Millennium Ecosystem Assessment

Bharathidasan University

Programme: MSc Environmental Science and Sustainable Management

Course Title: ECOSYSTEM SERVICES AND SUSTAINABILITY

Course Code: 21PGEC04-1

Unit- III Assessment of Ecosystem Services

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Millennium Ecosystem Assessment Findings

Millennium Ecosystem Assessment

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

Millennium Ecosystem Assessment

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

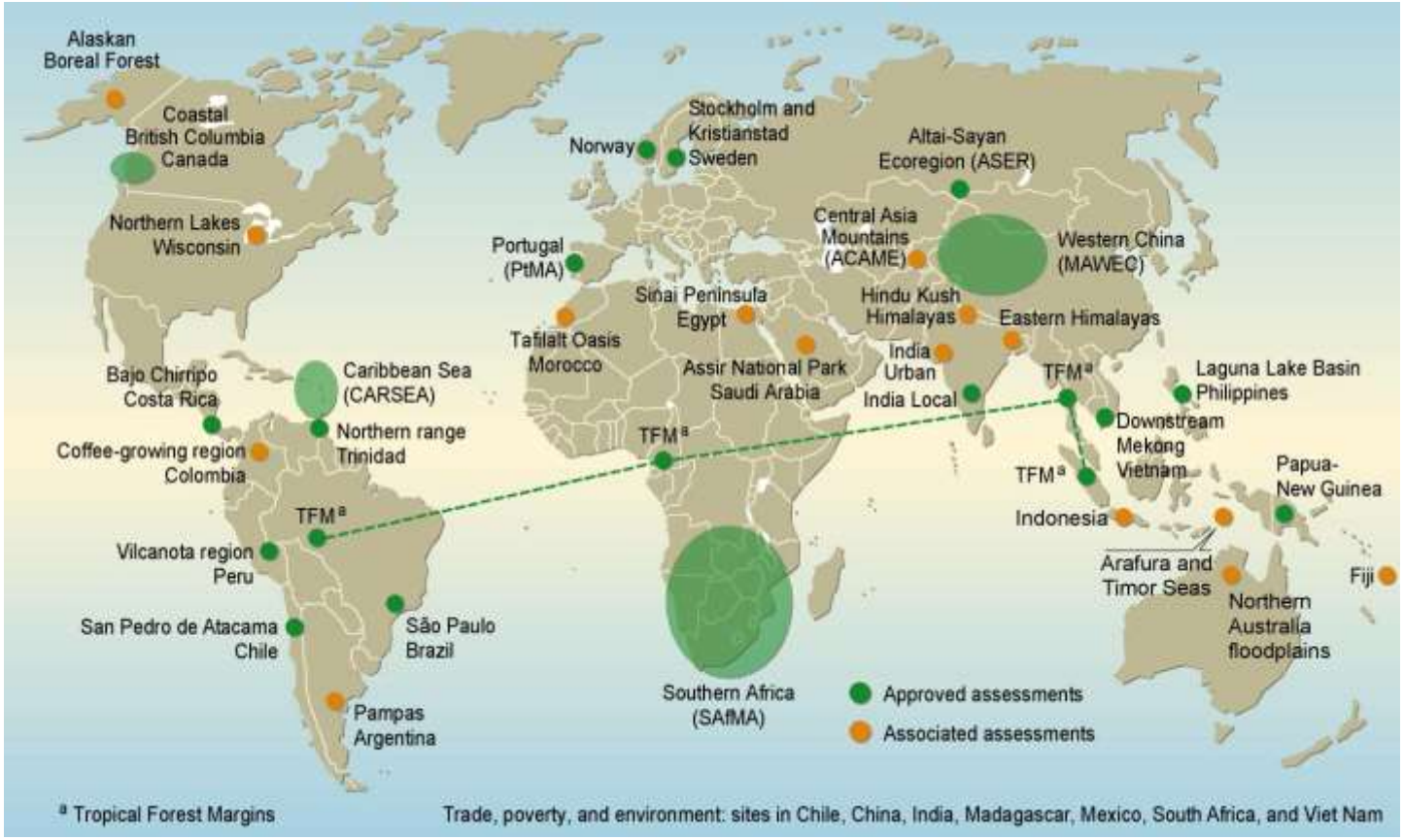
- Clarifies where there is broad consensus within the scientific community and where issues remain unresolved

Policy relevant not policy prescriptive

Defining Features

Multi-scale assessment

- Includes information from 33 sub-global assessments



Different ways to use MA Findings

Decision-making and Management

- The framework used – particularly the focus on ecosystem services – helps in incorporating the environmental dimension into sustainable development policy and planning
- Provides planning and management tools
- Serves as a benchmark
- Provides foresight concerning consequences of decisions affecting ecosystems
- Identifies response options
- Identifies priorities

Assessment, Capacity, and Research

- Provides a framework and tools for assessment
- Helps build capacity
- Guides future research

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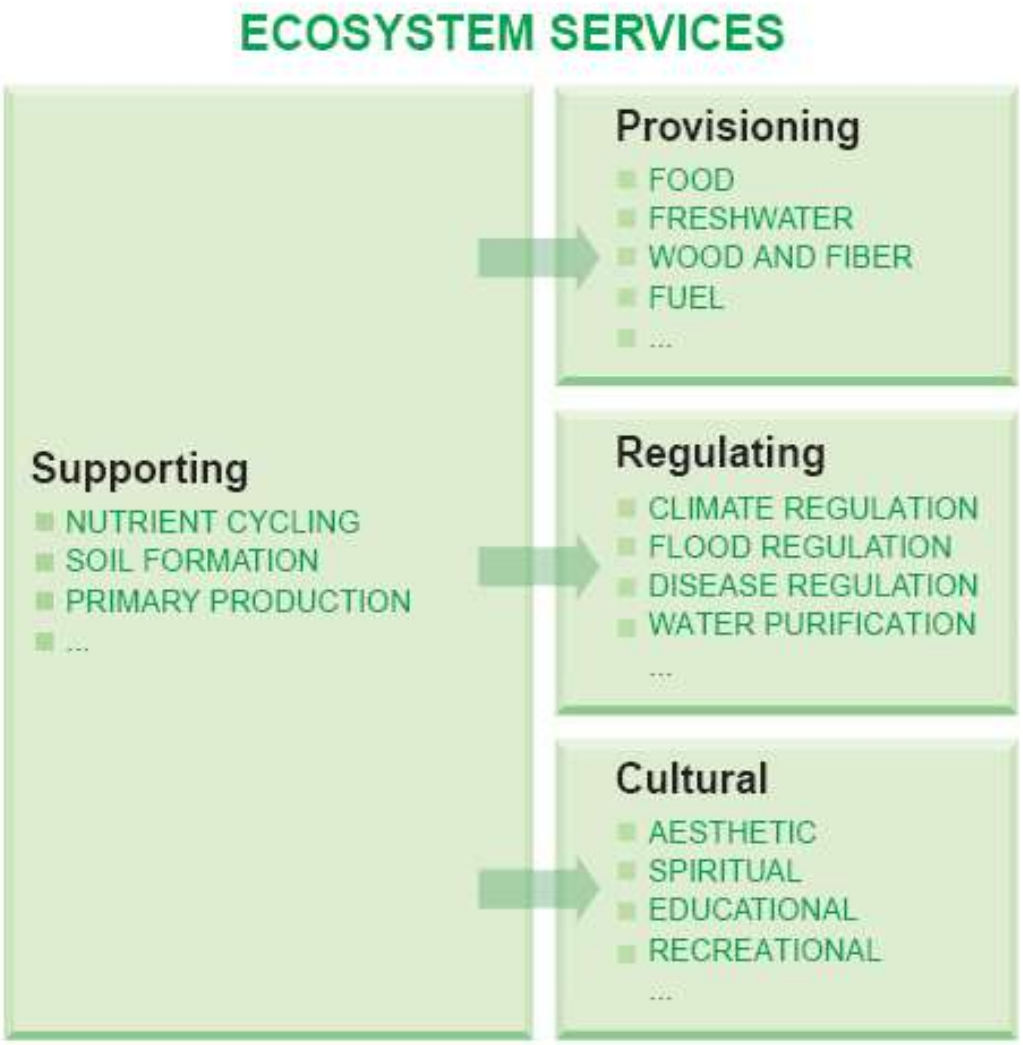
Focus: Ecosystem Services

The benefits people obtain from ecosystems



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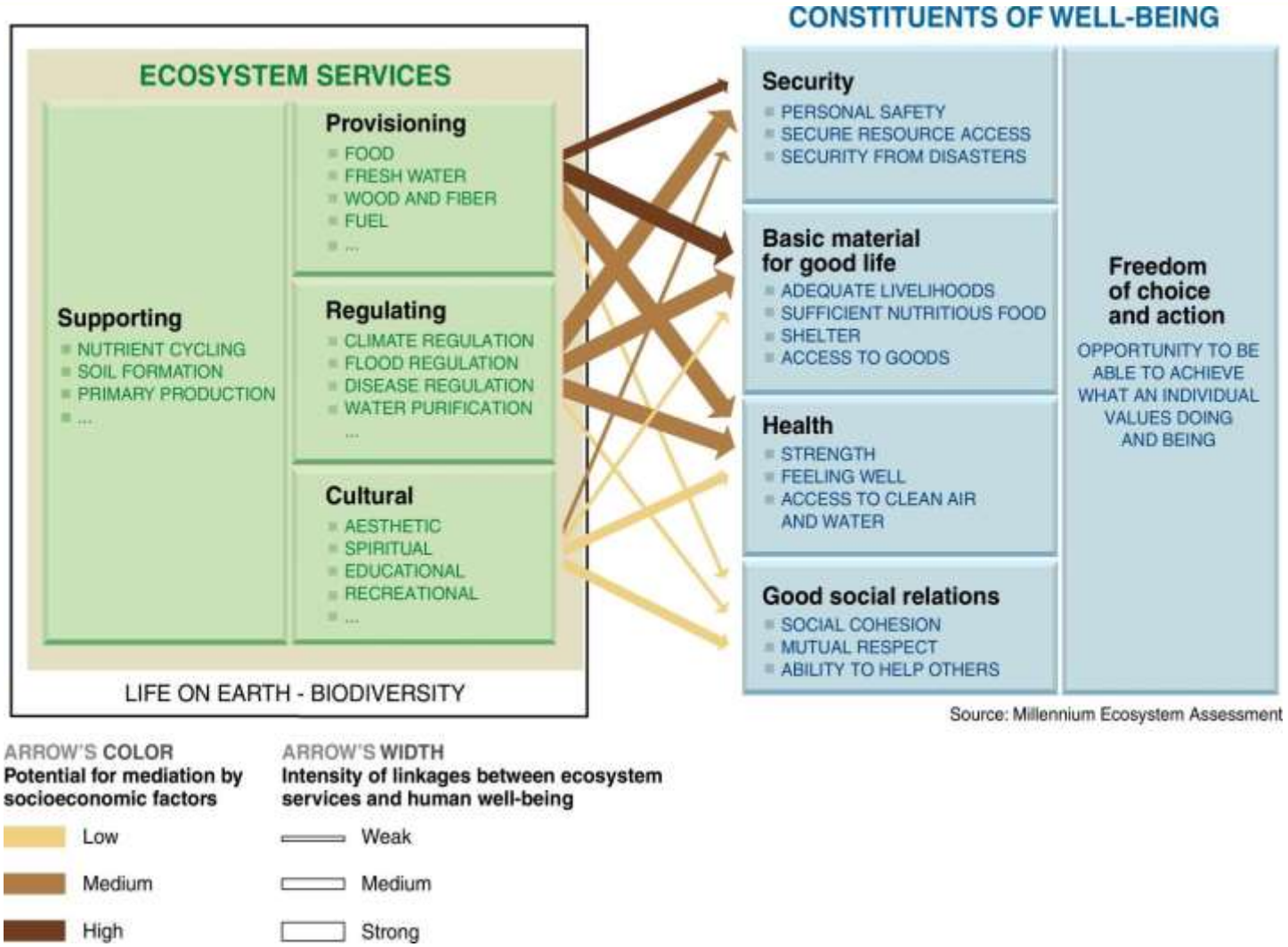
Focus: Consequences of Ecosystem Change for Human Well-being



Source: Millennium Ecosystem Assessment

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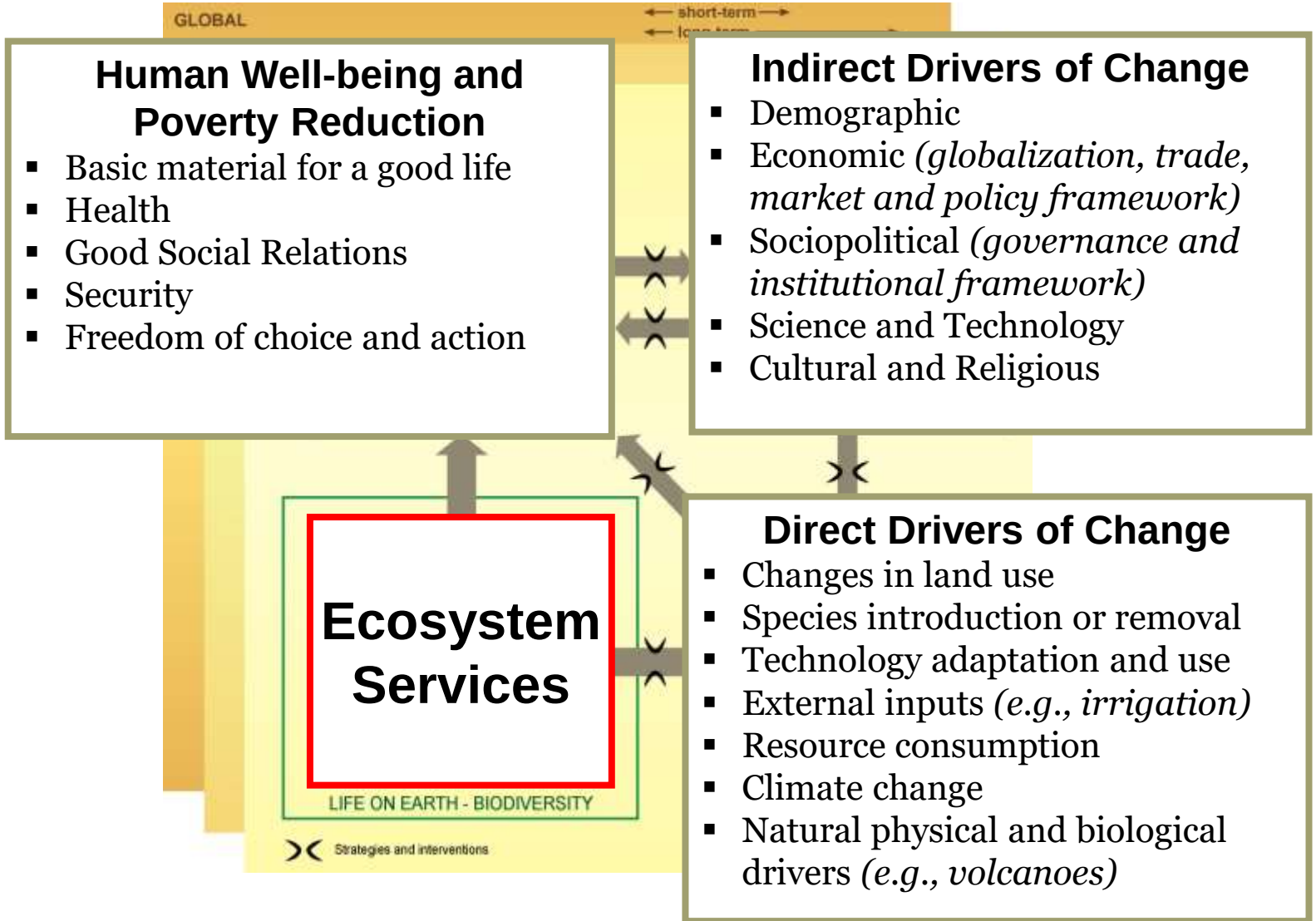
MA Framework



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Four Working Groups

Condition and Trends	Scenarios	Responses
▪ 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?	▪ Given plausible changes in primary drivers, what will be the consequences for ecosystems, their services, and human well-being?	▪ What can we do to enhance well-being and conserve ecosystems?

Sub-Global	▪ 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

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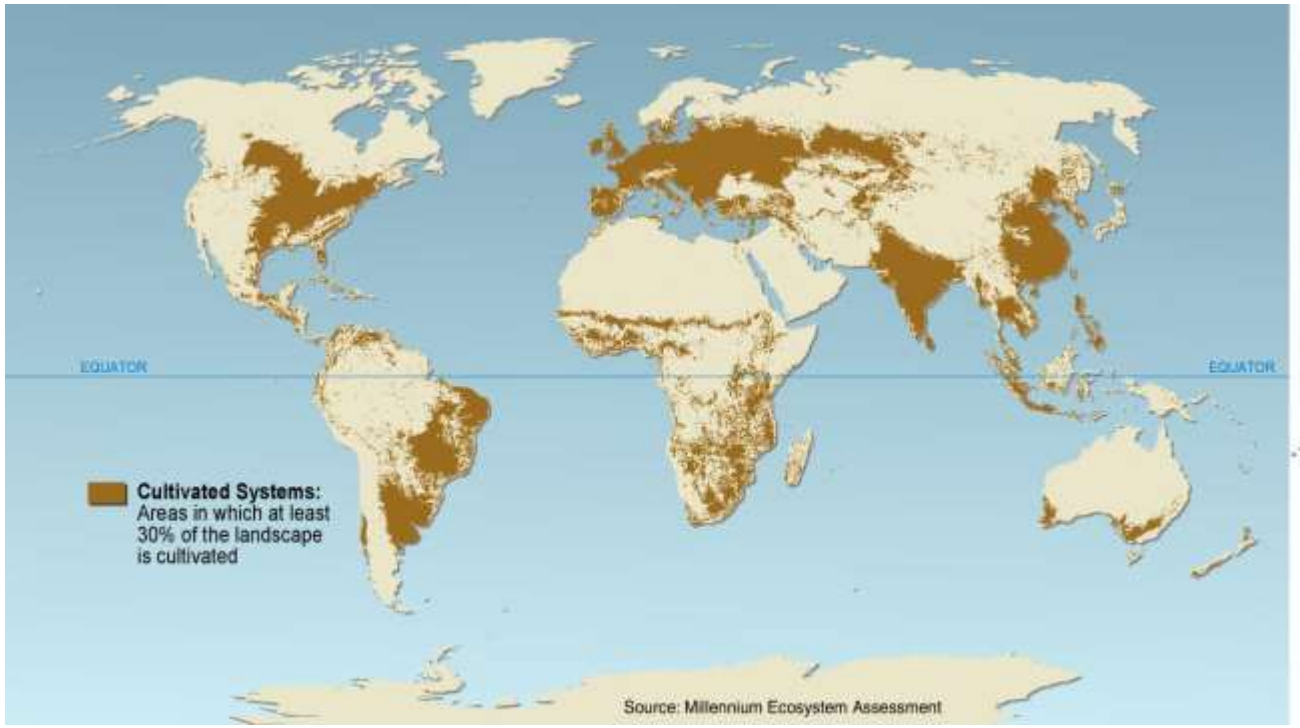
Unprecedented change in structure and function of ecosystems

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

(Defined as areas where at least 30% of the landscape is in croplands, shifting cultivation, confined livestock production, or freshwater aquaculture)

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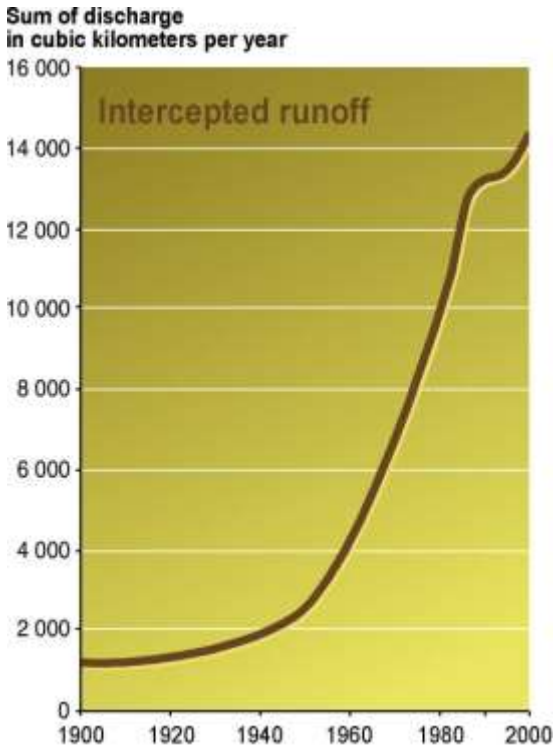
Unprecedented change: Ecosystems

- 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)

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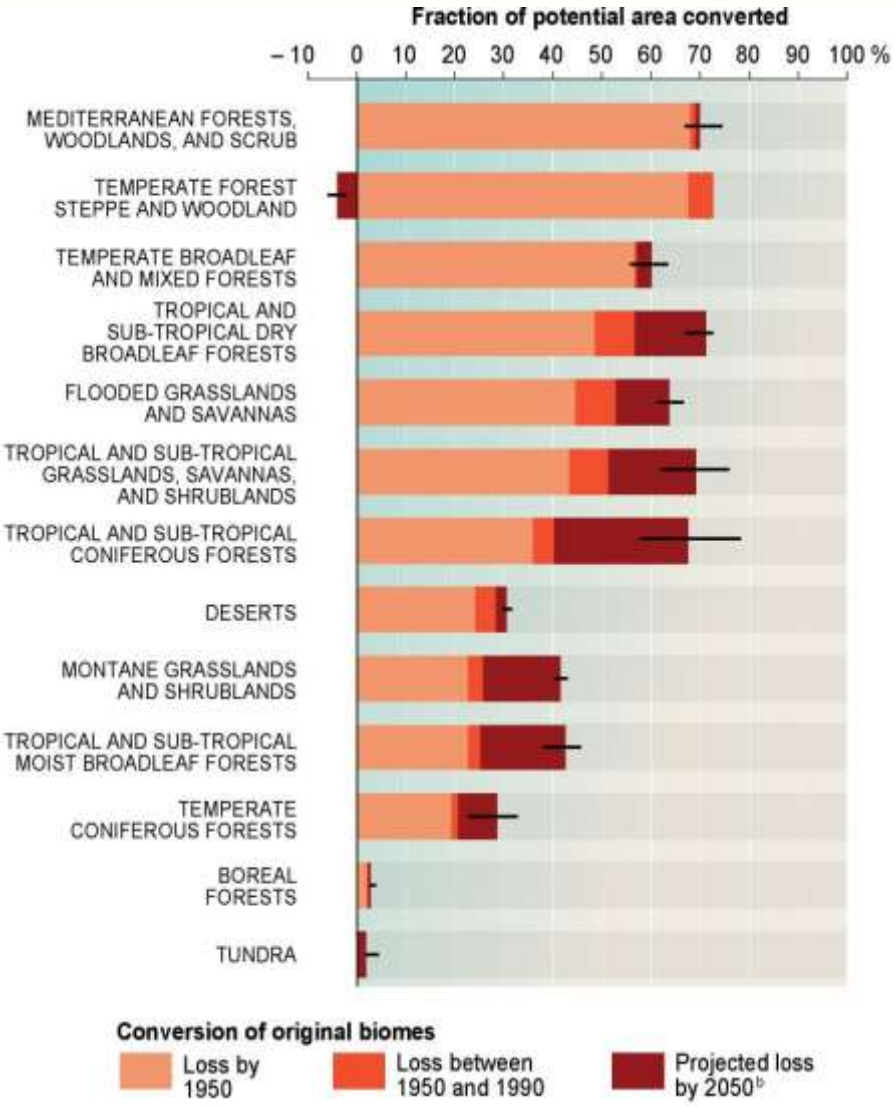
Unprecedented change: Ecosystems

- 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



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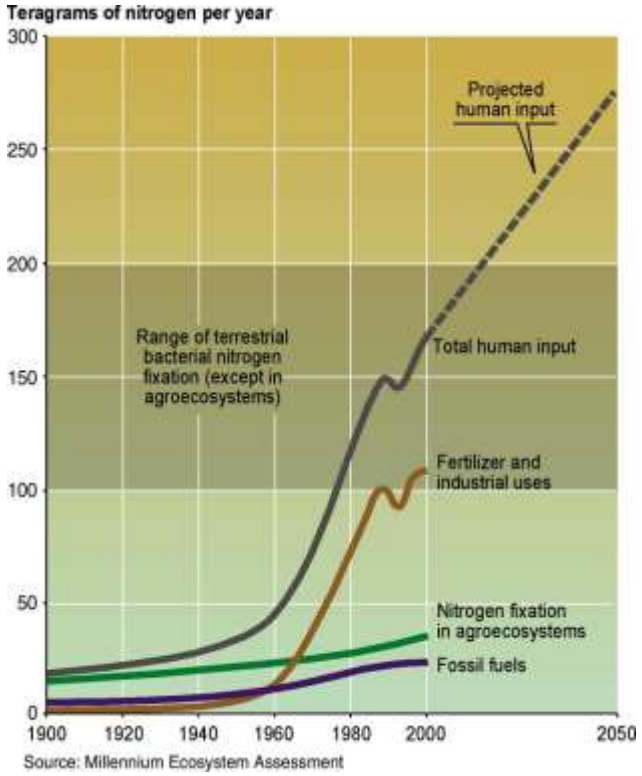
Unprecedented change: Biogeochemical Cycles

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 CO_2 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

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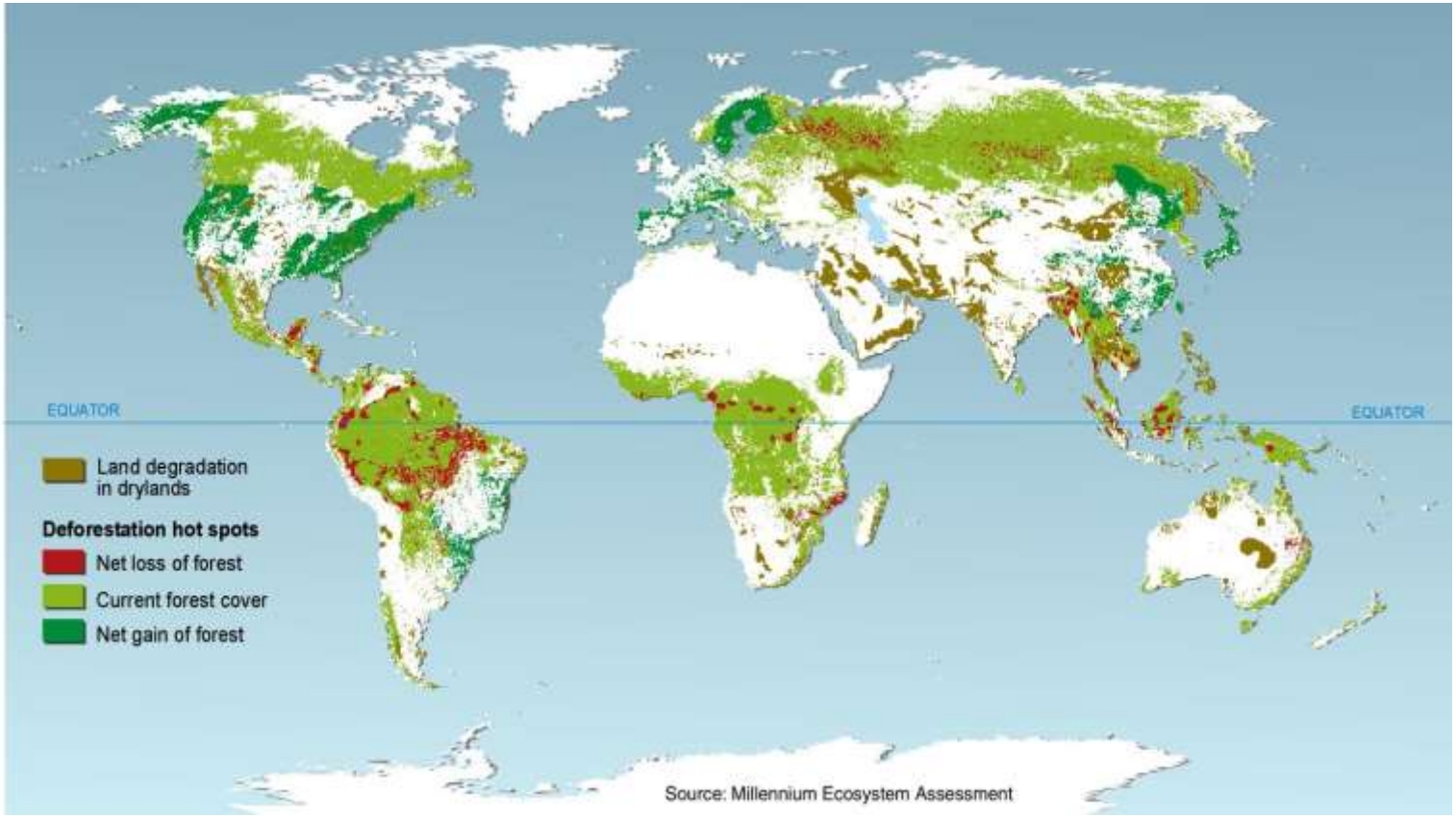
Some ecosystem recovery now underway but high rates of conversion continue

- 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



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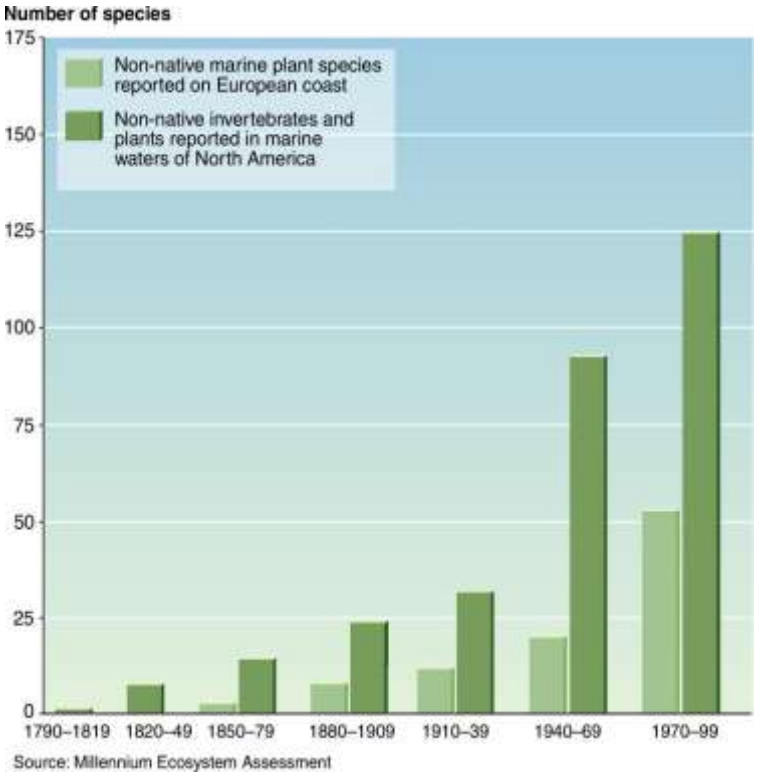
Significant and largely irreversible changes to species diversity

- 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

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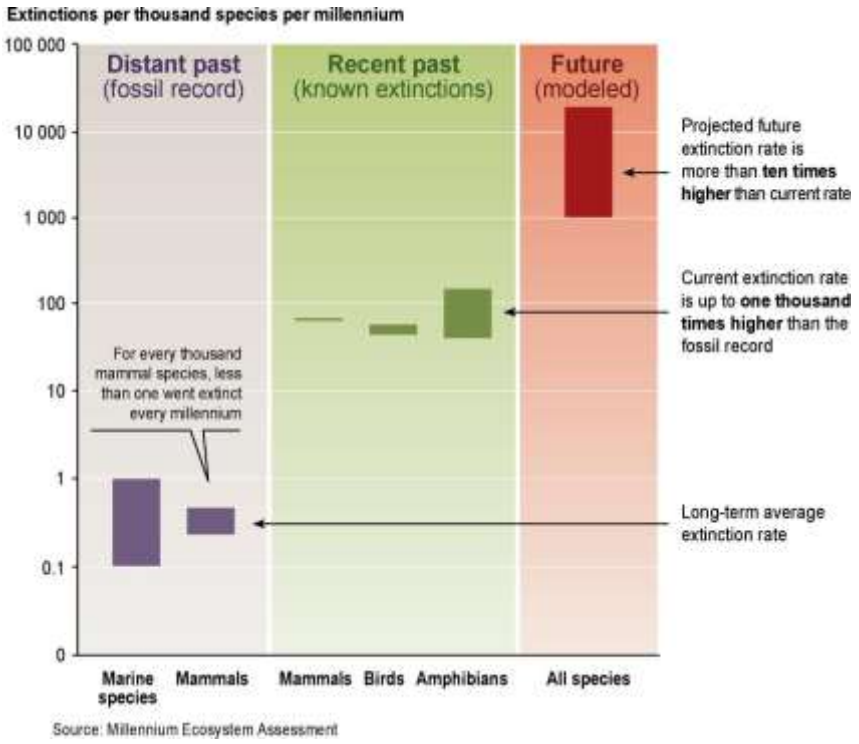
Significant and largely irreversible changes to species diversity

- 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)*



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   - 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

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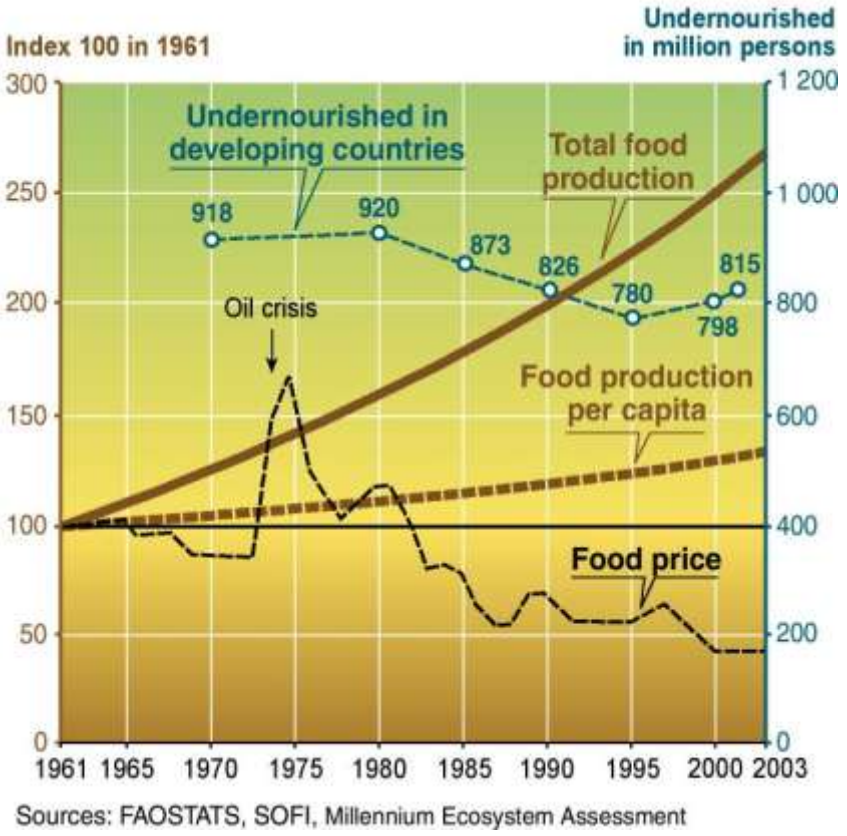
Changes to ecosystems have provided substantial benefits

- 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 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

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Degradation and unsustainable use of ecosystem services

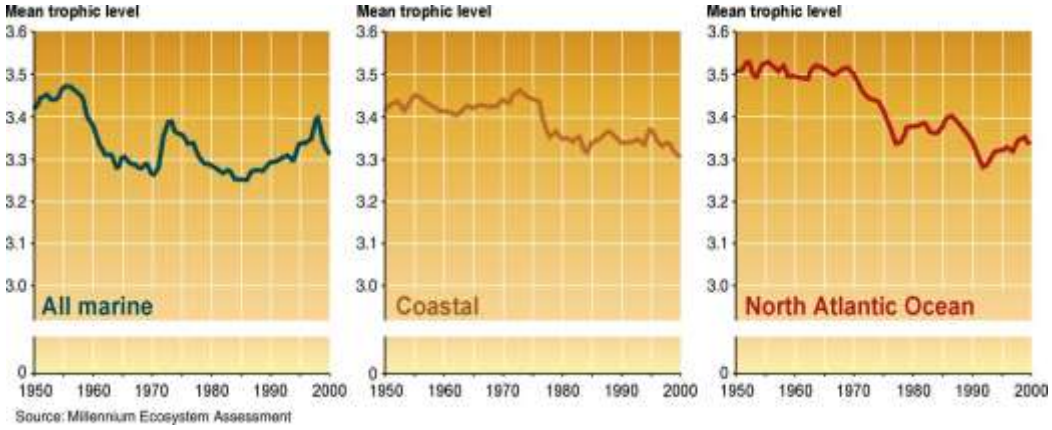
- Approximately 60% (15 out of 24) of the ecosystem services evaluated in this assessment are being degraded or used unsustainably
- The degradation of ecosystem services often causes significant harm to human well-being and represents a loss of a natural asset or wealth of a country

Status of Provisioning Services

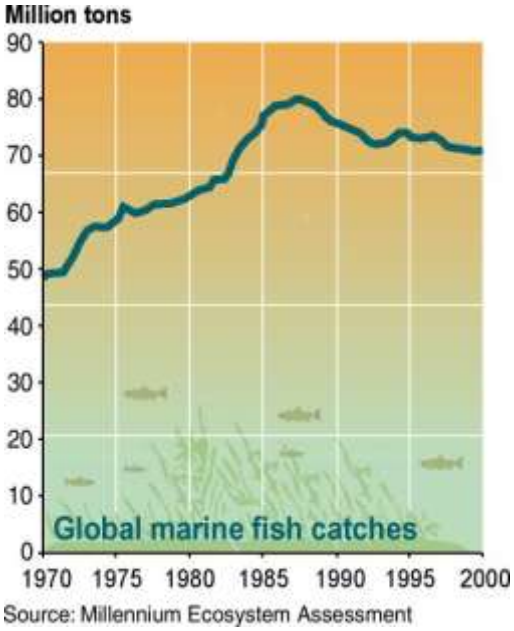
Service		Status
Food	**crops**	↑
	livestock	↑
	capture fisheries	↓
	aquaculture	↑
	wild foods	↓
Fiber	**timber**	+/–
	cotton, silk	+/–
	wood fuel	↓
Genetic resources		↓
Biochemicals, medicines		↓
Fresh water		↓

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

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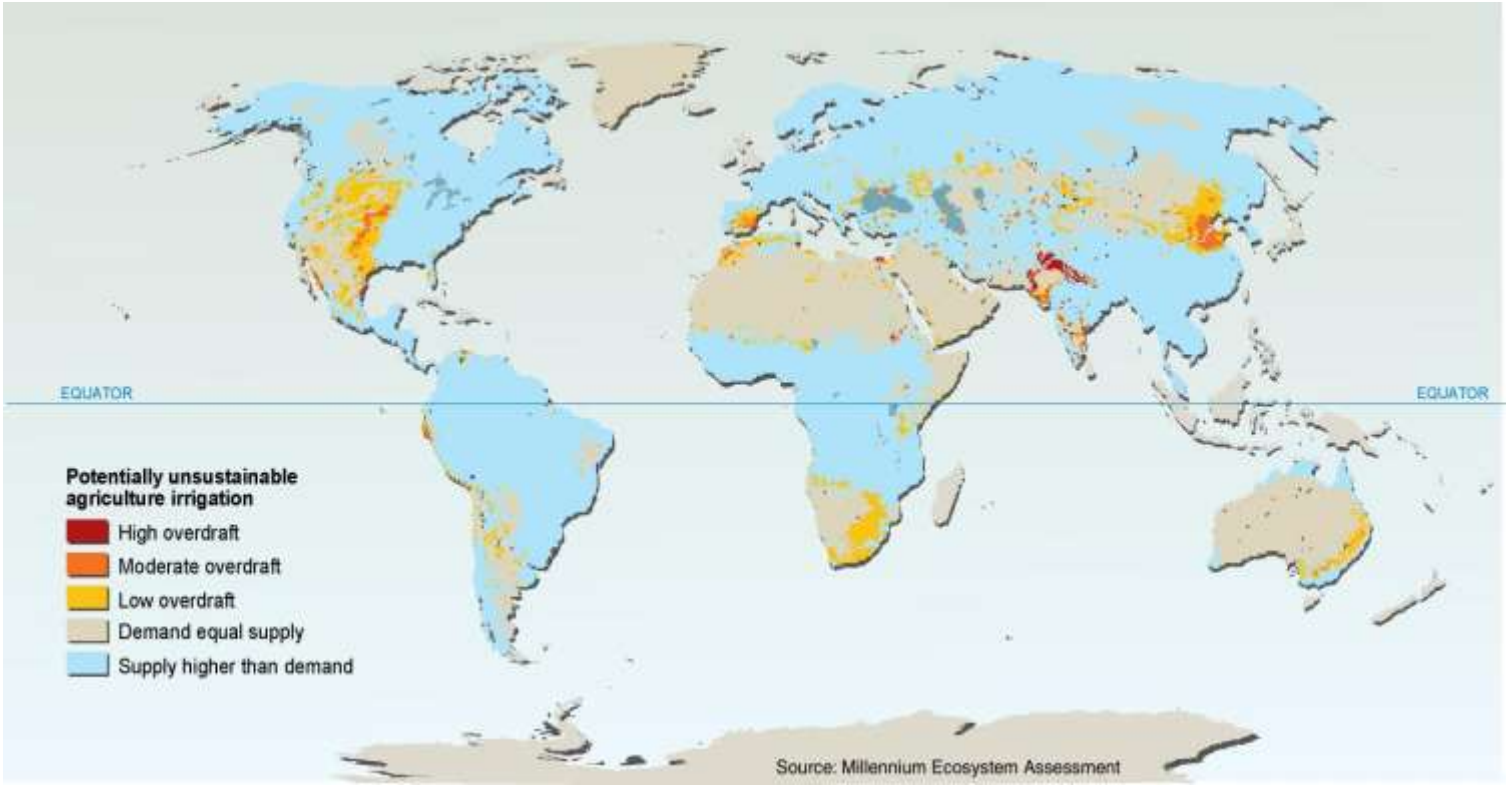
Water

- 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)*



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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

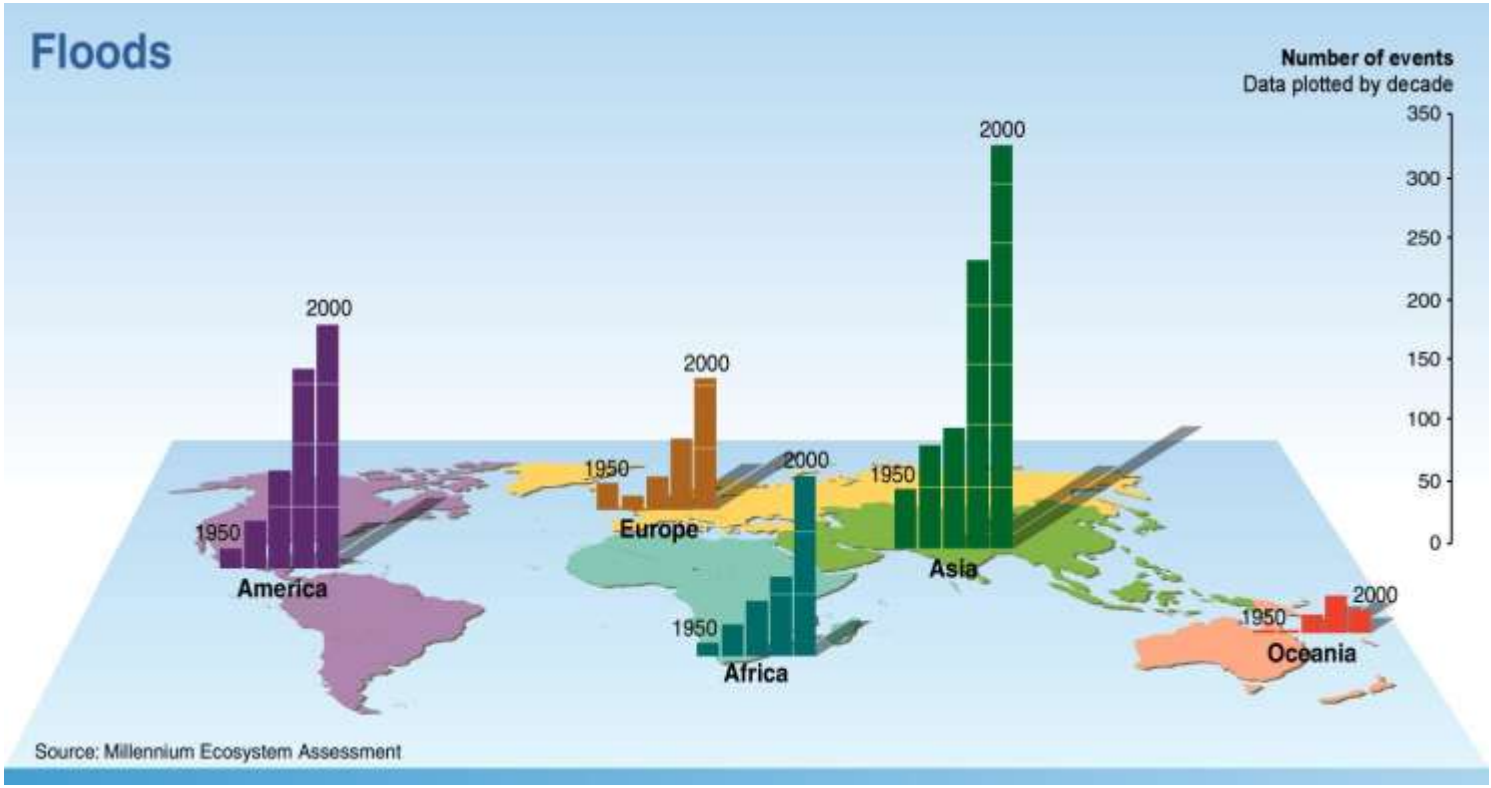
Pollination

- 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



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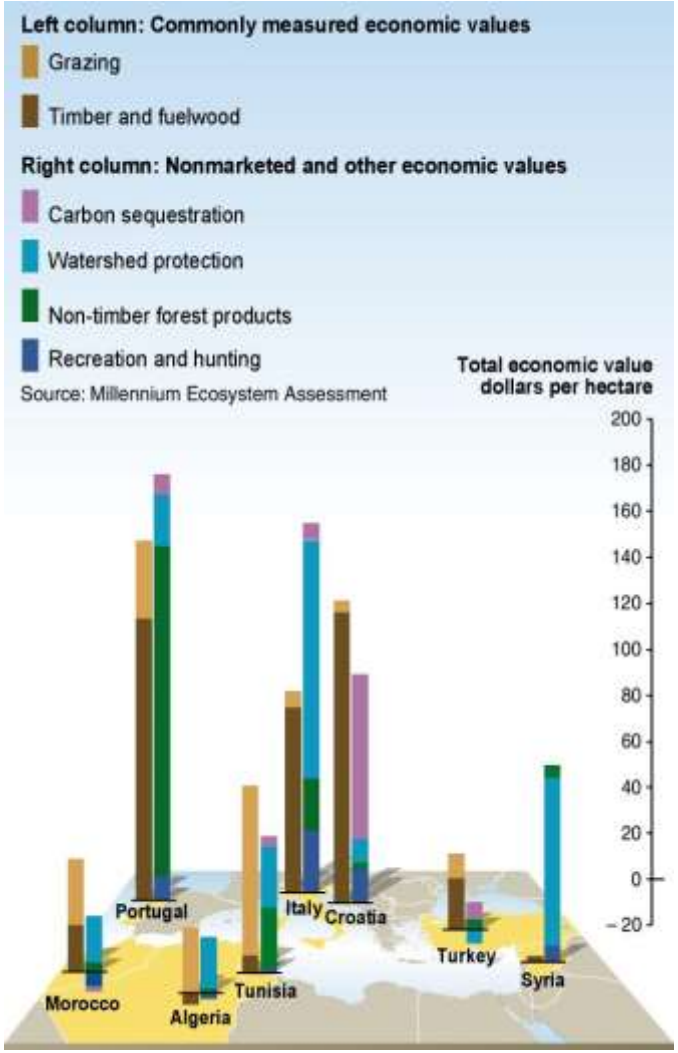
Degradation of ecosystem services often causes significant harm to human well-being

- 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.

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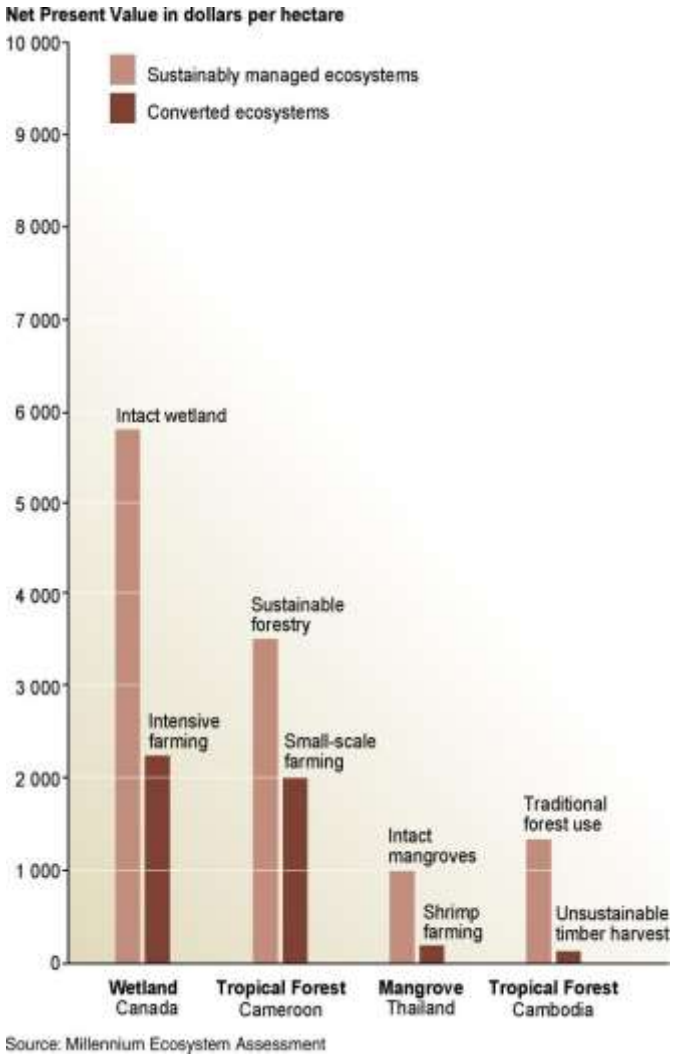
Degradation of ecosystem services often causes significant harm to human well-being

- 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 retraining
- 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

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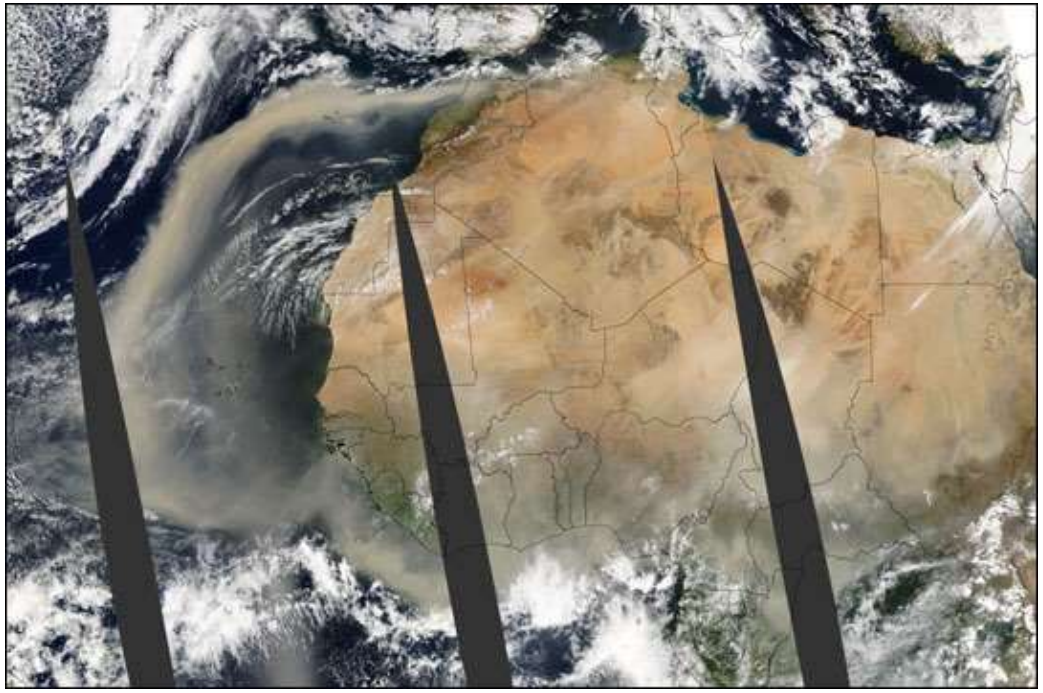
Wealthy populations cannot be insulated from ecosystem degradation

- 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

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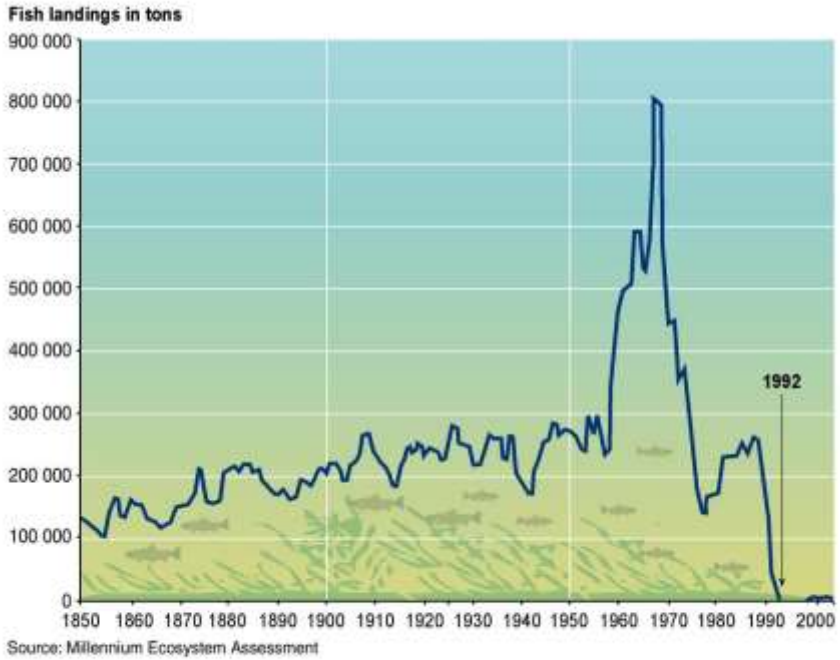
Increased likelihood of nonlinear changes

- 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



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, than 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

Examples of nonlinear change

Species introductions and losses

- The introduction of the zebra mussel into aquatic systems in the United States resulted in the extirpation of native clams in Lake St. Clair and annual costs of $100 million to the power industry and other users

Regional climate change

- Deforestation generally leads to decreased rainfall. Since forest existence depends on rainfall, forest loss can result in a positive feedback, accelerating the rate of decline in rainfall which in turn can lead to a nonlinear change in forest cover

Factors causing increase in likelihood of nonlinear changes

- The loss of species and genetic diversity decreases the resilience of ecosystems, which is the level of disturbance that an ecosystem can undergo without crossing a threshold to a different structure or functioning
- Growing pressures from drivers such as overharvesting, climate change, invasive species, and nutrient loading push ecosystems toward thresholds that they might otherwise not encounter

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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

Pattern of winners and losers has not been taken into account in management decisions

- Many changes in ecosystem management have involved the privatization of what were formerly common pool resources often harming individuals who depended on those resources
- Some of the people affected by changes in ecosystem services are highly vulnerable
- Significant differences between the roles and rights of men and women in developing countries lead to increased vulnerability of women to changes in ecosystem services
- The reliance of the rural poor on ecosystem services is rarely measured and thus typically overlooked in national statistics and poverty assessments

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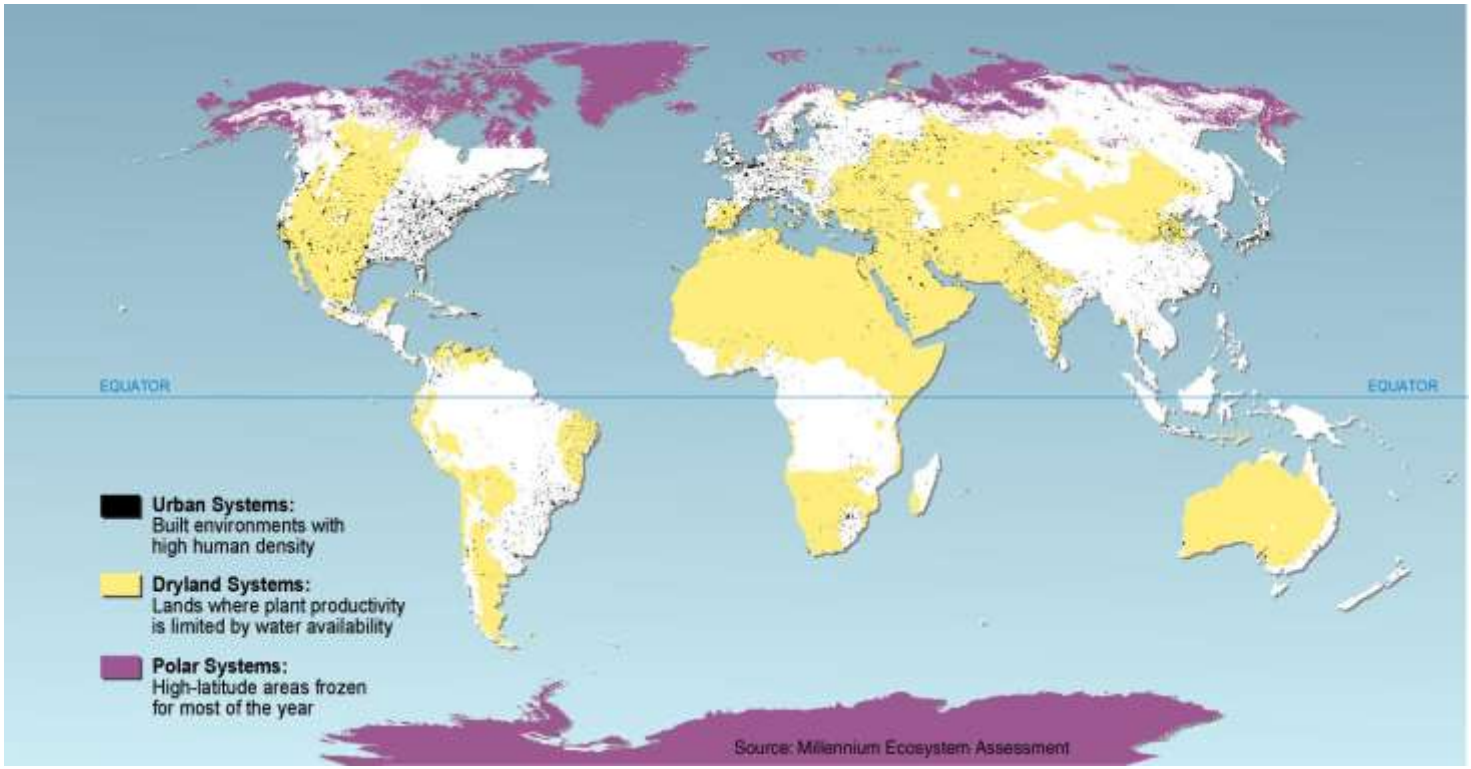
Ecosystem services and poverty reduction

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

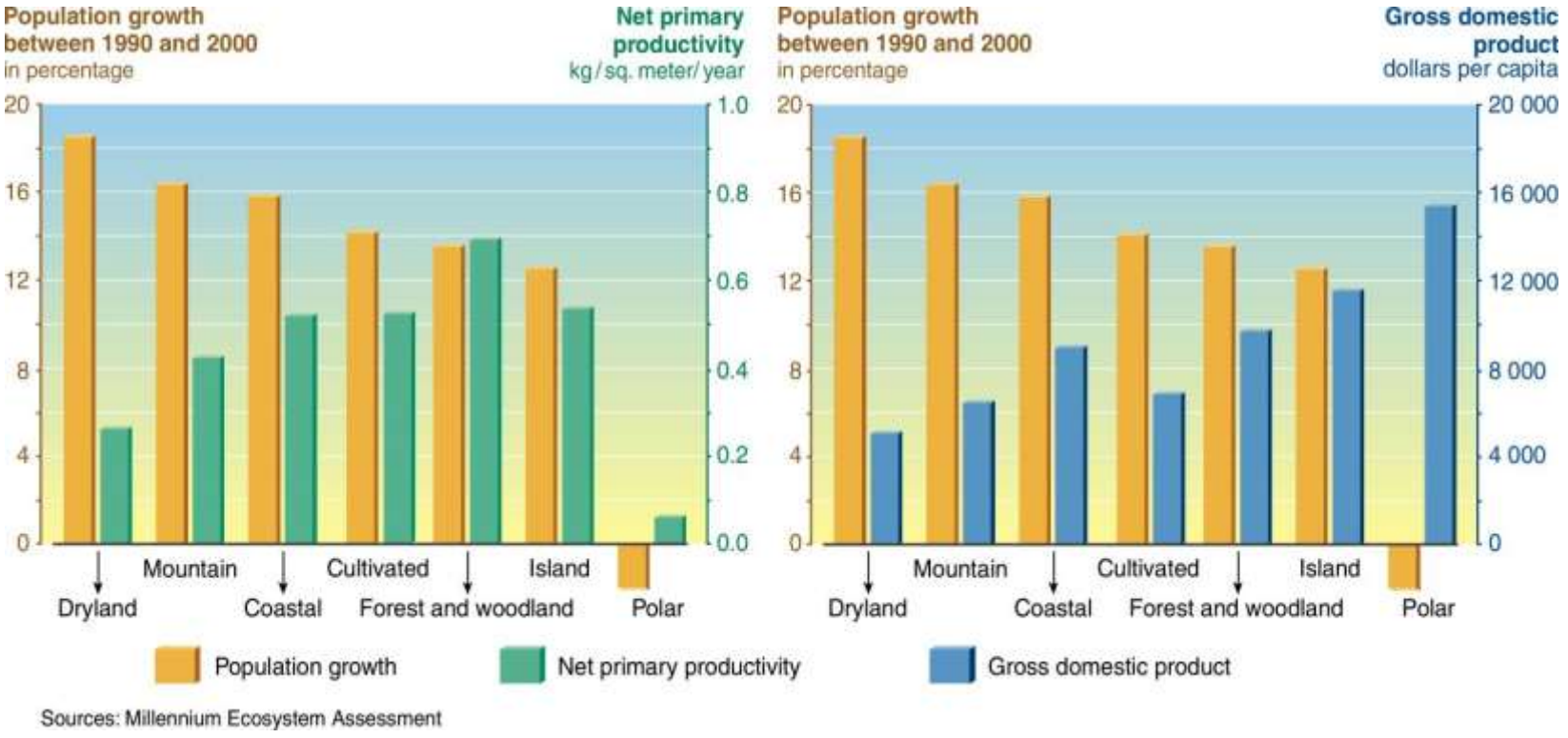
Critical concern: Dryland systems

- 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

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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

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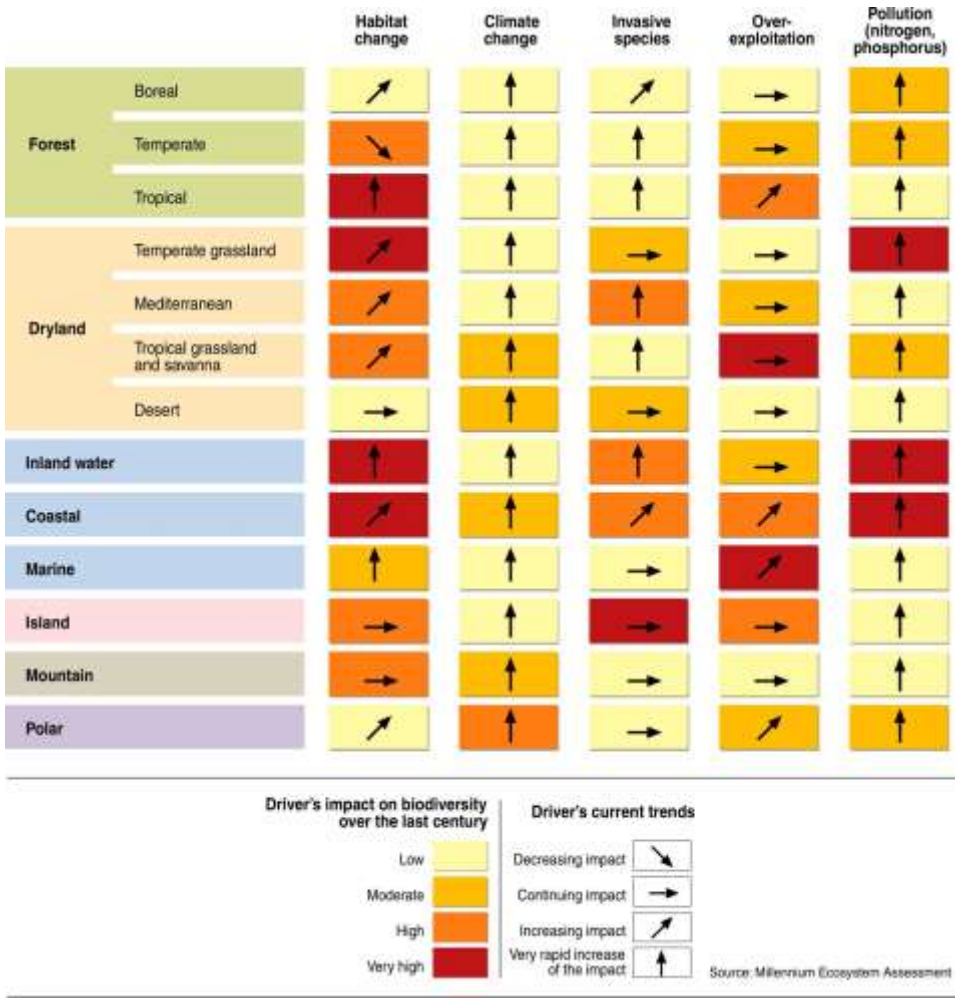
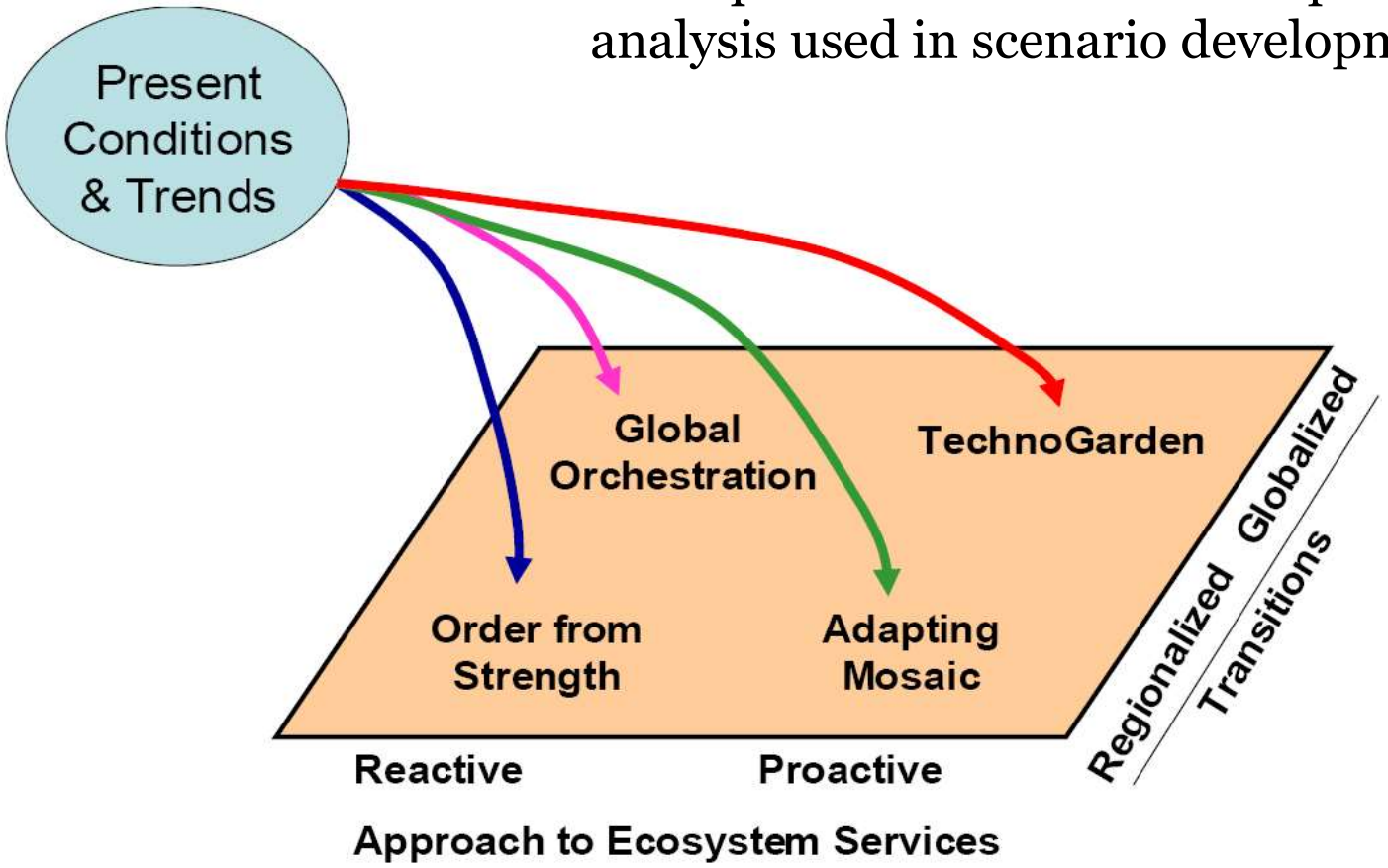
Direct drivers growing in intensity



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

MA Scenarios

- Not predictions – scenarios are plausible futures
- Both quantitative models and qualitative analysis used in scenario development



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.

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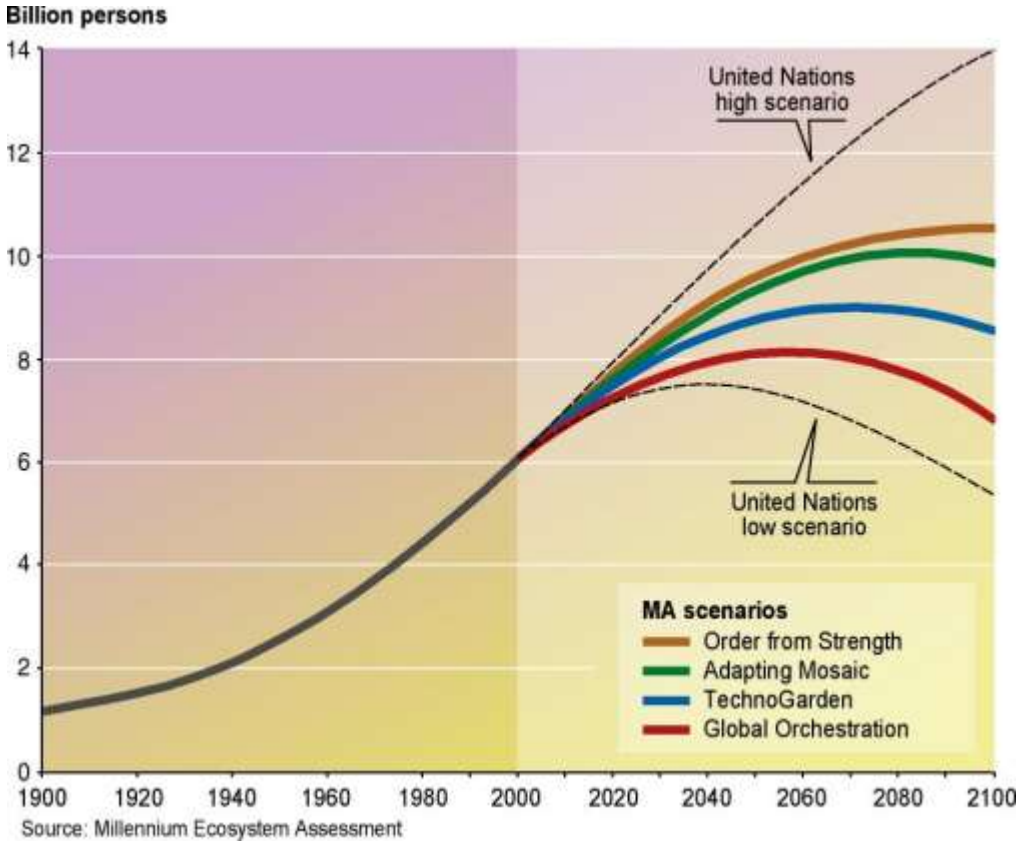
Changes in indirect drivers

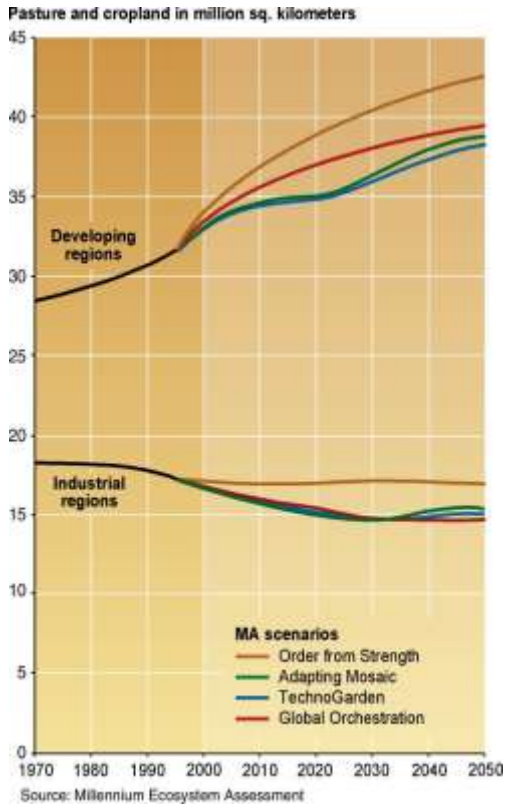
In MA Scenarios:

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

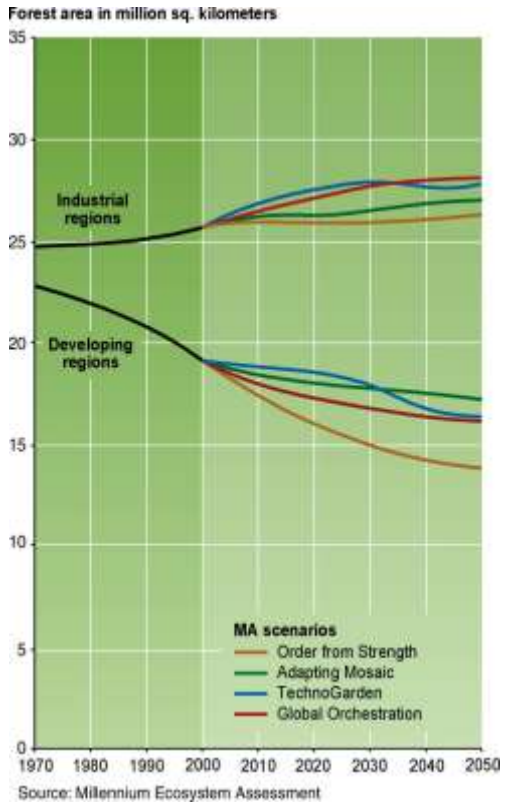


Changes in direct drivers

Changes in crop land and forest area under MA Scenarios



Crop Land



Forest Area

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Changes in direct drivers

Habitat transformation:

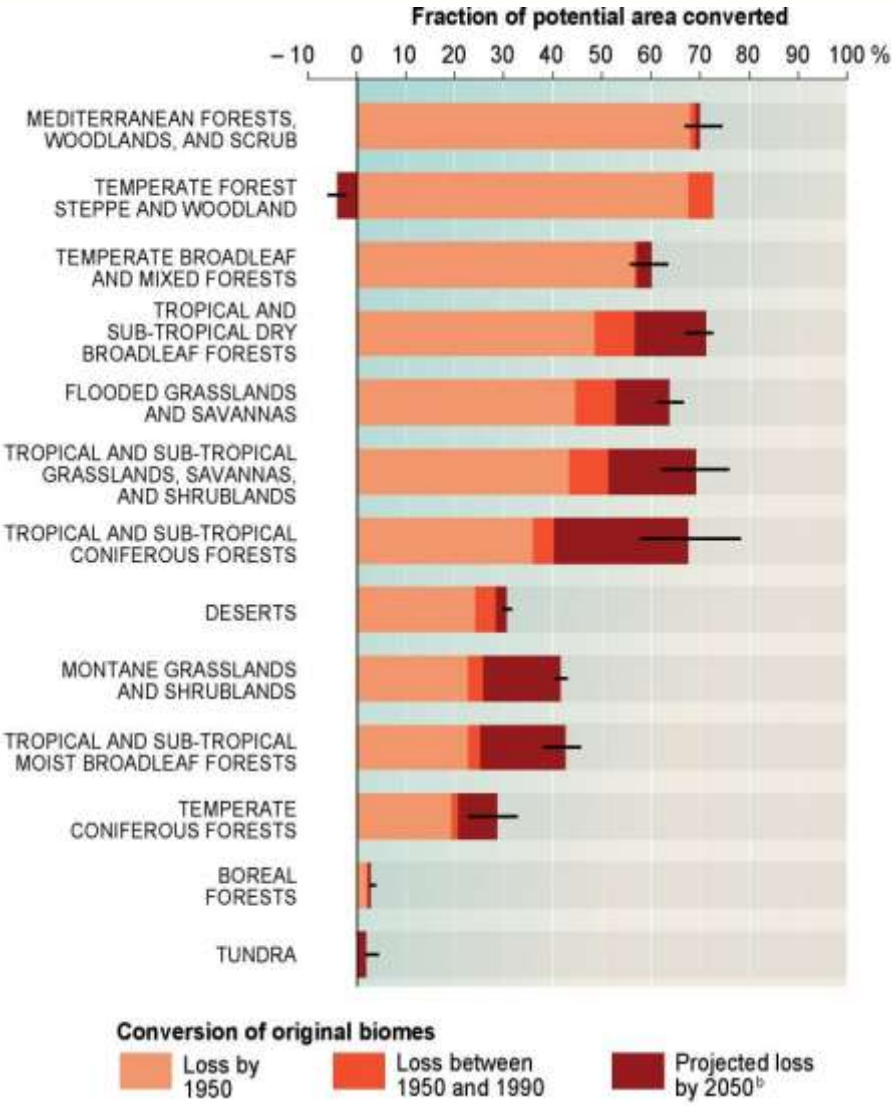
- Further 10–20% of grassland and forestland is projected to be converted by 2050

Overexploitation, overfishing:

- Pressures continue to grow in all scenarios

Invasive alien species:

- Spread continues to increase



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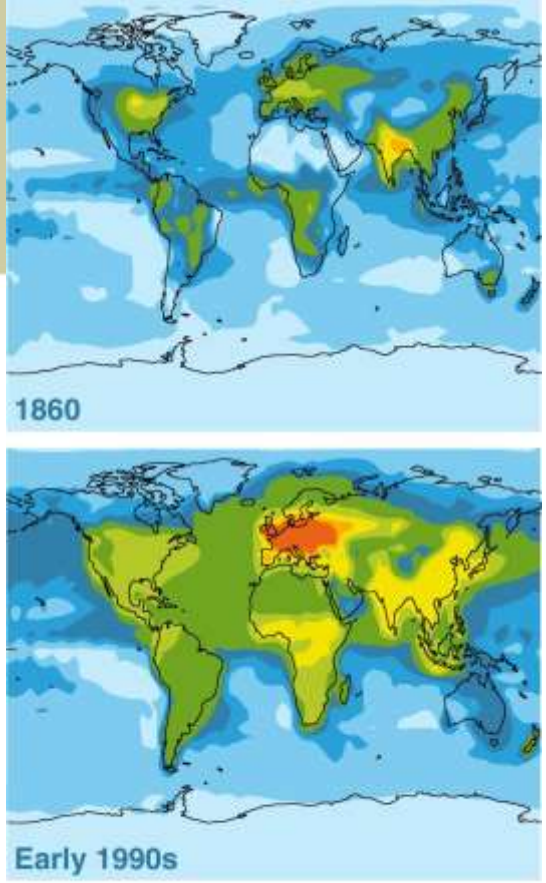
Changes in direct drivers: Nutrient loading

- 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 United States)

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 ozone in the stratosphere
- 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 direct drivers: Climate Change

Observed recent impacts of climate changes on ecosystems:

- Changes in species distributions
- Changes in population sizes
- Changes in the timing of reproduction or migration events
- Increase in the frequency of pest and disease outbreaks
- Many coral reefs have undergone major, although often partially reversible, bleaching episodes when local sea surface temperatures have increased

Changes in direct drivers: Climate Change

Potential future impacts

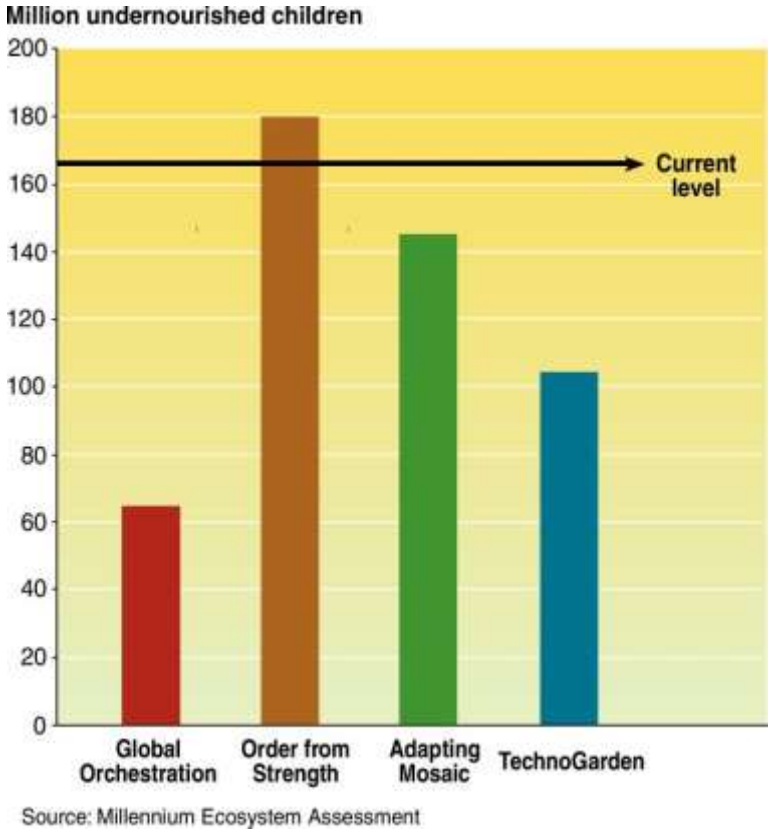
- By the end of the century, climate change and its impacts may be the dominant direct driver of biodiversity loss and changes in ecosystem services globally
- Harm to biodiversity will grow worldwide with increasing rates of change in climate and increasing absolute amounts of change
- Some ecosystem services in some regions may initially be enhanced by projected changes in climate. As climate change becomes more severe the harmful impacts outweigh the benefits in most regions of the world

Net harmful impact on ecosystem services

- The balance of scientific evidence suggests that there will be a significant net harmful impact on ecosystem services worldwide if global mean surface temperature increases more than 2^{o} C above preindustrial levels (*medium certainty)*. This would require CO_2 stabilization at less than 450 ppm.

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*)

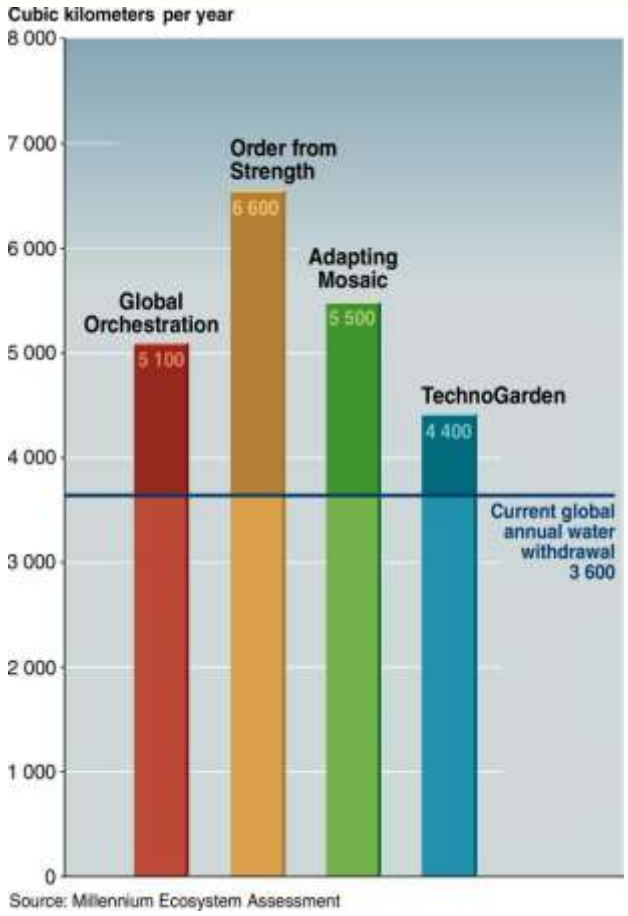


Child undernourishment in 2050 under MA Scenarios

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

Degradation of ecosystem services is a significant barrier to achievement of MDGs

Many of the regions facing the greatest challenges in achieving the 2015 targets coincide with regions facing the greatest problems of ecosystem degradation

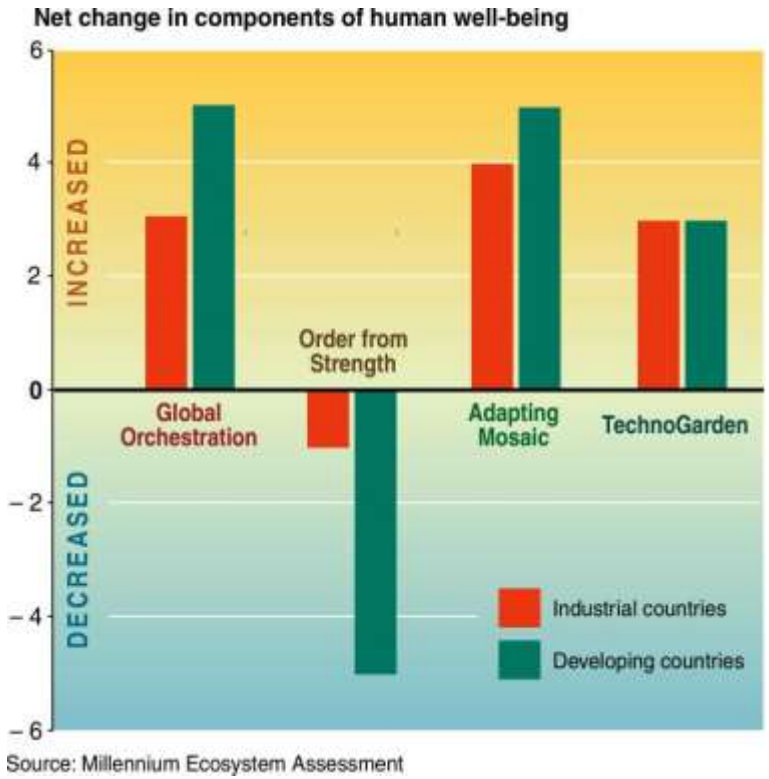
Although socioeconomic factors will play a primary role in achieving many of the MDGs, targets are unlikely to be met without improvement in ecosystem management for goals such as:

- Poverty Reduction
- Hunger
  - *All four MA scenarios project progress but at rates far slower than needed to attain the MDG target. The improvements are slowest in the regions in which the problems are greatest: South Asia and sub-Saharan Africa*
- Child mortality
  - *Three of the MA scenarios project reductions in child undernourishment of between 10% and 60% but undernourishment increases by 10% in* one.
- Disease
  - *Progress toward this Goal is achieved in three scenarios, but in one scenario the health and social conditions for the North and South further diverge, exacerbating health problems in many low-income regions*
- Environmental Sustainability including access to water

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

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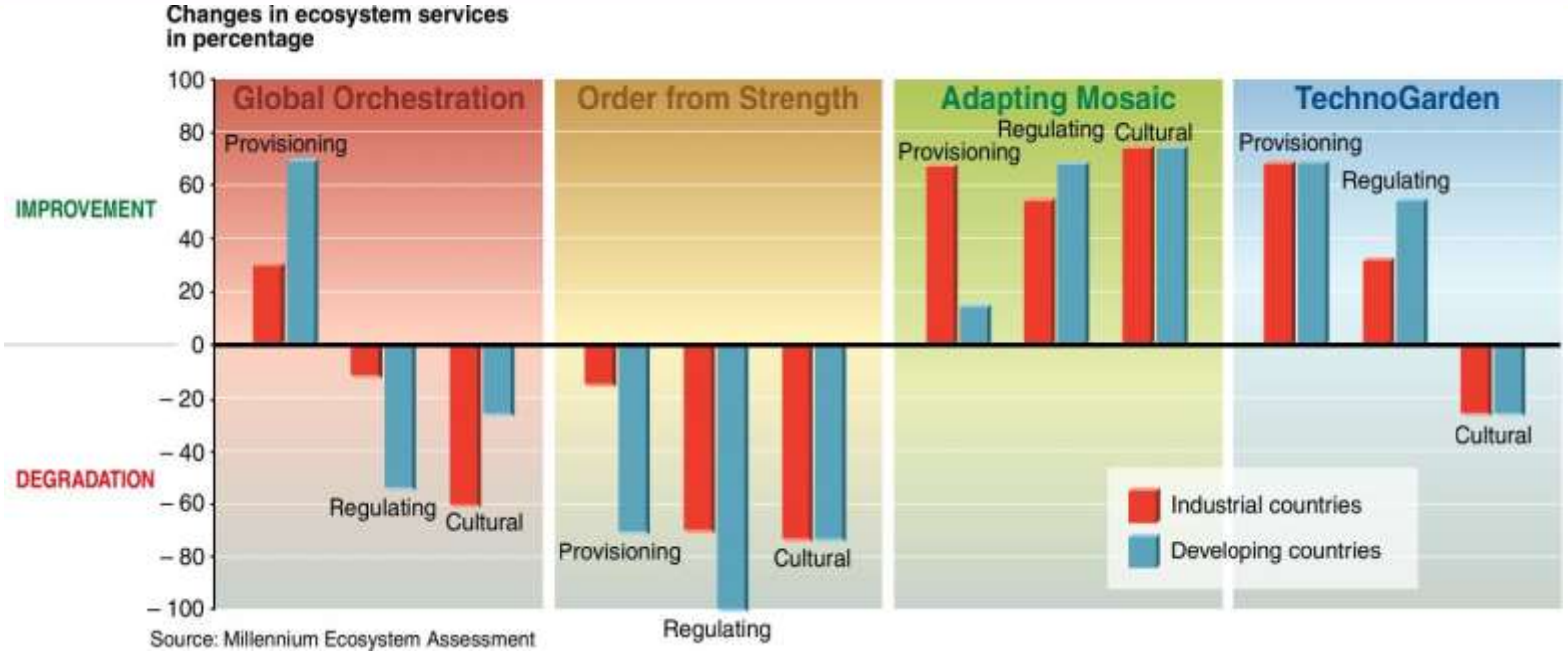
Improvements in services can be achieved by 2050



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.

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 that are 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.

MA Responses Assessment

The MA assessed 74 response options for ecosystem services, integrated ecosystem management, conservation and sustainable use of biodiversity, and climate change

Responses: Institutions

Changes in institutional and environmental governance frameworks are sometimes required to create the enabling conditions for effective management of ecosystems, while in other cases existing institutions could meet these needs but face significant barriers.

Promising Responses

- Integration of ecosystem management goals within other sectors and within broader development planning frameworks
- Increased coordination among multilateral environmental agreements and between environmental agreements and other international economic and social institutions
- Increased transparency and accountability of government and private-sector performance on decisions that have an impact on ecosystems, including through greater involvement of concerned stakeholders in decision-making

Responses: Economics

Economic and financial interventions provide powerful instruments to regulate the use of ecosystem goods and services

Promising Responses

- Elimination of subsidies that promote excessive use of ecosystem services (and, where possible, transfer these subsidies to payments for non-marketed ecosystem services)
  - *Subsidies paid to the agricultural sectors of OECD countries between 2001 and 2003 averaged over $324 billion annually, or one third the global value of agricultural products in 2000*
  - *Compensatory mechanisms may be needed for poor people who are adversely affected by the removal of subsidies*
  - *removal of agricultural production subsidies within the OECD would need to be accompanied by actions to minimize adverse impacts on ecosystem services in developing countries*

Responses: Economics

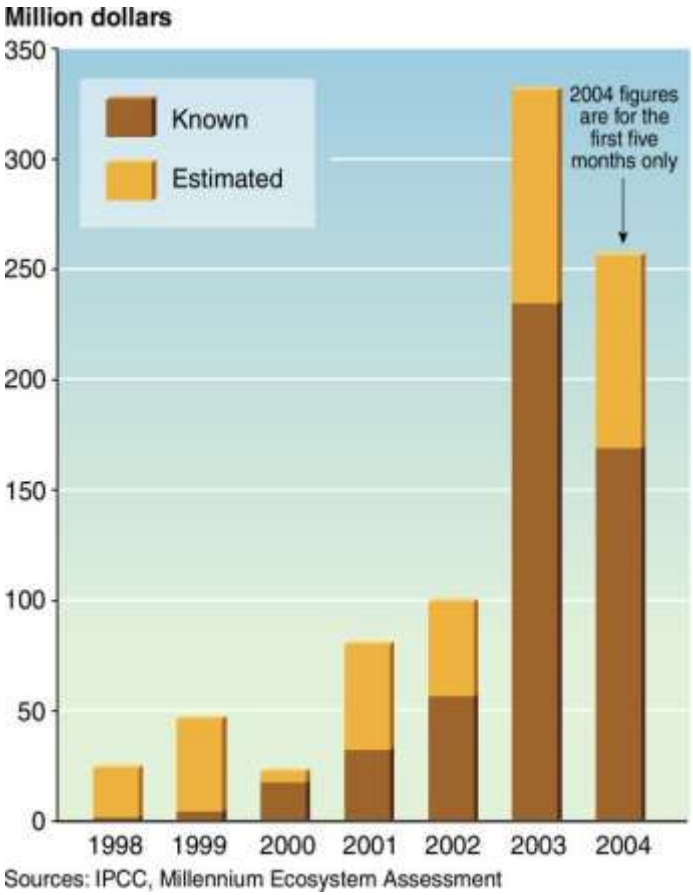
Promising Responses

- Greater use of economic instruments and market-based approaches in the management of ecosystem services (where enabling conditions exist):
  - *Taxes or user fees for activities with "external" costs (e.g. include taxes on excessive application of nutrients)*
  - *Payment for ecosystem services*

    For example, in 1996 Costa Rica established a nationwide system of conservation payments under which Costa Rica brokers contracts between international and domestic "buyers" and local "sellers" of sequestered carbon, biodiversity, watershed services, and scenic beauty
  - *Mechanisms to enable consumer preferences to be expressed through markets such as existing certification schemes for sustainable fisheries and forest practices*

Responses: Economics

- Market-based approaches (continued)
  - *Creation of markets, including through cap-and-trade systems*
    - One of the most rapidly growing markets related to ecosystem services is the carbon market. The value of carbon trades in 2003 was approximately $300 million. About one quarter of the trades involved investment in ecosystem services (hydropower or biomass)
    - It is speculated that this market may grow to some $44 billion by 2010



Total Carbon Market Value per Year

Responses: Social & Behavioral

These are generally interventions that stakeholders initiate and execute through exercising their procedural or democratic rights in efforts to improve ecosystems and human well-being

Promising Responses

- Measures to reduce aggregate consumption of unsustainably managed ecosystem services
  - *Behavioral changes that could reduce demand for threatened ecosystem services can be encouraged through actions such as education and public awareness programs, promotion of demand-side management, commitments by industry to use raw materials that are from sources certified as being sustainable, and improved product labeling*
- Communication and education
- Empowerment of groups particularly dependent on ecosystem services or affected by their degradation, including women, indigenous peoples, and young people

Responses: Technological

Development and diffusion of technologies designed to increase the efficiency of resource use or reduce the impacts of drivers such as climate change and nutrient loading are essential

Promising Responses

- Promotion of technologies that enable increased crop yields without harmful impacts related to water, nutrient, and pesticide use
- Restoration of ecosystem services
- Promotion of technologies to increase energy efficiency and reduce greenhouse gas emissions

Responses: Knowledge

Effective management of ecosystems is constrained both by the lack of knowledge and information about ecosystems and by the failure to use adequately the information that does exist

Promising Responses

- Incorporation of nonmarket values of ecosystems in resource management decisions
- Use of all relevant forms of knowledge and information in assessments and decision-making, including traditional and practitioners' knowledge
- Enhancement of human and institutional capacity for assessing the consequences of ecosystem change for human well-being and acting on such assessments

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

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The United Nations Environment Programme coordinates the Millennium Ecosystem Assessment Secretariat, which is based at the following partner institutions:

- Food and Agricultural Organization of the United Nations, Italy
- Institute of Economic Growth, India
- International Maize and Wheat Improvement Center, Mexico (*until 2004)*
- Meridian Institute, United States
- National Institute of Public Health and the Environment, Netherlands (*until mid-2004)*
- Scientific Committee on Problems of the Environment, France
- UNEP-World Conservation Monitoring Centre, United Kingdom
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- University of Wisconsin, United States
- World Resources Institute, United States
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May 16	Human Health Synthesis
May 19	Synthesis for the Convention on Biological Diversity
June 10	Business and Industry Synthesis
June 17	Synthesis for the Convention to Combat Desertification
To be determined	Synthesis for the Ramsar Wetlands Convention
September	Publication of Technical Volumes (Island Press) ▪ State and Trends ▪ Scenarios ▪ Multi-Scale Assessments ▪ Responses 

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