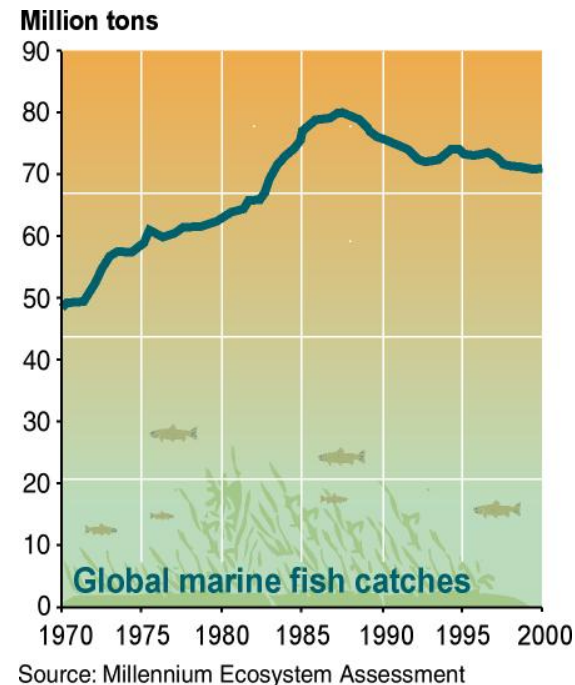
Service		Status
Food	crops	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fiber	timber	+/-
	cotton, silk	+/-
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Fresh water		↓

Capture Fisheries

25% of commercially exploited marine fish stocks are overharvested (*high certainty*)



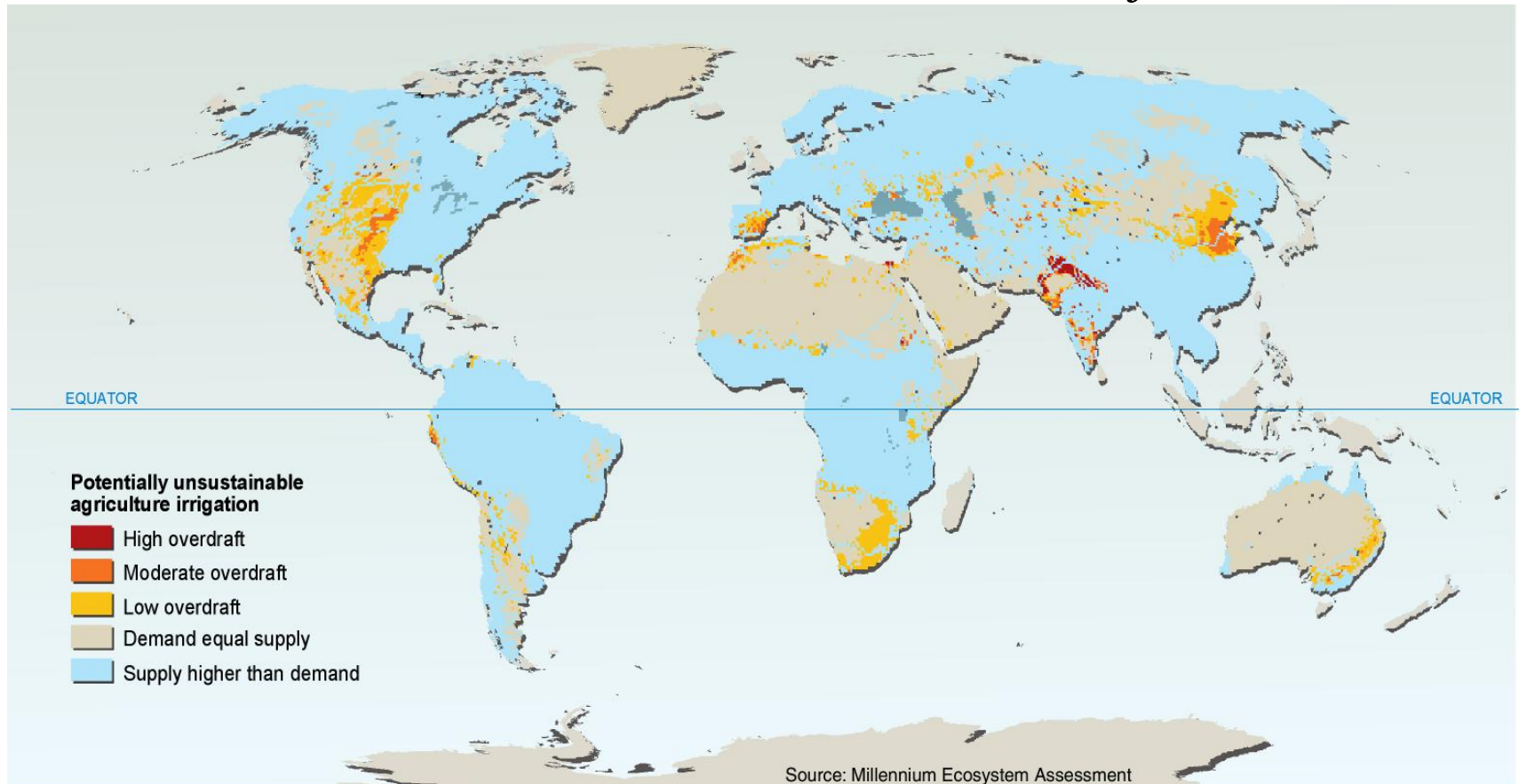
Trophic level of fish captured is declining in marine and freshwater systems



Marine fish harvest declining since the late 1980s

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*)



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	+/-

Regulating Services

Air quality regulation

- Ability of the atmosphere to cleanse itself of pollutants has declined since pre-industrial times but not by more than 10%

Regional and local climate regulation

- Changes in land cover have affected regional and local climates both positively and negatively, but there is a preponderance of negative impacts ; for example, tropical deforestation and desertification have tended to reduce local rainfall

Water purification and waste treatment

- Globally, water quality is declining, although in most industrial countries pathogen and organic pollution of surface waters has decreased over the last 20 years
- Nitrate concentration has grown rapidly in the last 30 years

Regulating Services

Pest regulation

- In many agricultural areas, **pest control** provided by natural enemies has been replaced by the **use of pesticides** – such pesticide use has itself **degraded the capacity of agroecosystems to provide pest control**

Pollination

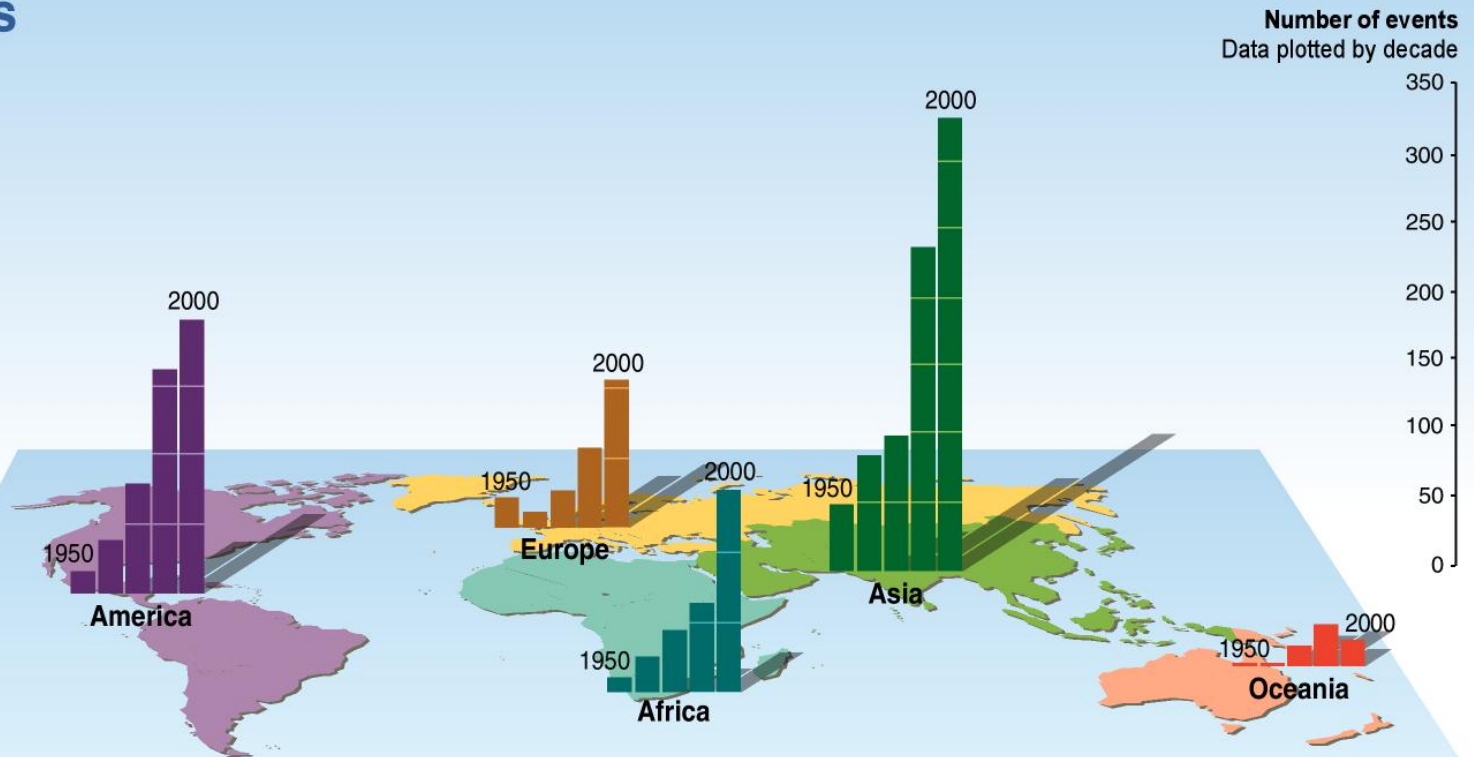
- There is **established but incomplete evidence** of a **global decline** in the abundance of **pollinators**

Regulating Services

Natural hazard regulation

- The capacity of ecosystems to **buffer** from **extreme events** has been **reduced** through loss of wetlands, forests, mangroves
- **People** increasingly **occupying regions exposed to extreme events**

Floods

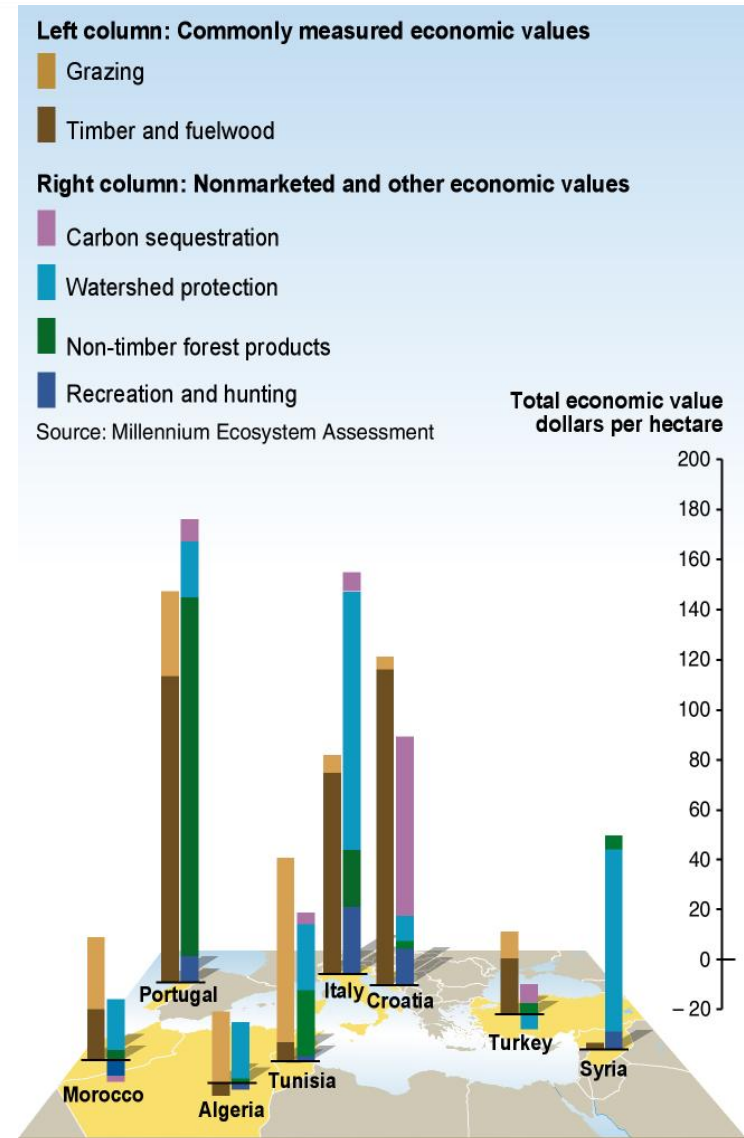


Source: Millennium Ecosystem Assessment

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

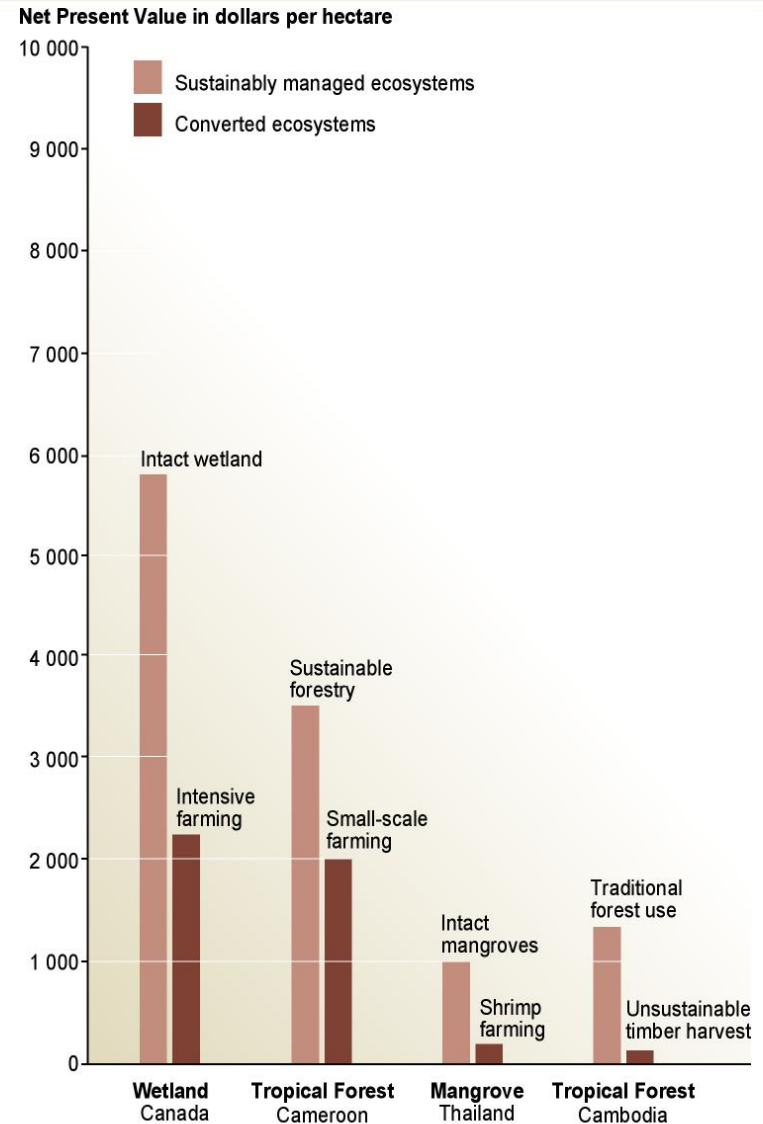
- **Degradation** tends to lead to the **loss of non-marketed benefits** from ecosystems
- The **economic value** of these benefits is often high and **sometimes higher than the marketed benefits**

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



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

- The **total economic value** associated with **managing ecosystems** more sustainably is **often higher than the value associated with conversion**
- Conversion may still occur because private economic benefits are often greater for the converted system



Source: Millennium Ecosystem Assessment

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

Examples of Costs:

- The 1992 collapse of the Newfoundland cod fishery cost ~\$2 billion in income support and re-training workers
- The “external” cost of agriculture in the UK in 1996 (damage to water, soil, and biodiversity) was \$2.6 billion, or 9% of yearly gross farm receipts
- Episodes of harmful (including toxic) algal blooms in coastal waters are increasing
- The frequency and impact of floods and fires has increased significantly in the past 50 years, in part due to ecosystem changes. Annual losses from extreme events totaled ~\$70 billion in 2003

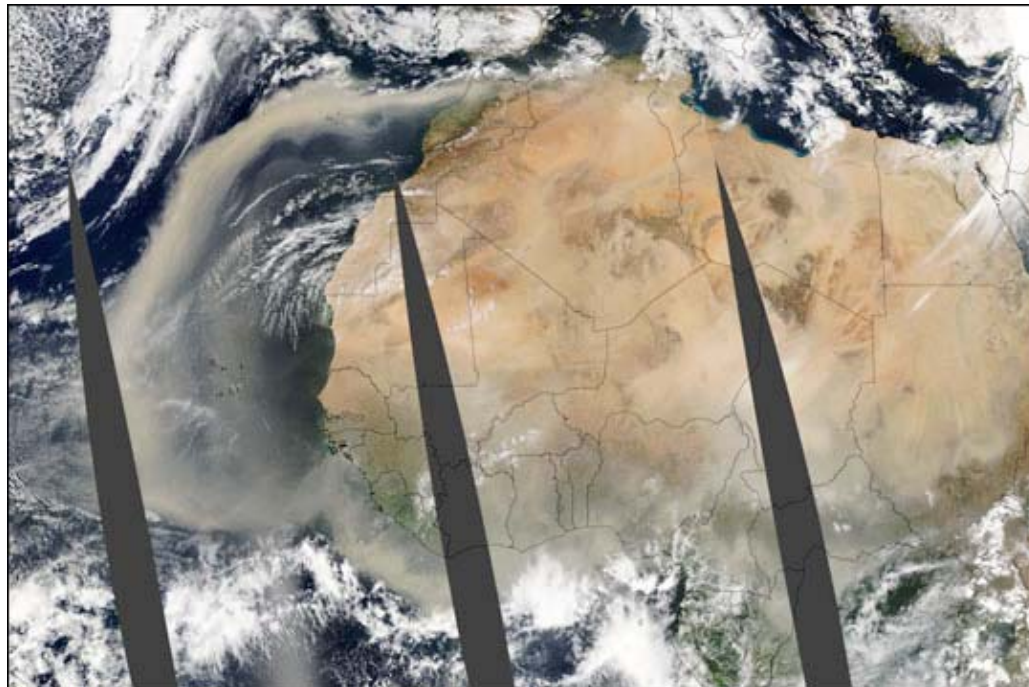
The degradation of ecosystem services represents loss of a capital asset

Loss of wealth due to ecosystem degradation is not reflected in economic accounts

- **Ecosystem services**, as well as resources such as mineral deposits, soil nutrients, and fossil fuels **are capital assets**
- **Traditional national accounts** do not include measures of resource depletion or of the degradation of these resources
- A country could cut its forests and deplete its fisheries, and this would show only as a positive gain in GDP without registering the corresponding decline in assets (wealth)
- A number of countries that appeared to have positive growth in net savings (wealth) in 2001 actually experienced a loss in wealth when degradation of natural resources were factored into the accounts

Wealthy populations cannot be insulated from ecosystem degradation

- The physical, economic, or social impacts of ecosystem service degradation may **cross boundaries**
- Many sectors of industrial countries still depend directly on ecosystem services.
- **Wealth cannot buffer people from changes in all ecosystem services** (e.g., cultural services, air quality)
- **Changes in ecosystems** that contribute to climate change **affect all people**



Source: NASA Earth Observatory

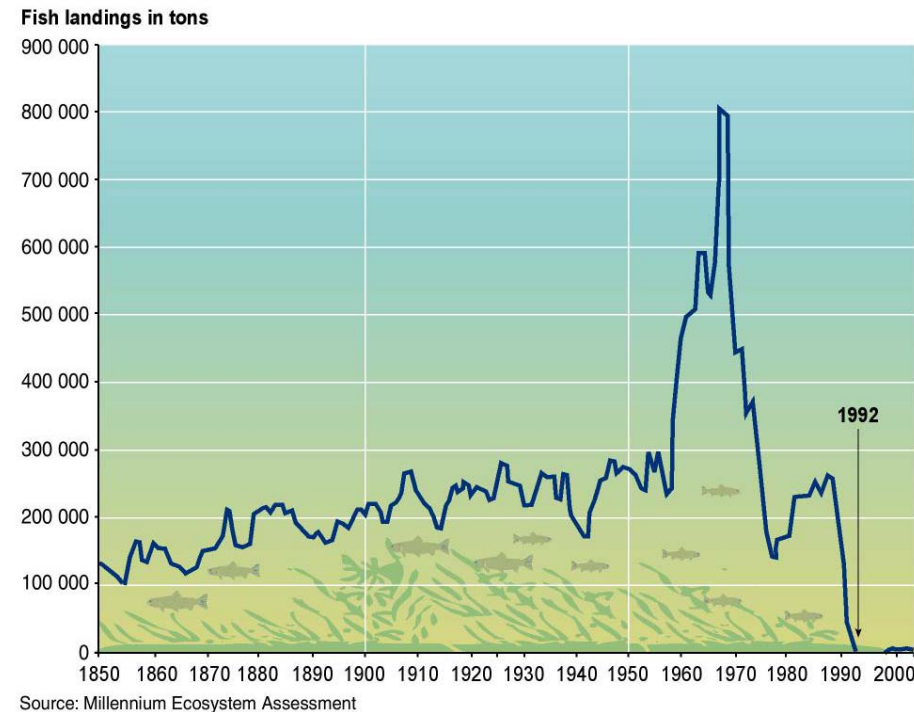
Dust Cloud Off the Northwest Coast of Africa extending to South America

MA Findings - Outline

- 1. Ecosystem Changes in Last 50 Years**
- 2. Gains and Losses from Ecosystem Change**
Three major problems may decrease long-term benefits
 - Degradation of Ecosystem Services
 - Increased Likelihood of Nonlinear Changes
 - Exacerbation of Poverty for Some People
- 3. Ecosystem Prospects for Next 50 Years**
- 4. Reversing Ecosystem Degradation**

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



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

Examples of nonlinear change

Eutrophication and hypoxia

- Once **a threshold of nutrient loading** is achieved, **changes** in freshwater and coastal ecosystems **can be abrupt and extensive**, creating harmful algal blooms (including blooms of toxic species) and sometimes leading to the formation of oxygen-depleted zones, killing all animal life

Disease emergence

- If, on average, each infected person infects at least one other person, then an epidemic spreads, while if the infection is transferred on average to less than one person, the epidemic dies out.

During the 1997/98 El Niño, excessive flooding caused cholera epidemics in Djibouti, Somalia, Kenya, Tanzania, and Mozambique

MA Findings - Outline

- 1. Ecosystem Changes in Last 50 Years**
- 2. Gains and Losses from Ecosystem Change**
Three major problems may decrease long-term benefits
 - Degradation of Ecosystem Services
 - Increased Likelihood of Nonlinear Changes
 - Exacerbation of Poverty for Some People
- 3. Ecosystem Prospects for Next 50 Years**
- 4. Reversing Ecosystem Degradation**

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

Ecosystem services and poverty reduction

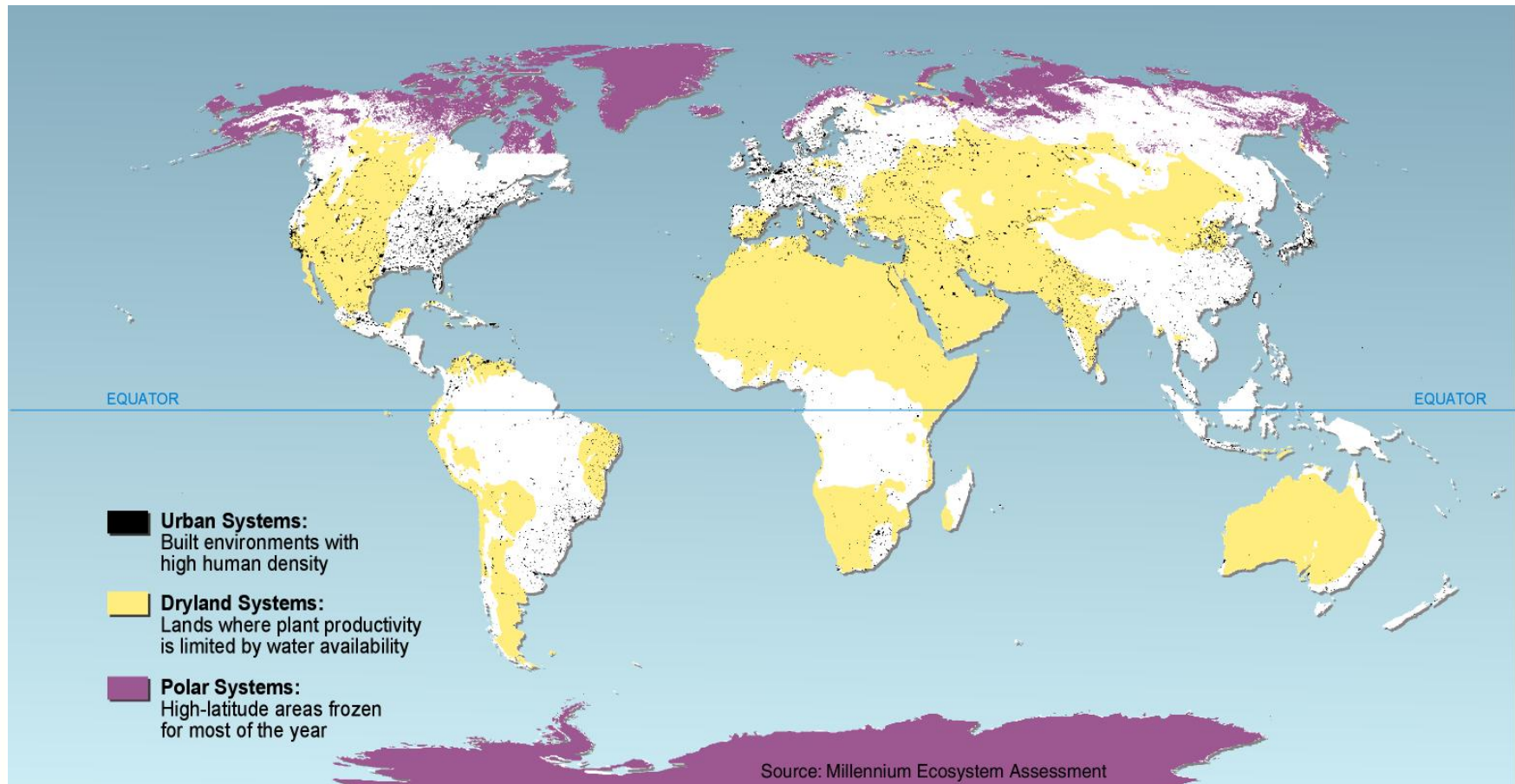
Degradation of ecosystem services harms poor people

- Half the urban population in Africa, Asia, Latin America, and the Caribbean suffers from one or more **diseases associated with inadequate water and sanitation**
- The **declining state of capture fisheries** is reducing an inexpensive source of protein in developing countries.
Per capita fish consumption in developing countries, excluding China, declined between 1985 and 1997
- **Desertification** affects the livelihoods of millions of people, including a large portion of the poor in drylands

Ecosystem services and poverty reduction

Critical concern: Dryland systems

- Cover 41% of Earth's land surface and more than 2 billion people inhabit them, 90% of whom are in developing countries



Ecosystem services and poverty reduction

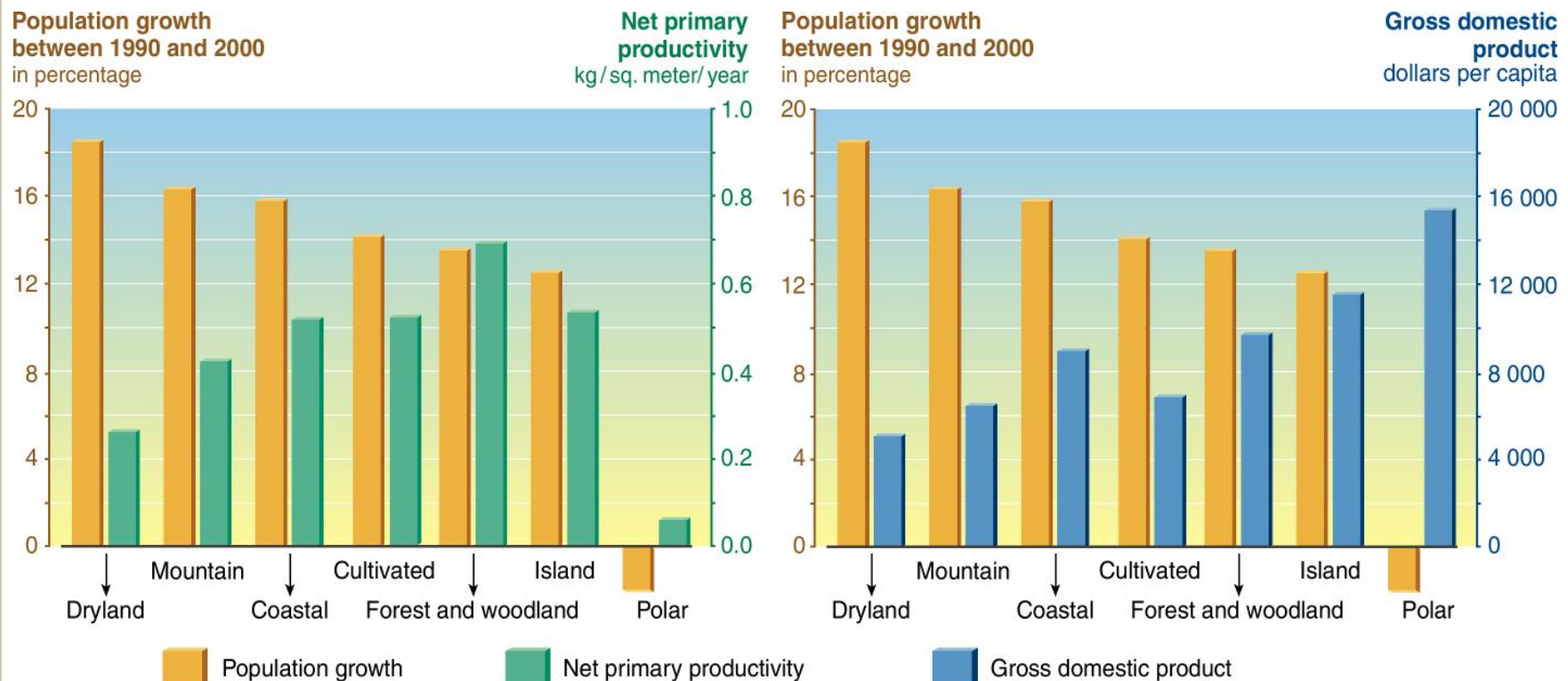
Critical concern: Dryland systems

- **Development** prospects in dryland regions of developing countries are particularly closely **linked to** the condition of **ecosystem services**
- People living in drylands tend to have the **lowest levels of human well-being**, including the **lowest per capita GDP** and the highest infant mortality rates
- Drylands have only 8% of the world's renewable water supply
- **Per capita water availability** is currently **only two thirds** of the level required for minimum levels of human well-being
- Approximately 10–20% of the world's drylands are degraded (*medium certainty*)

Ecosystem services and poverty reduction

Critical concern: Dryland systems

- Dryland systems experienced the highest population growth rate in the 1990s



Sources: Millennium Ecosystem Assessment

MA Findings - Outline

- 1. Ecosystem Changes in Last 50 Years**
- 2. Gains and Losses from Ecosystem Change**
Three major problems may decrease long-term benefits
 - Degradation of Ecosystem Services
 - Increased Likelihood of Nonlinear Changes
 - Exacerbation of Poverty for Some People
- 3. Ecosystem Prospects for Next 50 Years**
- 4. Reversing Ecosystem Degradation**

Finding #3:

- The degradation of ecosystem services **could grow significantly worse** during the first half of this century

Direct drivers: growing in intensity

		Habitat change	Climate change	Invasive species	Over-exploitation	Pollution (nitrogen, phosphorus)
Forest	Boreal	↗	↑	↗	→	↑
	Temperate	↘	↑	↑	→	↑
	Tropical	↑	↑	↑	↗	↑
Dryland	Temperate grassland	↗	↑	→	→	↑
	Mediterranean	↗	↑	↑	→	↑
	Tropical grassland and savanna	↗	↑	↑	→	↑
	Desert	→	↑	→	→	↑
Inland water		↑	↑	↑	→	↑
Coastal		↗	↑	↗	↗	↑
Marine		↑	↑	→	↗	↑
Island		→	↑	→	→	↑
Mountain		→	↑	→	→	↑
Polar		↗	↑	→	↗	↑

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

Driver's impact on biodiversity over the last century

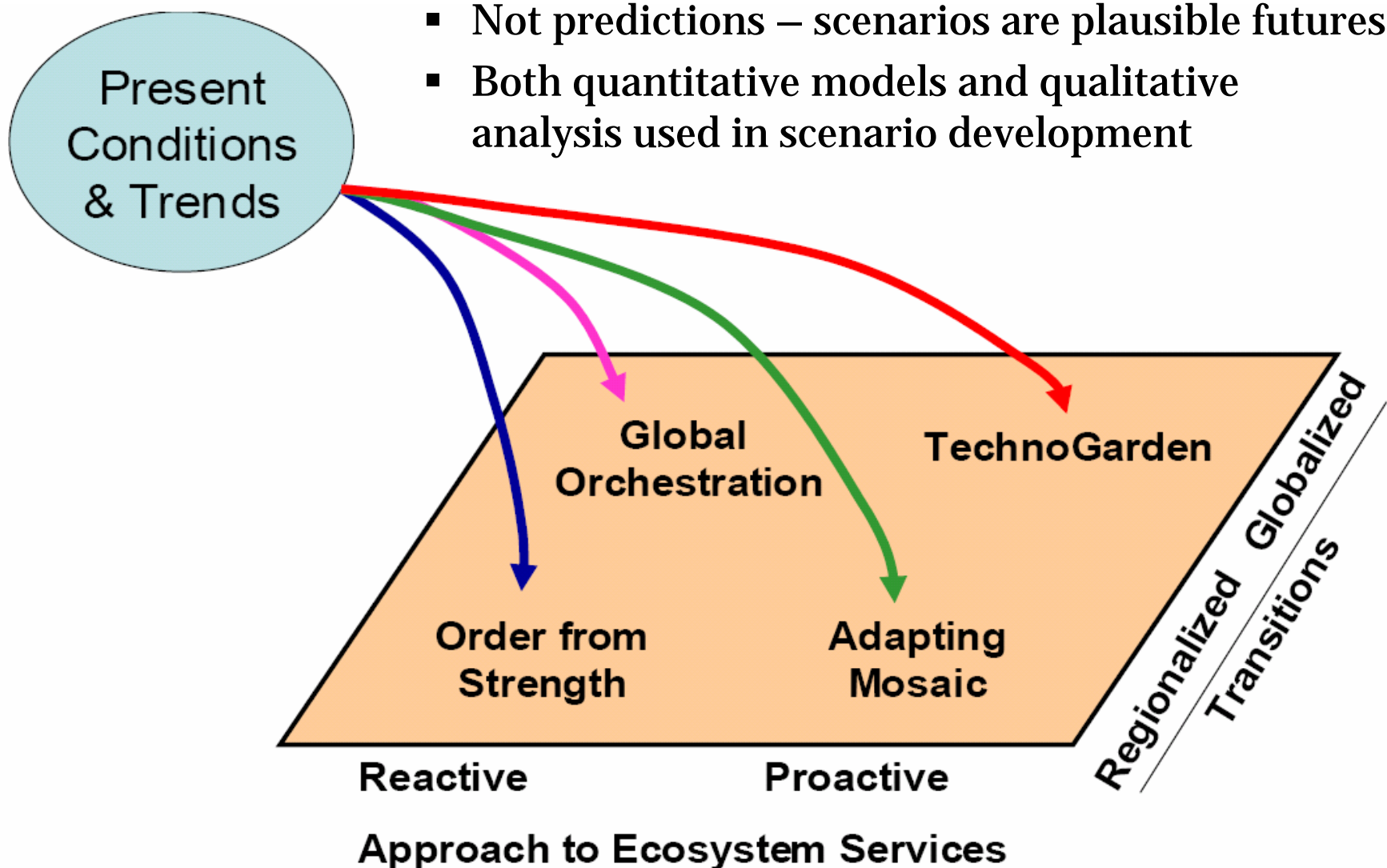
Low
Moderate
High
Very high

Driver's current trends

Decreasing impact
Continuing impact
Increasing impact
Very rapid increase of the impact

Source: Millennium Ecosystem Assessment

MA Scenarios



Scenario Storylines



- **Global Orchestration** Globally connected society that focuses on **global trade and economic liberalization** and takes a **reactive approach to ecosystem problems** but that also takes **strong steps to reduce poverty and inequality** and to invest in public goods such as infrastructure and education.



- **Order from Strength** Regionalized and fragmented world, concerned with security and protection, emphasizing primarily **regional markets**, paying little attention to public goods, and taking a **reactive approach to ecosystem problems**.

Scenario Storylines



- **Adapting Mosaic** **Regional watershed-scale** ecosystems are the focus of political and economic activity. **Local institutions** are strengthened and local ecosystem management strategies are common; societies develop a strongly **proactive approach** to the management of ecosystems.

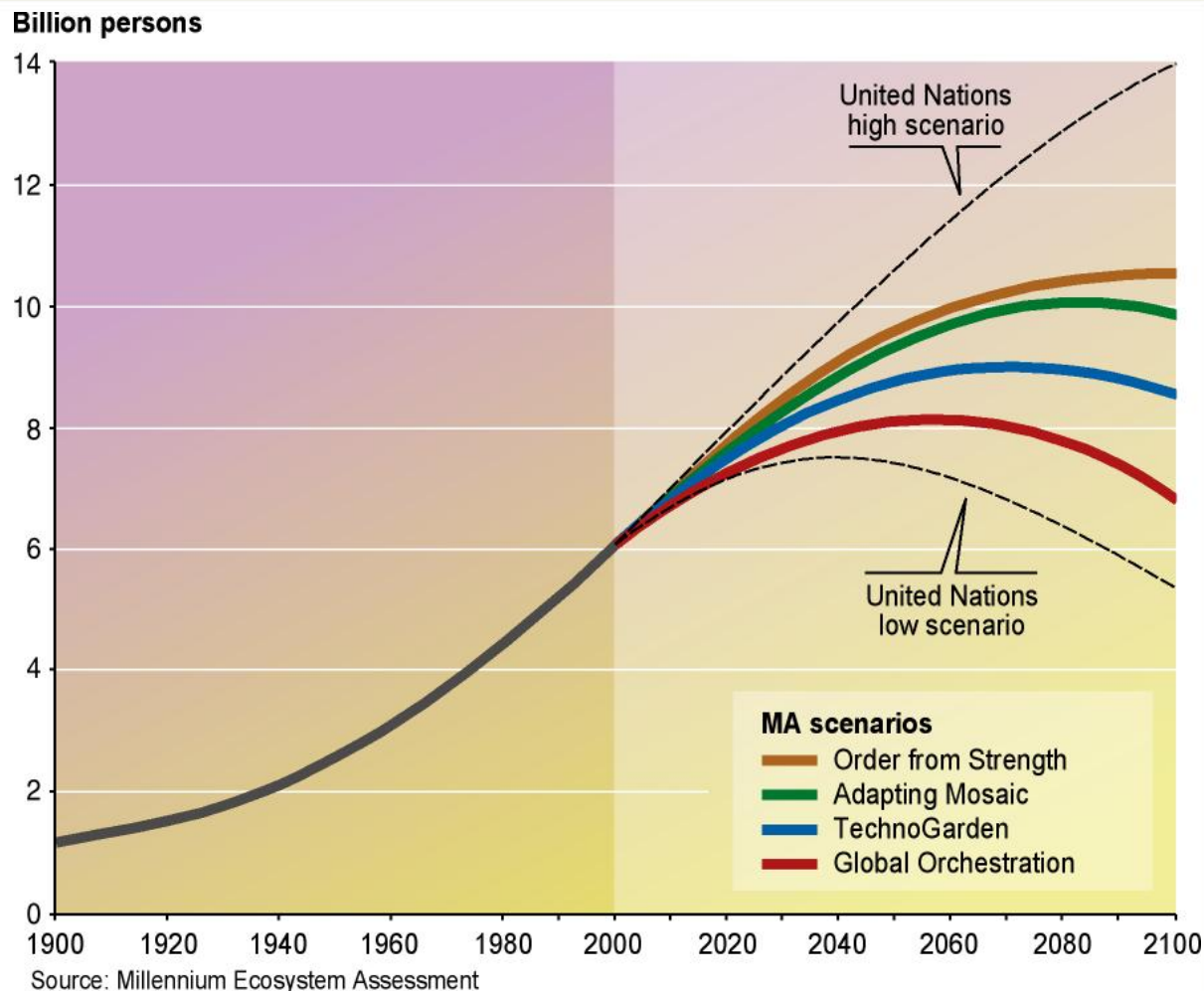


- **TechnoGarden** **Globally** connected world relying strongly on **environmentally sound technology**, using **highly managed, often engineered**, ecosystems to deliver ecosystem services, and taking a **proactive approach** to the management of ecosystems in an effort to avoid problems.

Changes in indirect drivers

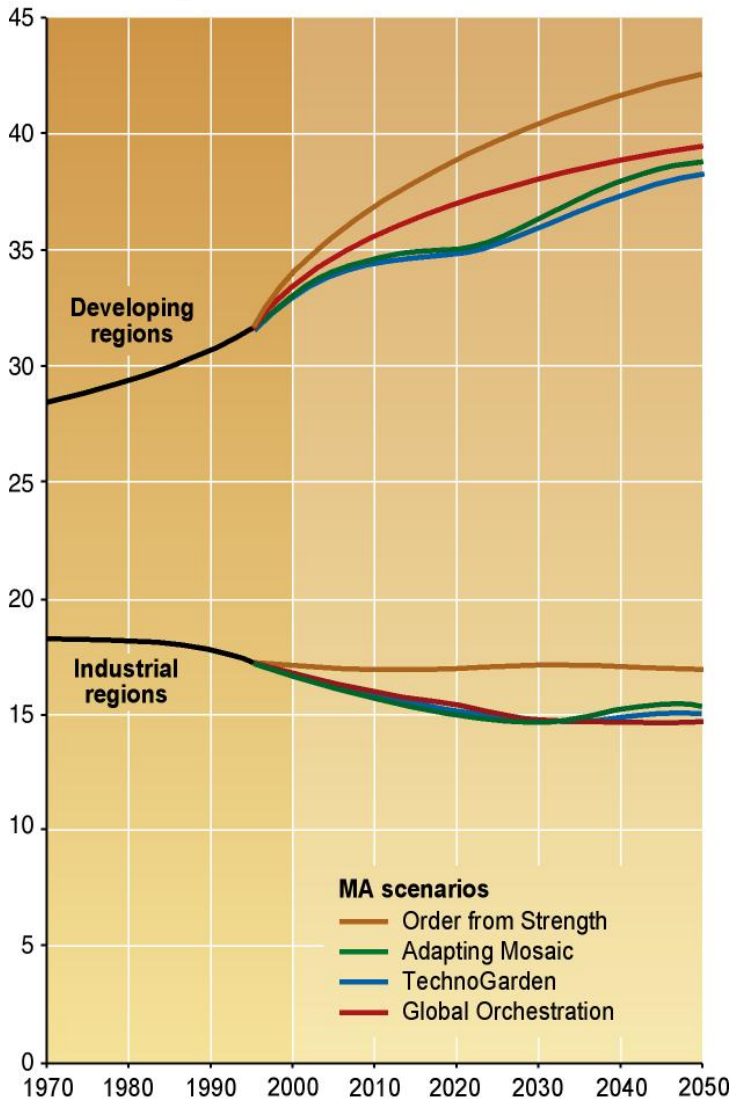
In MA Scenarios:

- Population projected to grow to 8–10 billion in 2050
- Per capita income projected to increase two- to fourfold



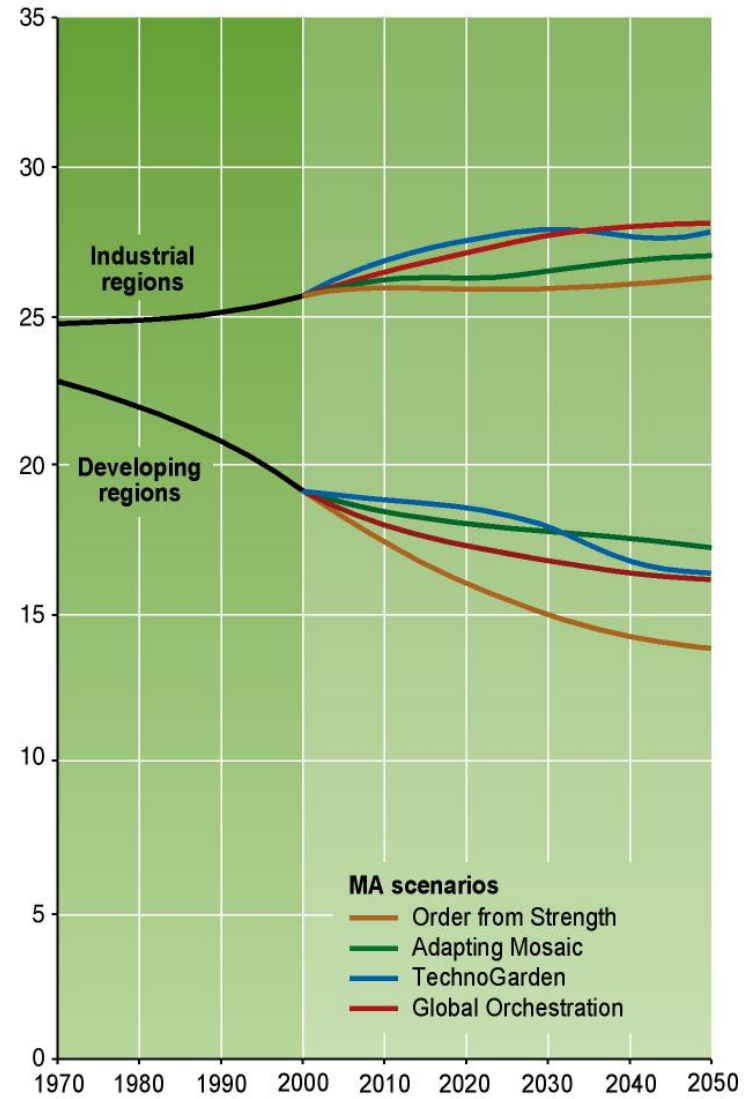
Changes in direct drivers: crop land and forest area

Pasture and cropland in million sq. kilometers



Source: Millennium Ecosystem Assessment

Forest area in million sq. kilometers



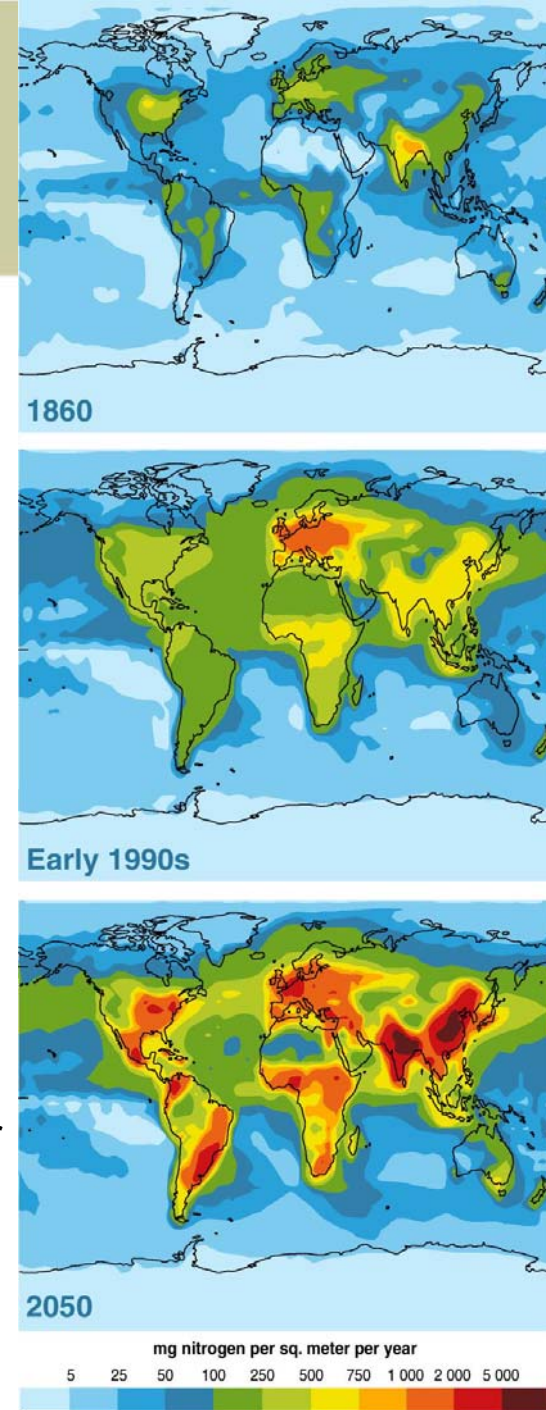
Source: Millennium Ecosystem Assessment

Changes in direct drivers: Nutrient loading

- Humans have **already doubled** the flow of reactive nitrogen on the continents, and some projections suggest that this **may increase** by roughly **a further two thirds by 2050**

Estimated Total Reactive Nitrogen Deposition from the Atmosphere

Accounts for 12% of the reactive nitrogen entering ecosystems, although it is higher in some regions (e.g., 33% in the USA)



Changes in direct drivers

Impacts of Excessive Nitrogen Flows

Environmental effects:

- **eutrophication** of freshwater and coastal ecosystems
- contribution to **acid rain**
- **loss of biodiversity**

Contribution to:

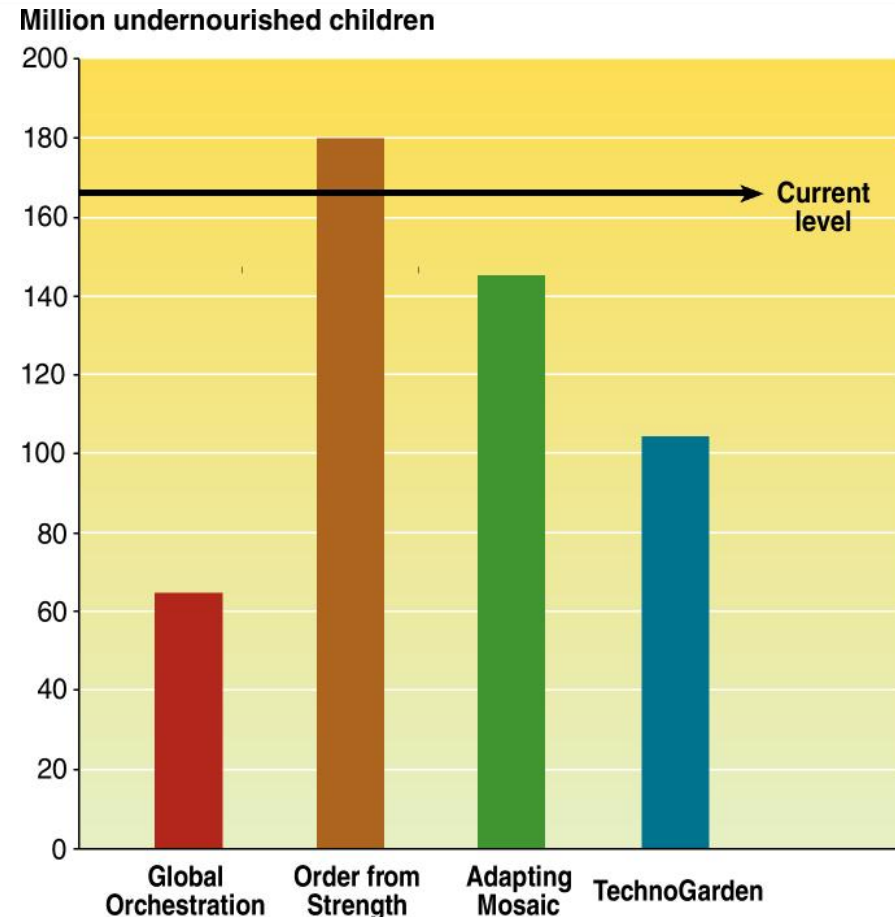
- creation of ground-level ozone
- destruction of stratospheric ozone
- contribution to global warming

Resulting health effects:

- consequences of ozone pollution on **asthma and respiratory function**
- **increased allergies** and asthma due to increased pollen production
- **risk of blue-baby syndrome**
- increased risk of **cancer and other chronic diseases** from nitrate in drinking water,
- increased risk of a variety of **pulmonary and cardiac diseases** from production of fine particles in the atmosphere

Changes in ecosystem services under MA Scenarios

- Demand for food crops is projected to grow by 70–85% by 2050, and water withdrawals by 30-85%
- Food security is not achieved by 2050, and child undernutrition would be difficult to eradicate (and is projected to increase in some regions in some MA scenarios)
- Globally, the equilibrium number of plant species is projected to be reduced by roughly 10–15% as the result of habitat loss over the period of 1970 to 2050 (*low certainty*)



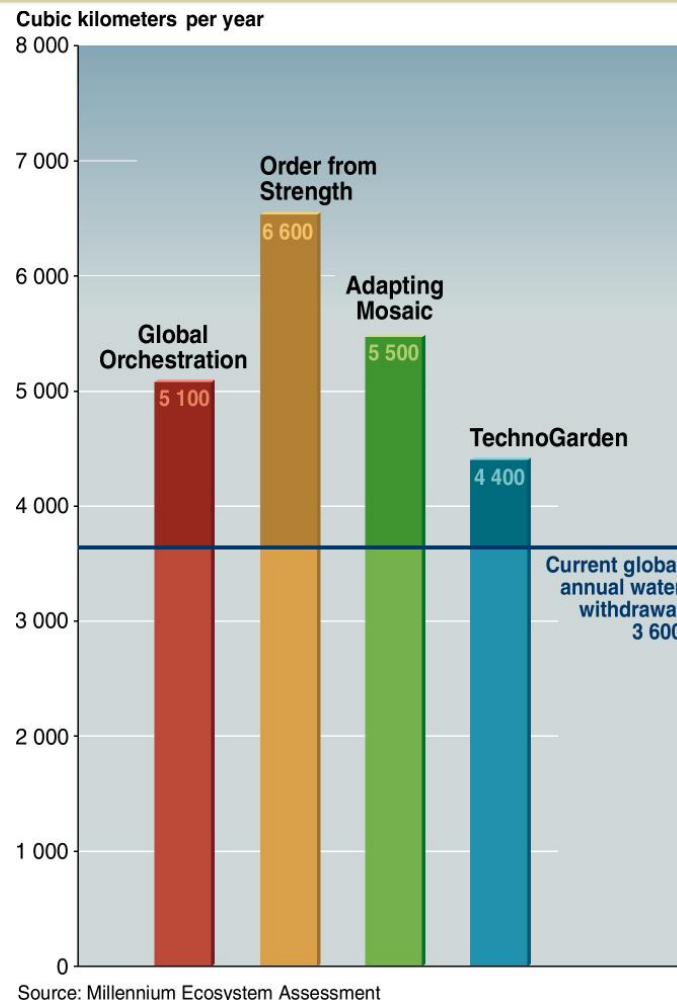
Source: Millennium Ecosystem Assessment

Child undernourishment in 2050 under MA Scenarios

Changes in ecosystem services under MA Scenarios

Water Availability

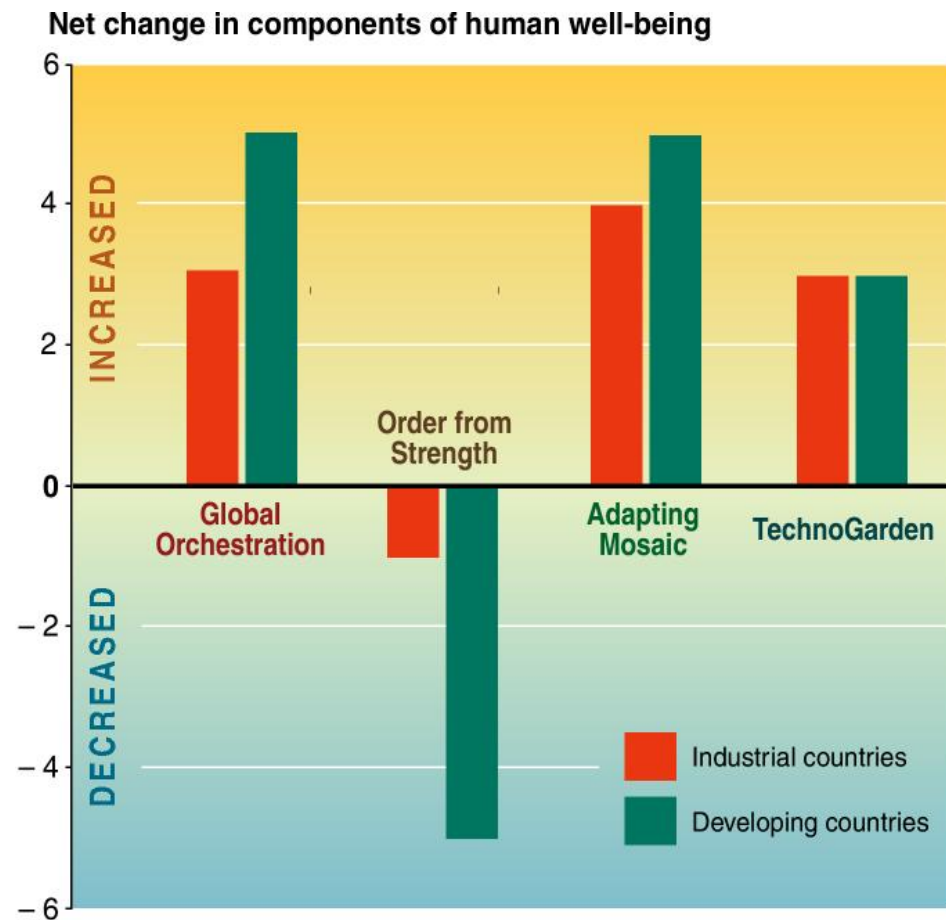
- Global water availability increases under all MA scenarios. By 2050, global **water availability increases by 5–7%** (depending on the scenario)
- Demand** for water is projected to grow by between **30% and 85%**



**Water Withdrawals in 2050
under MA Scenarios**

Changes in human well-being under MA scenarios

- In three of the four MA scenarios, between three and five of the components of well-being (material needs, health, security, social relations, freedom) improve between 2000 and 2050
- In one scenario (*Order from Strength*) conditions are projected to decline, particularly in developing countries



Source: Millennium Ecosystem Assessment

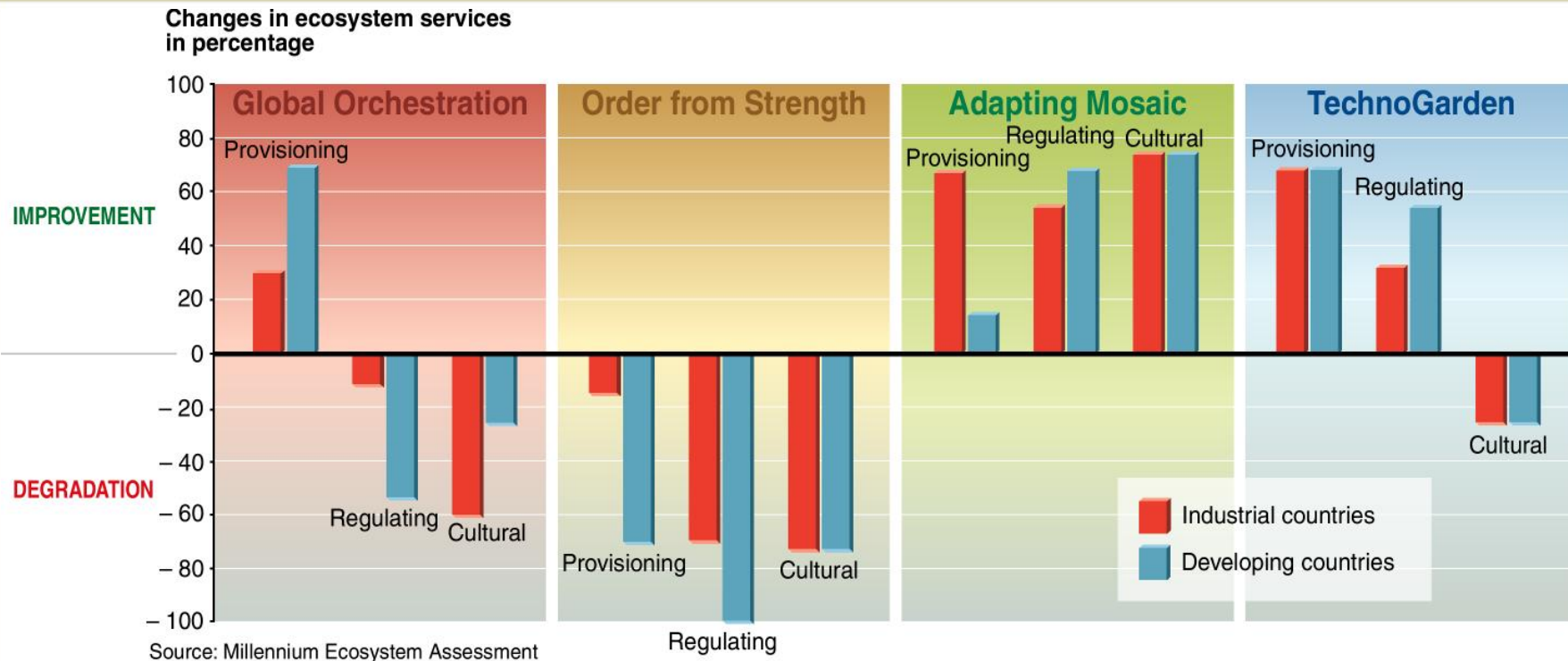
MA Findings - Outline

- 1. Ecosystem Changes in Last 50 Years**
- 2. Gains and Losses from Ecosystem Change**
Three major problems may decrease long-term benefits
 - Degradation of Ecosystem Services
 - Increased Likelihood of Nonlinear Changes
 - Exacerbation of Poverty for Some People
- 3. Ecosystem Prospects for Next 50 Years**
- 4. Reversing Ecosystem Degradation**

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

Improvements in services can be achieved by 2050



Three of the four scenarios show that **significant changes in policy can partially mitigate the negative consequences** of growing pressures on ecosystems, although the changes required are large and not currently under way

Examples of changes in policies and practices that yield positive outcomes

Global Orchestration

- Major **investments in public goods** (e.g., education, infrastructure) and poverty reduction
- **Trade barriers** and distorting **subsidies eliminated**

Adapting Mosaic

- Widespread use of **active adaptive management**
- **Investment in education** (countries spend 13% of GDP on education, compared to 3.5% today)

TechnoGarden

- Significant investment in **development of technologies** to **increase efficiency** of use of ecosystem services
- Widespread use of '**payments for ecosystem services**' and development of **market mechanisms**

Past actions and potential for substitution

Previous responses to ecosystem degradation

- **Past actions** have yielded **significant benefits**, but these improvements have **generally not kept pace** with growing pressures and demands.
 - *For example, **more than 100,000 protected areas** covering about **11.7% of the terrestrial surface** have now been established, and these play an important role in the conservation of biodiversity and ecosystem services*
- **Technological advances** have also helped **lessen the pressure on ecosystems per unit increase in demand** for ecosystem services.

Substitutes

- **Substitutes can be developed** for some but not all ecosystem services. The **cost of substitutes is generally high**, and they may also have other negative environmental consequences

Responses – Importance of Indirect Drivers

Ecosystem degradation can rarely be reversed without actions that address one or more indirect drivers of change:

- **population change** (including growth and migration)
- change in **economic activity** (including economic growth, disparities in wealth, and trade patterns)
- **sociopolitical factors** (including factors ranging from the presence of conflict to public participation in decision-making)
- **cultural factors**
- **technological change**

Collectively these factors influence the level of production and consumption of ecosystem services and the sustainability of the production.

Summary

- Over the past 50 years, **humans have changed ecosystems more rapidly and extensively** than in any comparable period of time in human history, largely to meet **rapidly growing demands for food, fresh water, timber, fiber and fuel**
- 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** in the form of the **degradation of many ecosystem services**, increased risks of nonlinear changes, and the exacerbation of poverty for some groups of people
- 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
- **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 has considered but these involve **significant changes in policies, institutions and practices**, that are not currently under way

Millennium Ecosystem Assessment

Sustainability

“a need to
maintain or
improve”

types, scale,
magnitude,
and frequency

Apollo photo
not the
dark-side

A New Year's
celebration -
for your Time
Zone or for
the planet?



We need to think about how our actions impact the planet.

We need to think globally and act locally in ways that benefit the whole system.

think
global
act
loco

10/18/2007

KDHE Denies Permit For Holcomb Expansion

Secretary of the Kansas Department of Health and Environment Roderick Bremby denied the final construction permit for Sunflower Electric Power Corporation's Holcomb Expansion today.



Visit the MA Website

www.MAweb.org

All MA reports
available to download
Access to core data
MA 'outreach' kit

- Slides
- Communication tools



Guide to the Millennium Assessment Reports

Full Reports



The Working Group assessment reports are between 500–800 pages in length, with a volume of summaries of about 120 printed pages. [Learn](#)

[more](#)

- [Current States & Trends](#)
- [Scenarios](#)
- [Policy Responses](#)
- [Multiscale Assessments](#)

Synthesis Reports

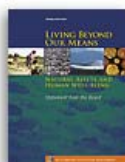


The first set of assessment reports consists of an overall synthesis and 5 others that interpret the MA findings for specific audiences. [Learn](#)

[more](#)

- [Overall synthesis](#)
- [Biodiversity](#)
- [Desertification](#)
- [Business & Industry](#)
- [Wetlands and Water](#)
- [Health](#)

Statement of the MA Board



The MA Board of Directors has developed an interpretation of the key messages to emerge from the assessment, entitled *Living Beyond Our Means: Natural Assets and Human Well-being*. [Learn more](#)

- [Learn more](#)
- [Download the Statement](#)
- [About the MA Board of Directors](#)

A Framework for Assessment



In late 2003, the MA and Island Press published *Ecosystems and Human Well-being: A Framework for Assessment*. This volume lays out the assumptions, processes and parameters that were used in the MA. [Learn more](#)



About the Millennium Assessment

The Millennium Ecosystem Assessment assessed the consequences of ecosystem change for human well-being. From 2001 to 2005, the MA involved the work of more than 1,360 experts worldwide. Their findings provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainably. [Read More](#)

Useful Links



[Order printed reports from Island Press](#)

[GreenFacts.org](#)

[GreenFacts: Popularized synthesis report](#)



[MA Data Portal](#)