Scientific Facts on

Biodiversity

& Human Well-being

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MA (2005)

Summary & Details:
GreenFacts

Level 2 - Details on Biodiversity

This Digest is a faithful summary of the leading scientific consensus report
produced in 2005 by the Millennium Ecosystem Assessment (MA):
"Ecosystems and Human Well-being: Biodiversity Synthesis"

The full Digest is available at: https://www.greenfacts.org/en/biodiversity/

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- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

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1. Biodiversity: What is it, where is it, and why is it important?

1.1 What is biodiversity?

Read also our summary of the Global Biodiversity Outlook 2 of the Convention on Biological Diversity [see https://www.greenfacts.org/en/global-biodiversity-outlook/index.htm]

Biodiversity is a contraction of biological diversity. It reflects the number, variety and variability of living organisms and how these change from one location to another and over time. Biodiversity includes diversity within species (genetic diversity), between species (species diversity), and between ecosystems (ecosystem diversity).

Biodiversity is important in all ecosystems, not only in those that are "natural" such as national parks or natural preserves, but also in those that are managed by humans, such as farms and plantations, and even urban parks. Biodiversity is the basis of the multiple benefits provided by ecosystems to humans.

Biodiversity is difficult to quantify precisely even with the tools and data sources that are available. But precise answers are seldom needed to sufficiently understand biodiversity, how it is changing, and the causes and consequences of such change.

Various ecological indicators, such as the number of species in a given area, are used to measure different aspects of biodiversity. They form a critical component of monitoring, assessment, and decision-making and are designed to communicate information quickly and easily to policy-makers. However, no single indicator captures all the dimensions of biodiversity.

Linkages among Biodiversity, Ecosystem Services & Human Well-being [see Annex 1, p. 26]

Measuring Biodiversity: More than Species Richness [see Annex 2, p. 27]

Ecological Indicators & Biodiversity [see Annex 3, p. 28]

Criteria for Effective Ecological Indicators [see Annex 5, p. 30]

1.2 Where is biodiversity?

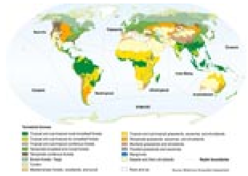
Proportion of named species [see Annex 12, p. 35]

Life, and thus biodiversity, is essentially everywhere on Earth's surface and in every drop of its bodies of water. This is seldom appreciated because most organisms are small or invisible to the naked eye, and many are rare, short-lived or hidden.

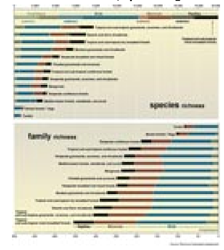
Documenting biodiversity is difficult. The best known dimension of biodiversity is the classification of animals and plants into species, which mainly focuses on animals observable to the naked eye, temperate ecosystems, and aspects that are used by people. Only 1.7-2 million of the 5 to 30 million species that are thought to exist on Earth have been identified so far. More complete inventories are badly needed to correct for this deficiency.

1.2.1 While available data is often insufficient to provide an accurate picture of the extent and distribution of all components of biodiversity, they allow useful approximations. For instance, useful species distribution data is available for some areas, such as the temperate regions of North America, Europe and Asia, for instance for some birds and mammals.

Indicators can be used to build on these inventories. Biomes are ecological communities of organisms associated with particular climatic and geographic conditions, such as deserts, grasslands, and tropical rainforests. Studying them can provide a broad picture of the various different ecological functions within a community and of its biological diversity.



Map of the different biomes [see Annex 14, p. 37]



Species richness in different biomes [see Annex 13, p. 36]

Earth can also be divided into eight biogeographic realms which share a broadly similar biological evolutionary history. Between realms there is a marked difference in species composition.

1.2.2 Based on present knowledge of how biodiversity changes over time, rough estimates can be made of the rates at which species become extinct. The history of life is characterized by considerable change. Fossils allow to estimate the extinction rate of species that were abundant and large enough to have left a fossil trace. Current rates of extinction are discussed in Question 3 [see https://www.greenfacts.org/en/biodiversity/l-3/3-extinction-endangered-species.htm#0p0].

The dynamics of changes in natural systems and of human responses are quite different. This is due to the fact that it takes some time for changes in an ecosystem to become apparent, that feedbacks between socioeconomic and ecological systems are complex, and that it is difficult to predict thresholds at which sudden or rapid changes will occur.

Crossing a threshold may cause rapid substantial changes in biodiversity and in the benefits the ecosystem can provide to humans. This has been observed in open aquatic ecosystems when a temperature threshold was crossed or when resources were overexploited. For example, an increased nutrient input can cause the shift of coral dominated reefs to an algal dominated ecosystem, which is less diverse and productive from a biological point of view. Invasive species can also act as triggers for dramatic changes in ecosystem structure. For example, the introduction of a carnivorous jellyfish-like animal in the Black Sea caused the loss of 26 major fisheries species and has contributed to the subsequent growth of the oxygen-deprived "dead" zone.

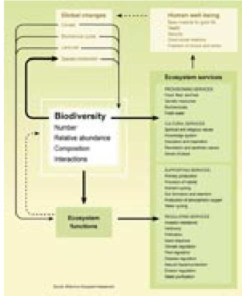
1.3 What is the link between biodiversity and ecosystem services?

Read our summary of the Millenium Ecosystem Assessement [see https://www.greenfacts.org/en/ecosystems/index.htm]

Ecosystem services are the benefits obtained by people from ecosystems. These include:

- **provisioning services** such as food, clean water, timber, fiber, and genetic resources;
- **regulating services** such as the regulation of climate, floods, disease, water quality, and pollination;
- **cultural services** such as recreational, aesthetic, and spiritual benefits;
- **supporting services** such as soil formation, and nutrient cycling.

Biodiversity plays an important role in the way ecosystems function and in the services they provide. Species composition matters as much or more than species richness when it comes to ecosystem services, since the functioning of an ecosystem, and thus its ability to provide services to humans, is strongly influenced by the ecological characteristics of the most abundant species, not by the number of species.



Biodiversity and ecosystem services
[see Annex 15, p. 38]

The local loss of an essential species can disrupt ecosystem services for a long time. Changes in the interactions between species can also lead to negative impacts on ecosystem processes.

Table: Ecological Surprises Caused by Complex Interactions [see Annex 53, p. 75]

On land, biodiversity affects key ecosystem processes such as the production of living matter, nutrient and water cycling, and soil formation and retention. All of these govern and ensure supporting services that are necessary for the production of all other ecosystem services. Differences between regions in terms of ecosystem processes are driven mostly by differences in climate, in resource availability, and in other external factors, and not by differences in species richness. Though losses of biodiversity may have only small impacts on an ecosystem in the short term, they may reduce its capacity to adjust to changing environments in the future.

Biodiversity also affects regulating services that regulate **ecosystem processes**, climate, floods, disease, and water quality:

- The preservation of the number, types, and relative abundance of resident species can enhance resistance of a wide range of natural and semi-natural ecosystems against invasive species.
- There have been worldwide declines in the diversity of pollinating insects that are essential for the reproduction of many plants.
- Biodiversity, in particular the diversity of plant forms and the distribution of landscape patches, influences climate at local, regional, and global scales. Thus changes in land use and land cover that affect biodiversity can in turn affect climate. Some components of biodiversity affect carbon sequestration and thus are important in fighting climate change.
- The ecosystem's ability to control pests is strongly dependent on biodiversity and benefits food security, rural households, and national incomes of many countries.
- The microbes living in the sea contribute to pollution control by removing toxic substances from the environment, but how species diversity influences this removal is not well understood.

2. Why is biodiversity loss a concern?

Biodiversity is essential for the benefits the ecosystems can provide to humans and hence for human well-being. Its role goes beyond ensuring the availability of raw materials to include security, resiliency, social relations, health, and freedoms and choices. While many people have benefited over the last century from the conversion of natural ecosystems to human-dominated ecosystems, other people have suffered from the consequences of biodiversity losses.

2.1 What are the main links between biodiversity and human well-being?

Biodiversity and the many ecosystem services that it provides are a key factor determining human well-being. Biodiversity loss has-direct and indirect negative effects on several factors:

2.1.1 **Food security**: The availability of biodiversity is often a "safety net" that increases food security and the adaptability of some local communities to external economic and ecological disturbances. Farming practices that maintain and make use of agricultural biodiversity can also improve food security.

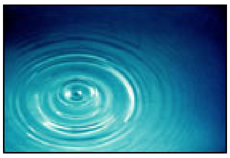
Table: Percentage of households dependent on indigenous plant–based coping mechanisms at Kenyan and Tanzanian site. [see Annex 54, p. 76]

2.1.2 **Vulnerability**: Many communities have experienced more natural disasters over the past several decades. For example, because of the loss of mangroves and coral reefs, which are excellent natural buffers against floods and storms, coastal communities have increasingly suffered from severe floods.

2.1.3 **Health**: A balanced diet depends on the availability of a wide variety of foods, which in turn depends on the conservation of biodiversity. Moreover, greater wildlife diversity may decrease the spread of many wildlife pathogens to humans.

2.1.4 **Energy security**: Wood fuel provides more than half the energy used in developing countries. Shortage of wood fuel occurs in areas with high population density without access to alternative and affordable energy sources. In such areas, people are vulnerable to illness and malnutrition because of the lack of resources to heat homes, cook food, and boil water.

2.1.5 **Clean water:** The continued loss of forests and the destruction of watersheds reduce the quality and availability of water supplied to household use and agriculture. In the case of New York City, protecting the ecosystem to ensure continued provision of clean drinking water was far more cost-effective than building and operating a water filtration plant.



See also our Water resource Digest [see https://www.greenfacts.org/en/water-resources/index.htm]

2.1.6 **Social relations:** Many cultures attach spiritual, aesthetic, recreational, and religious values to ecosystems or their components. The loss or damage to these components can harm social relations, both by reducing the bonding value of shared experience as well as by causing resentment toward groups that profit from their damage.

Social Consequences of Biodiversity Degradation [see Annex 6, p. 30]

2.1.7 **Freedom of choice**: Loss of biodiversity, which is sometimes irreversible, often means a loss of choices. The notion of having choices available irrespective of whether any of them will be actually picked is an essential constituent of the freedom aspect of well-being.

2.1.8 **Basic materials**: Biodiversity provides various goods - such as plants and animals - that individuals need in order to earn an income and secure sustainable livelihoods. In addition to agriculture, biodiversity contributes to a range of other sectors, including "ecotourism", pharmaceuticals, cosmetics, and fisheries. Losses of biodiversity, such as the collapse of the Newfoundland cod fishery can impose substantial costs at local and national level.

2.2 What competing goals can affect biodiversity?

When society has multiple goals, many of which depend on biodiversity, ecosystem services, and the many constituents of well-being, difficult decisions involving trade-offs among competing goals have to be made. When humans modify an ecosystem to improve one of the services it provides this generally results in changes to other ecosystem services. For example, actions to increase food production can lead to reduced water availability for other uses, and degraded water quality.

In the long term, the value of services lost may greatly exceed the short-term economic benefits that are gained from transforming ecosystems.

In Sri Lanka, for example, the clearing of tropical forest for agriculture initially reduced the habitat for malaria-transmitting mosquitoes which live in forests. But later, other mosquito species occupied the changed habitat, contributing to the resurgence of malaria.

Only four of the ecosystem services examined in this assessment have been enhanced by human changes.

Enhanced services include crops, livestock, aquaculture, and, to some extent, carbon sequestration

Degraded services include fisheries, water supply, capacity of ecosystems to treat waste, water purification, natural hazard protection, regulation of air quality, regulation of regional and local climate, regulation of erosion, and many cultural services.

An analysis of trade-offs can help decision-makers make efficient decisions among competing goals.

Table: Trends in the Human Use of Ecosystem Services [see Annex 55, p. 77]

- Provisioning services [see Annex 55, p. 77]
- Regulating services [see Annex 56, p. 79]
- Cultural services [see Annex 57, p. 81]
- Supporting services [see Annex 58, p. 83]

2.3 What is the value of biodiversity for human well-being?

Unlike goods bought and sold on markets, many ecosystem services do not have markets or readily observable prices. This means that the importance of biodiversity and natural processes in producing ecosystem services that people depend on is not reflected in financial markets.

Degradation of ecosystem services could be significantly slowed or reversed if their full economic value were taken into account in decision-making.

A way of assigning monetary values to them is to rely on non-market valuation methods. These methods have been applied to clean drinking water, recreation, or commercially harvested species.

Non-market values can be either the value to society from the active use of the asset or a "non-use" value, which reflects the value of an asset beyond any use, such as the value of existence of species. Measuring the latter poses a great challenge to those trying to measure the complete value of conserving biodiversity and natural processes.

The private use value of biodiversity and ecosystem services by individuals will typically ignore the "external" benefits of conservation to society in general. For example, a farmer may benefit from intensive use of the land but generally does not bear all the consequences caused by leaching of excess nutrients and pesticides into ground or surface water, or the consequences of loss of habitat for native species.

Economic Costs and Benefits of Ecosystem Conversion [see Annex 7, p. 31]

Intensive use of ecosystems often produces the greatest short-term advantage, but excessive and unsustainable use can lead to losses in the long term. A country could cut its forests and deplete its fisheries, and this would show only as a positive gain to GDP, despite the loss of capital assets, because of the income generated by the sale of those products.

Moreover, many ecosystem services, such as groundwater, are available freely to those who use them and so again their degradation is not reflected by standard economic valuation methods.

2.4 How are the impacts of biodiversity loss distributed geographically?

The well-being of many social groups and individuals can increase when biodiversity is used, changed, or lost. However, the changes in ecosystems are harming many of the world's poorest people, who are less able to adjust to these changes and who are affected by even greater poverty, as they have limited access to substitutes or alternatives. For example, poor farmers often cannot afford using modern methods for services previously provided by biodiversity. In addition, substitution of some services, such as the reliance on toxic and persistent pesticides to control certain pests, may have negative environmental and human health effects.

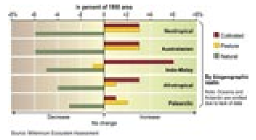
Many communities depend on a range of biological products for their material welfare. Poor people have historically disproportionately lost access to biological products and ecosystem services as demand for those services has grown. The transfer in ownership of ecosystem resources often excludes local communities, and the products of their exploitation are not destined for the local market.

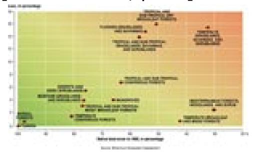
Changes in the structure of societies that affect access to resources can have impacts on ecosystem services. This may also help to explain why some people living in environmental resource-rich areas nevertheless rank low in measures of human well-being. An increase in international trade has improved the well-being of many people, but others, such as those who were dependant on the resources being exploited for export, have been adversely affected. Conflicts can arise when different social groups compete for the same resources, and although many such conflicts have been managed cooperatively, it is also common for one group to benefit at the expense of the other.

Concepts & Measures of Poverty [see Annex 8, p. 32]

Conflicts Between the Mining Sector & Local Communities in Chile [see Annex 9, p. 32]

3. What are the current trends in biodiversity?


Land area in natural condition
[see Annex 18, p. 41]


Native habitat losses
[see Annex 31, p. 53]

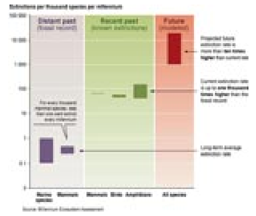
For all aspects of biodiversity, current pace of change and loss is hundreds of times faster than previously in recorded history and the pace shows no indication of slowing down.

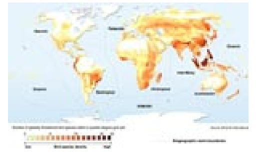
Virtually all of Earth's ecosystems have been dramatically transformed through human actions, for example, 35% of mangrove and 20% of coral reef areas have been lost.

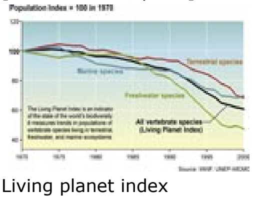
Land areas where the changes have been particularly quick over the past two decades include:

- the Amazon basin and Southeast Asia (deforestation and expansion of croplands);
- Asia (land degradation in drylands); and
- Bangladesh, Indus Valley, parts of Middle East and Central Asia, and the Great Lakes region of Eastern Africa.

Across the world, ecosystems have continued to be converted for agricultural and other uses at a constant pace over at least the last century. Conversion has been slower in areas, such as Mediterranean forests, where most suitable land for agriculture had already been converted by 1950 and where the majority of native habitats had already been lost.


Extinction rates
[see Annex 33, p. 55]


Threatened bird species
[see Annex 36, p. 58]


Living planet index
[see Annex 37, p. 59]

Species extinction is a natural part of Earth's history. However, over the past 100 years humans have increased the extinction rate by at least 100 times compared to the natural rate. The current extinction rate is much greater than the rate at which new species arise, resulting in a net loss of biodiversity.

Within well-studied groups (conifers, cycads, amphibians, birds, and mammals), between 12% and 52% of species are threatened with extinction, according to the IUCN Red List (see Red List Indices for birds [see Annex 35, p. 57]). In general the most threatened species are those that are higher up the food chain, have a low population density, live long, reproduce slowly, and live within a limited geographical area. Within many species groups, such as amphibians, African mammals, and birds in agricultural lands, the majority of species have faced a decline in the size of their population, in their geographical spread, or both. Exceptions are almost always due to human interventions, such as protection in reserves, or to species that tend to thrive in human-dominated landscapes.

The Living Planet Index compiled by the WWF is an indicator of trends in the overall abundance of wild species. Between 1970 and 2000, it indicates declines in all environments.

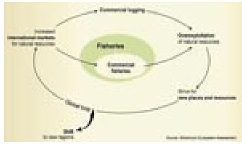
Since 1960, intensification of agricultural systems coupled with specialization by plant breeders and the harmonizing effects of globalization have led to a substantial reduction in the genetic diversity of domesticated plants and animals. Today a third of the 6 500 breeds of domestic species are threatened with extinction.

Comparing different types of measurements of biodiversity loss is not simple. The rate of change in one aspect of biodiversity, such as loss of species richness, does not necessarily reflect the change in another, such as habitat loss.

Furthermore, the fact that the distribution of species on Earth is becoming more homogeneous as a result of human activities represents a loss of biodiversity that is often missed when only considering changes in terms of total numbers of species.

4. What factors lead to biodiversity loss?

4.1 What is a "driver" and how does it affect biodiversity?



Overexploitation and interactions between drivers [see Annex 38, p. 60]

Natural or human-induced factors that directly or indirectly cause a change in biodiversity are referred to as drivers.

- Direct drivers that explicitly influence ecosystem processes. include land use change, climate change, invasive species, overexploitation, and pollution.
- Indirect drivers, such as changes in human population, incomes or lifestyle, operate more diffusely, by altering one or more direct drivers.

Some direct drivers of change are easier to measure than others, for instance, fertilizer usage, water consumption, irrigation, and harvests. For other drivers, indicators are not as well developed and measurement data is less readily available. This is the case for non-native species, climate change, land cover conversion, and landscape fragmentation.

Changes in biodiversity are driven by combinations of drivers that work over time, on different scales, and that tend to amplify each other. For example, population and income growth combined with technological advances can lead to climate change.

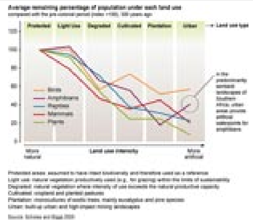
Direct Drivers: Southern African example [see Annex 10, p. 33]

4.2 What are indirect drivers of biodiversity change?

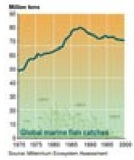
Five major indirect drivers that influence biodiversity are:

- **Change in Economic activity:** Global economic activity is now nearly seven times what it was 50 years ago and it is expected to grow further. The many processes of globalization have been removing regional barriers, weakening national connections, and increasing the interdependence among people and between nations.
- **Population change:** World population has doubled in the past forty years, reaching 6 billion in 2000. The fact that more and more people live in cities increases the demand for food and energy and thereby pressures on ecosystems.
- **Socio-Political factors:** The trend toward democratic institutions over the past 50 years has enabled new forms of management of environmental resources.
- **Cultural and Religious factors:** Culture conditions individuals' perceptions of the world, and their priority setting, for instance in terms of conservation.
- **Science and Technology:** The development and diffusion of scientific knowledge and technologies can on the one hand allow for increased efficiency in resource use and on the other hand provide the means to increase exploitation of natural resources.

4.3 Which direct drivers are critical in different ecosystems?


Effect of land use intensity
[see Annex 19, p. 42]


Extend of cultivated systems
[see Annex 20, p. 43]


Global marine fish catch
[see Annex 21, p. 44]

Different direct drivers are critical in different ecosystems. Historically, habitat and land use change have had the biggest impact on biodiversity in all ecosystems, but climate change and pollution are projected to increasingly affect all aspects of biodiversity. Overexploitation and invasive species have been important as well and continue to be major drivers of changes in biodiversity.

Over the past 50 years, the most important direct drivers of change have been:

In terrestrial ecosystems:

land cover change, mainly by conversion to cropland. Only areas unsuited to crop plants, such as deserts, boreal forests, and tundra, remain relatively intact. Deforestation and forest degradation are currently particularly extensive in the tropics. Nearly a quarter of the Earth's surface is currently covered by cultivated systems.

In marine ecosystems:

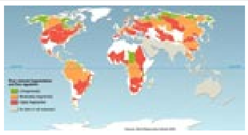
fishing is the major direct human pressure affecting the structure, function, and biodiversity of the oceans. In all oceans, a number of fish stocks targeted in fisheries have collapsed because they have been overfished or fished above their maximum sustainable levels. After a peak in the late 1980s, the global amount fished has been declining.


See also our Fisheries Digest [see https://www.greenfacts.org/en/fisheries/index.htm]

In freshwater ecosystems:

water regime changes, such as those following the construction of large dams; invasive species, which can lead to species extinction; and pollution, such as high levels of nutrients.

4.4 How are specific direct drivers affecting biodiversity?


Fragmentation of river flow
[see Annex 28, p. 51]

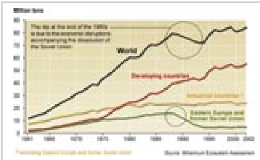
4.4.1 Natural disturbances (such as fires) or changes in land use (such as road construction) lead to the fragmentation of forests. Such habitat changes have a significant impact on biodiversity, as small fragments of habitat can only support small populations that tend to be more vulnerable to extinction.

*Click on any **continent** below to view maps which estimate the amount of:*
Forest fragmentation induced by human activities

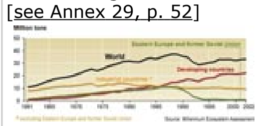
4.4.2 Invasive alien species that establish and spread outside their normal distribution have been a major cause of extinction. This has particularly affected islands and freshwater habitats and continues to be a problem in many areas, as effective preventive measures are lacking. In New Zealand, for example, plants have been introduced at a rate of 11 species per year since European settlement in 1840.

4.4.3 **Overexploitation** remains a serious threat to many species, such as marine fish and invertebrates, trees, and animals hunted for meat. Most industrial fisheries are either fully or overexploited, while destructive fishing techniques harm estuaries and wetlands. The overexploitation of bushmeat is in a similar situation, where sustainable levels of exploitation are poorly understood, and the catches difficult to manage effectively. The trade in wild plants and animals and their derivatives is estimated to reach nearly $160 billion annually. Because this trade crosses national borders, the effort to regulate it requires international cooperation to safeguard certain species from overexploitation.

4.4.4 Over the past four decades, excessive levels of nutrients in soil and water have emerged as one of the most important drivers of ecosystem change in terrestrial, freshwater, and coastal ecosystems. More than half of all the synthetic nitrogen fertilizers ever used on Earth have been used since 1985, and phosphorous uses are now three times what they were in 1960.



Use of nitrogen fertilizers [see Annex 29, p. 52]

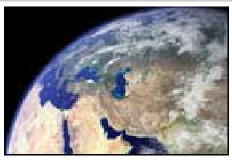


Use of phosphorous fertilizers [see Annex 30, p. 52]

The total amount of nitrogen made available to organisms by human activities now exceeds that from all natural sources combined. Excessive additions of nitrogen and phosphorous to freshwater or coastal marine systems can lead to excessive plant and algae growth (eutrophication) and a lack of oxygen as well as to other environmental problems.

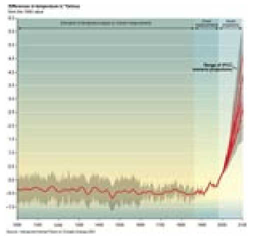
4.5 How is climate change affecting biodiversity?

Recent changes in climate, such as warmer temperatures in certain regions, have already had significant impacts on biodiversity and ecosystems. They have affected species distributions, population sizes, and the timing of reproduction or migration events, as well as the frequency of pest and disease outbreaks. Projected changes in climate by 2050 could lead to the extinction of many species living in certain limited geographical regions. By the end of the century, climate change and its impacts may become the main direct driver of overall biodiversity loss.



See also our Climate Change Digests [see https://www.greenfacts.org/en/digests/climate-change.htm]

While the growing season in Europe has lengthened over the last 30 years, in some regions of Africa the combination of regional climate changes and human pressures have led to decreased cereal crop production since 1970. Changes in fish populations have also been linked to large-scale climate variations such as "El Nio". As climate change will become more severe, the harmful impacts on ecosystem services will outweigh the benefits in most regions of the world. The Intergovernmental Panel on Climate Change (IPCC) project that the average surface temperature will rise by 2 to 6.4C by 2100 compared to pre-industrial levels. This is expected to cause global negative impacts on biodiversity.



Historical and projected temperatures
[see Annex 32, p. 54]

According to the projections:

- Climate change is likely to exacerbate the loss of biodiversity and increase the risk of extinctions.
- Water availability and quality will decrease in many arid and semiarid regions.
- The risk of floods and droughts will increase.
- The reliability of hydropower and biomass production in some regions will decrease.
- Diseases, such as malaria, dengue and cholera, are likely to become more frequent in many regions and so are other health problems linked to heat stress, malnutrition, and natural disasters.
- Agricultural productivity may decrease in the tropics and sub-tropics, and fisheries may be adversely affected as well.
- Changes in climate, in land use, and in the spread of invasive species will limit both the capability of species to migrate and the ability of species to survive in fragmented habitats.

4.6 How quickly are drivers causing change?

Today many drivers of extinction, such as land use change, emerging disease, and invasive species, are all occurring together and at a greater intensity than in the past. Because exposure to one threat often makes a species more susceptible to a second, and so on, multiple threats may have unexpectedly dramatic impacts on biodiversity.

See also GreenFacts' Ecosystem Change Digest
[see https://www.greenfacts.org/en/ecosystems/index.htm]

Drivers affecting biodiversity range from local to global and from immediate to long-term,. Climate change may operate on a spatial scale of a large region, whereas political change may operate at the scale of a nation or a municipal district. Socio-cultural changes typically occur slowly, on a time scale of decades, while economic changes tend to occur more rapidly.

Many impacts of management interventions on ecosystems are slow to become apparent. For example, a population cannot recover more quickly than the time needed to give birth to a new generation, and recovery will often take several generations. Moreover, human institutions are often slow to reach decision and to implement them. In addition, none of the drivers appears to be slowing or well controlled and we have not yet seen all of the consequences of changes that occurred in the past.

The extinction of species due to habitat loss has a significant lag time. For some species this process can be rapid, but for other sit may take 100 to 10 000 years. Time lags between habitat reduction and extinction provide an opportunity for humans to restore habitats and rescue species from extinction. Notwithstanding this, habitat restoration measures will not be likely to save the most sensitive species, which will become extinct soon after habitat loss.

5. How might biodiversity change in the future under various plausible scenarios?

Four plausible scenarios explore the future of biodiversity and human well-being for the next 50 years and beyond. Under all of them, biodiversity loss is projected to continue extremely quickly over the next 50 years. Though the loss cannot be halted over this time period, it can be slowed down through better ecosystem protection, restoration, and management.

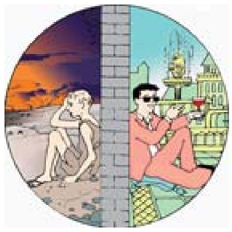
5.1 Which scenarios have been explored in this assessment?

The four plausible scenarios explored in this assessment consider **two possible paths of world development:** increasing globalization or increasing regionalization. The scenarios also consider **two different approaches to environmental issues:** in one approach, actions are reactive and address problems only after they become obvious, in the other approach, ecosystem management is proactive and deliberately aims for long-term maintenance of ecosystem services.

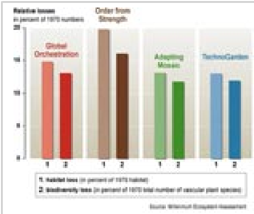
The four scenarios are:

- **Global Orchestration** **[see Annex 48, p. 69]** - This scenario depicts a globally-connected society that focuses on global trade and economic liberalization and takes a reactive approach to ecosystem problems. Under this scenario, poverty is reduced, but a number of ecosystem services are deteriorated. While progress is made on global environmental problems, such as greenhouse gas emissions and the depletion of marine fish stocks, some local and regional problems are exacerbated.
- **Order from Strength** **[see Annex 49, p. 70]** - This scenario represents a regionalized and fragmented world, concerned with security and protection, that and takes a reactive approach to ecosystem problems. The rich protect their borders, attempting to confine poverty, conflict, environmental degradation, and deterioration of ecosystem services to areas outside their borders.
- **Adapting Mosaic** **[see Annex 47, p. 68]** - In this scenario, regional ecosystems are the focus of political and economic activity. Societies develop a local strongly proactive approach to the management of ecosystems. Some regions are successful, others learn from them, but some ecosystems still suffer long-lasting degradation.
- **TechnoGarden** **[see Annex 50, p. 71]** - This scenario depicts a globally-connected world relying strongly on technology to provide or improve the provision of ecosystem services. Under this scenario, environmental problems are dealt with proactively in an effort to avoid problems. People push ecosystems to produce as much as possible, but this often undermines the ability of ecosystems to support themselves, which in turn can have serious consequences for human well-being.

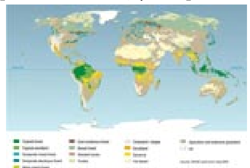
Further information about each scenario is provided in the links below:

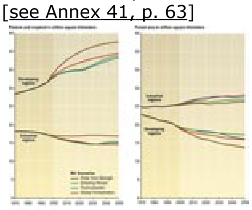
		World Development	
		globalization	regionalization
Ecosystem Management	reactive	 Global Orchestration [see Annex 48, p. 69]	 Order from Strength [see Annex 49, p. 70]
	proactive	 TechnoGarden [see Annex 50, p. 71]	 Adapting Mosaic [see Annex 47, p. 68]

5.2 How much biodiversity might be lost on land by 2050 and beyond?



Habitat loss as a Result of Land Use Change
[see Annex 40, p. 62]


Land cover map for 2000
[see Annex 41, p. 63]


Forest and croplands in scenarios
[see Annex 42, p. 64]

On land, according to all four scenarios, the expansion of agriculture, cities, and infrastructure, will cause habitat loss and lead to a continuing decline in the local and global biodiversity. The habitat loss between 1970 and 2050, will lead to the extinction of approximately 10-15% of the species in the long term (depending on the scenario). Losses of habitat and plant populations will be fastest in warm mixed forests, savannas, scrub, as well as tropical forests and woodlands.

More proactive approaches to the environment (TechnoGarden and Adapting Mosaic) will have more success in slowing terrestrial habitat and biodiversity loss in the near future than reactive approaches. The scenario most concerned with security and protection (Order from Strength) has the highest rate of biodiversity loss.

In general, developing countries will experience an expansion of their agricultural lands and a reduction of their forest cover (a 30% loss between 1970 and 2050). Although the reverse is expected to happen in industrial countries, the result will be a net loss of forest.

Overall, biodiversity loss will be driven by land use change to a greater extent than by climate change and excessive nutrient levels, but the impact of these drivers will be different in different ecological communities (biomes). Other factors such as overharvesting, invasive species, and pollution will also speed up biodiversity loss.

5.3 How much biodiversity might be lost in the aquatic environment by 2050 and beyond?

Vast changes are expected in world freshwater resources including freshwater habitats, fish production, and water supply. Reactive approaches to environmental problems (as in the Order from Strength [see Annex 49, p. 70] and Global Orchestration [see Annex 49, p. 70] scenarios) will lead to a more severe decline than proactive approaches.

Fish populations are projected to be lost from some river basins due to the combined effects of climate change and water withdrawals. Other significant drivers of freshwater biodiversity loss include eutrophication, acidification, and increased invasions by alien species. Freshwater systems that are projected to have the greatest biodiversity loss are rivers of poor tropical and sub-tropical countries.

According to the scenarios, the demand for fish and the risk of a major long-lasting collapse of fisheries will increase because of the human population, incomes, and preferences for fish are increasing.

5.4 How might human well-being be affected by ecosystem degradation?

5.4.1 Biodiversity loss will lead to a deterioration of the benefits that humans obtain from ecosystems. It will increase the likelihood of ecological surprises, such as rapid climate change, desertification, fisheries collapse, floods, landslides, wildfires, eutrophication, and disease. The vulnerability of human well-being to these adverse surprises is different in each scenario but it is greatest in "Order from Strength". Such changes will affect human well-being directly but also indirectly, for instance because of conflicts due to scarcer food and water resources.

Scenarios with a proactive approach that limits deforestation (Adapting Mosaic and TechnoGarden) are more successful in preserving the regulation of ecosystem processes . Deforestation combined with climate change will increasingly lead to flooding during storms, but also to fires during droughts, greatly increasing the risk of even greater climate change. Deforestation will also reduce the capacity of terrestrial ecosystems to absorb carbon (carbon sequestration).

During this century, global temperature may increase by 2.0 to 3.5°C, depending on the scenario (note on differences compared to IPCC projections). Moreover, precipitation may increase over most of the land area on Earth, though some arid regions may become even more arid and sea levels will rise. According to the scenarios, changes in ecosystem services will be particularly rapid, in "hot spot regions" such as sub-Saharan Africa, the Middle East and Northern Africa, and South Asia.


See also our IPCC summaries [see https://www.greenfacts.org/en/digests/climate-change.htm]

While the average GDP per person improves in all scenarios, this can mask increased inequity for instance in terms of food security.

5.4.2 The scenarios indicate that many environmental and development goals are interdependent. Therefore, partnerships and international environmental agreements are important and vary greatly from one scenario to another. Major decisions in the next 50-100 years will have to address trade-offs between agricultural production and water quality, land use and biodiversity, water use and aquatic biodiversity, current water use for irrigation and future agricultural production, and in fact all current and future use of nonrenewable resources.

For a given level of socioeconomic development, policies that conserve more biodiversity will also promote higher overall human well-being by preserving various ecosystem services. In order to anticipate unexpected shifts in ecosystems, policies can diversify the ecosystem services used in a particular region, choose reversible actions, monitor changes in ecosystems, and adjust as new knowledge about upcoming changes becomes available.

6. What actions can be taken to conserve biodiversity?

6.1 How do protected areas benefit biodiversity and humans?

Protected areas are an essential part of conservation programs, particularly for sensitive habitats. However, these areas alone are not sufficient to ensure the conservation of the full range of biodiversity.

For protected areas to be successful, sites need to be carefully chosen while making sure that different types of ecosystems are well represented. In many cases, geographic areas may be labeled as a protected area without sufficient management planning, monitoring and evaluation, and budgets for security and law enforcement. Marine and freshwater ecosystems are even less well protected than terrestrial ecosystems, leading to increasing efforts to expand marine protected areas. Yet, the enforcement of marine protected areas is difficult, as a large part of the world's oceans lies outside national jurisdictions.

Protected areas may increase poverty when they lead to local rural communities being excluded from resources upon which they have traditionally relied. However, protected areas can contribute to improved livelihoods when they are managed to benefit local people, hence the importance of participatory consultation and planning.

The impacts of climate change on protected areas will increase the risk of extinction of certain species and change the nature of ecosystems. Effective precautionary strategies that will help biodiversity adapt to changing conditions include corridors and other measures aimed at giving protected areas greater flexibility.

6.2 Can economic incentives benefit biodiversity and local communities?

Economic incentives that encourage the conservation and sustainable use of biodiversity show considerable promise. However, trade-offs between biodiversity, economic gains, and social needs have to be more realistically acknowledged.

- **Tradable development rights**, for instance, are marketable rights awarded to landowners in areas reserved for conservation. These rights can then be sold to the owners of land in development areas who need to hold a certain number of these marketable rights before being granted permission to develop. Alternatively they can be sold to organizations with conservation interests. Though these rights offer the potential to achieve a conservation objective at a low cost, they have been criticized for being complex and unable to protect specific sensitive habitats.
- Transferring **rights to own and manage ecosystem services** to private individuals gives them a stake in conserving those services. For example, in South Africa, this transfer encouraged conversion of land from cattle and sheep farming to profitable game farming, enabling conservation of indigenous wildlife.
- **Direct payments** to local landowners for instance to maintain forests on their land can contribute to biodiversity conservation, even if this instrument requires continuous financial commitments and sometimes leads to conflicts.

- **Indirect incentives** are often less effective than direct payments. For example, integrated conservation-development projects designed to allow local populations to benefit from the international willingness to pay for biodiversity conservation have only had limited success.
- **Removing or redirecting subsidies** that cause more harm than good can help mitigate biodiversity loss. For instance, agricultural subsidies in industrial countries reduce world prices for many commodities, encouraging developing countries to adopt unsustainable agricultural practices.

6.3 How can invasive species be addressed?

Tackling invasive species will become an increasingly important biodiversity conservation action. Prevention and early intervention have been shown to be most successful and cost-effective.

The control or eradication of an invasive species once it has become established, is often extremely difficult and costly. Chemical control, sometimes combined with mechanical removal like cutting or pruning, has not proven particularly successful in eradication. Biological control of invasive species through the introduction of other species has also been attempted, but can lead to unexpected results such as the extinction of other local species. The social and economic aspects of the control of invasive species have received less attention.

6.4 How do protected areas benefit biodiversity and humans?

6.4.1 To be effectively conserved and sustainably used, biodiversity must become a part of the management of production sectors, such as agriculture, fisheries, and forestry.


Farmer in a field of maize in Bolivia
Source: FAO

Agriculture is directly dependent on biodiversity. Yet, in recent decades, it has focused on maximizing yields using few relatively productive species and ignoring the potential importance of biodiversity. Some agricultural practices can contribute effectively to biodiversity conservation. Sustainable intensification, for instance, limits the land area needed for agricultural production, leaving a larger area available for biodiversity conservation. Other practices such as integrated pest management, some forms of organic farming, and protection of field margins habitats can promote synergies between agriculture and both domestic and wild biodiversity. Further research is needed on these interactions.

Sustainable **forestry** which addresses the livelihood needs of local inhabitants can be the most effective approach to control tropical deforestation at a local level. Forest management should center policies on existing land and water ownership at the community level and make use of relevant legal tools such as redesigning ownership to small-scale private control of forests, public-private partnerships, direct management of forests by indigenous people, and company-community partnerships. If they are to be effective, such measures need to be accompanied by enforcement while addressing education, training, health, and safety.

6.4.2 The **private sector** can make significant contributions to biodiversity conservation. Under the influence of shareholders, customers and public bodies, many companies are now showing greater corporate social and environmental responsibility, preparing their own biodiversity action plans. Further developments are likely to focus not only on the impact of companies on biodiversity, but also on ecosystem services and how companies rely on them, as well as on greater collaboration between companies and NGOs.

6.5 What governance approaches can promote biodiversity conservation?

To promote biodiversity conservation, **strong institutions are needed at all levels**. The principle that biodiversity should be managed at the lowest appropriate level has led to decentralization in many parts of the world. However, all levels of government need to be involved, with laws and policies developed by central governments in order to support the authority at the lower levels of government enabling them to provide incentives for sustainable resource management. Neither complete centralization nor complete decentralization of authority always results in better management.

In some countries **local norms and traditions** regarding property rights and ecosystems are much stronger than the law on paper. In that case, local knowledge, integrated with other scientific knowledge, becomes critical in managing local ecosystems.

It is well documented that many of the structural adjustment programs of the mid- to late 1980s aiming for economic stability, sectoral growth and poverty reduction caused deterioration in ecosystem services and a deepening of poverty in many developing countries. More efforts are needed in integrating biodiversity conservation and sustainable use activities within such large **decision-making frameworks.**

International cooperation requires increased commitments to conserve biodiversity and promote sustainable use of biological resources. Indeed, to be most effective, multilateral environmental agreements should include incentives, plus sanctions in case of violations or noncompliance. Moreover synergies should be sought between different agreements. Paradoxically, international agreements that deal with economic and political issues and not directly with environmental issues often have the greatest impact on biodiversity. Such agreements need to be closely linked with other agreements in order to take into account trade-offs and impacts on biodiversity.

Although biodiversity loss is a recognized global problem, most direct actions to halt or reduce loss need to be taken locally or nationally.

6.6 What are the key factors of success of conservation actions?

Numerous actions can improve the benefits humans obtain from ecosystems, without undermining biodiversity.

A series of key factors of successful actions against biodiversity loss have been identified, such as legal frameworks, financial resources, public participation, and good links with scientific bodies.

Key Factors of Successful Responses to Biodiversity Loss [see Annex 11, p. 34]

Education and communication programs help making scientific findings and data available to all of society. As a result, more informed people tend to value biodiversity conservation more, which facilitates the implementation of conservation actions.

Ecosystem restoration activities are now common in many countries to restore wetlands, forests, grasslands, estuaries, coral reefs, and mangroves. These activities will become increasingly important as more ecosystems become degraded while demands for their services continue to grow. Restoration is generally far more expensive than protecting the original ecosystem and full recovery is often not possible.

Projects that integrate conservation and development were often assumed to lead to **"win-win"** situations, but in practice they more often lead to conflicts. Indeed, trade-offs between conservation and development need to be acknowledged and decision-makers must explicitly consider the consequences of all options, determine the levels of acceptable biodiversity loss and promote stakeholder participation.

The Convention for Biological Diversity (CBD) and others have developed "ecosystem approaches" that provide a way of integrating different actions that affect ecosystems. These actions may take place over different time scales and over different geographic scales within a region. Integrating them into a coherent regional framework can highlight possible synergies and necessary trade-offs between actions.

In a particular location, when choosing between conservation and other activities, one should consider the positive gains provided by ecosystem services, and also take into account the full economic, social, and environmental cost of the proposed activities.

6.7 How could important drivers of biodiversity loss be addressed?

For biodiversity and ecosystem services to be protected more effectively, direct and indirect drivers of change must be addressed.

Possible actions include:

- **Removing or redirecting harmful subsidies**, such as agricultural and fisheries subsidies in developed countries that promote excessive use of specific ecosystem services and that reduce the competitiveness of developing countries.
- **Promoting sustainable intensification of agriculture**. Pressure on biodiversity could be lessened through technologies that increase the food yield per square km, without harmful trade-offs. In turn, biodiversity can contribute to agricultural productivity by contributing to pest control, pollination, soil fertility, and so on.
- **Slowing and adapting to climate change**. Actions to facilitate the adaptation of ecosystems to climate change, such as the development of ecological corridors or networks, will be necessary to mitigate negative impacts on biodiversity.
- **Limiting** the increase of the amount of nutrients present in soil and water linked to the use of fertilizers.
- Taking into account the **full economic value of ecosystem services** and the cost of their degradation in decision-making could help slow or reverse ecosystem degradation.
- Increasing the **transparency of decision-making processes** affecting ecosystems and the accountability of public and private decision-makers. Stakeholder participation helps reach decisions that are more effective and perceived as just. It can contribute to a better understanding of impacts by the public, increased accountability of decision-makers, and reduced corruption.
- **Integrating** biodiversity conservation **strategies and actions** within broader development planning frameworks, such as national development strategies or poverty reduction strategies.
- **Increasing coordination** between different international agreements that affect biodiversity directly or indirectly.
- Enhancing our **capacity to assess the consequences** of ecosystem change for human well-being and to take action.
- Addressing unsustainable **consumption patterns** that affect biodiversity.

7. Can the 2010 biodiversity targets be met?

In 2002, the Conference of the Parties of the Convention on Biological Biodiversity adopted the target to achieve a "significant reduction of the current rate of biodiversity loss at the global, regional, and national level as a contribution to poverty alleviation and to the benefit of all life on earth" by 2010. It also established eleven more specific goals and a series of sub-targets focusing on certain aspects of biodiversity.

Source: www.biodiv.org

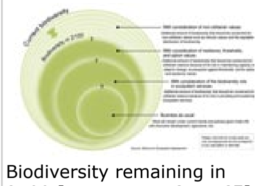
Meeting the targets would require unprecedented efforts. Given appropriate actions at global, regional, and especially national level, it is possible to achieve, by 2010, a reduction in the rate of biodiversity loss for certain aspects of biodiversity and in certain regions. Several sub-targets set under the Convention on Biological Biodiversity could thus be met.

Table: Prospects for Attaining the 2010 Sub-targets Agreed to under the Convention on Biological Diversity [see Annex 59, p. 85]

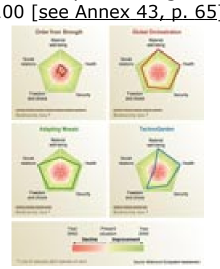
However, at global level, it is unlikely that the target of slowing down biodiversity loss will be met by 2010, since:

- current trends show few indications that the pace of biodiversity loss is slowing down;
- most of the direct drivers of biodiversity loss, such as land use change, climate change, pollution, and invasive alien species, are expected to increase;
- it can take years, decades, or even centuries for human institutions to take actions and for impacts on biodiversity and ecosystems to become apparent (time lags).

Since changes take place over different time frames, longer-term goals and targets-say, for 2050-are needed in addition to short-term targets to guide policy and actions.



Biodiversity remaining in 2100 [see Annex 43, p. 65]



Trade-offs between human well-being and biodiversity loss in MA scenarios [see Annex 44, p. 66]

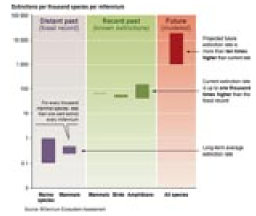
There is substantial scope for greater protection of biodiversity through actions justified on their economic merits for material or other benefits to human well-being. However, the total amount of biodiversity that would be conserved based strictly on utilitarian considerations is likely to be less than the amount present today. For example, a forested watershed could provide clean water and timber whether it was covered by a diverse native forest or a single-species plantation, but a single-species plantation may not provide significant levels of many other services, such as pollination, food, and cultural services. Ultimately, the level of biodiversity that survives on Earth will be determined not just by considerations of usefulness but also by ethical concerns such as the intrinsic value of species.

Biodiversity conservation policies will have to compete with other policies aiming to reduce poverty and hunger in the world. Indeed, efforts to achieve the Millennium Development Goals (MDG) set for 2015 will affect biodiversity and actions taken to reach the 2010 targets for biodiversity conservation will have consequences for the well-being of the world's poor. Trade-offs are sometimes inevitable though synergies are also possible. Therefore, efforts for the conservation and sustainable use of biodiversity need to be integrated into countries' strategies for poverty reduction.

8. Conclusion: main findings

8.1 What is the problem?

Finding 1. Human actions are fundamentally, and to a significant extent irreversibly, changing the diversity of life on Earth, and most of these changes represent a loss of biodiversity. Changes in important components of biological diversity were more rapid in the past 50 years than at any time in human history. Projections and scenarios indicate that these rates will continue, or accelerate, in the future.



Extiction rates
[see Annex 34, p. 56]

Species extinction is a natural part of Earth's history. However, over the past 100 years, humans have increased the extinction rate by at least 100 times compared to the natural rate, leading to a net loss of biodiversity. Some 12% of bird species, 23% of mammals, 25% of conifers, and 32% of amphibians are currently threatened with extinction, and similarly alarming threats of extinction may apply to aquatic organisms.

Many animal and plant populations have declined in numbers, geographical spread, or both. Genetic diversity has also declined globally, particularly among domesticated plants and animals in agricultural systems.

The distribution of species on Earth is becoming more homogeneous. This is caused by the extinction of species or loss of populations that had been unique to particular regions, and by the invasion or introduction of species into new areas.

Virtually all of Earth's ecosystems have now been dramatically transformed through human actions. Due to the expansion of agriculture, cities and infrastructure, the conversion of ecosystems is expected to continue between now and 2050.

8.2 Why is biodiversity loss a concern?

Finding 2. Biodiversity contributes both directly and indirectly to many constituents of human well-being, including security, basic material for a good life, health, good social relations, and freedom of choice and action.

Over the last century, many people have benefited from the transformation of natural ecosystems and the exploitation of biodiversity, but the losses in biodiversity and changes in ecosystem services have adversely affected the well-being of some people and exacerbated poverty in some social groups.

Many of the actions that have caused the homogenization or loss of biodiversity have provided substantial benefits to humans. Agriculture, fisheries, and forestry, for example, have yielded revenues that have enabled investments in industrialization and economic growth. However, the benefits have not been fairly distributed among people and many of the costs of changes in biodiversity have not been taken into account by decision-makers.

When humans modify an ecosystem to improve one of the services it provides, it generally results in changes to other ecosystem services. For example, actions to increase food production can lead to reduced water availability for other uses, and degraded water quality. Although a few ecosystem services have been enhanced by humans, many other ecosystem services have been degraded.

Many costs associated with changes in biodiversity may be slow to become apparent, or may appear only at some distance from where biodiversity was changed. Some changes in ecosystems are gradual until a particular pressure on the ecosystem reaches a threshold, at which point rapid shifts to a new state occur. For instance, a steady increase in fishing pressure can cause the sudden collapse of fisheries.

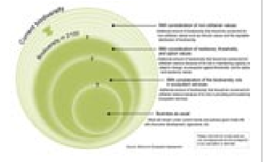
Biodiversity loss is important in its own right because biodiversity has spiritual, aesthetic, recreational, and other cultural values, because many people ascribe intrinsic value to biodiversity, and because it represents unexplored options for the future.

8.3 What is the value of biodiversity?

Finding 3. Although many individuals benefit from the actions and activities that lead to biodiversity loss and ecosystem change, the full costs borne by society is often higher. This is revealed by improved valuation techniques and information on ecosystem services.

Even in cases where our knowledge of benefits and costs is incomplete, a precautionary approach may be justified when the costs associated with ecosystem changes may be high or the changes irreversible.

Even in cases where the costs borne by society exceeded the benefits, ecosystem conversion has often been promoted because the cost associated with the loss of ecosystem services was not taken into account, because the private gains were significant (although less than the public losses), and also because subsidies sometimes distorted the market.



Biodiversity in 2100
[see Annex 16, p. 39]

The benefits that could be gained from better ecosystem management are poorly reflected in conventional economic indicators. A country could cut its forests and deplete its fisheries and this would show only as a positive gain in GDP despite the loss of the capital asset.

The costs resulting from ecosystem "surprises", such as extreme events like floods and fire, can be very high.

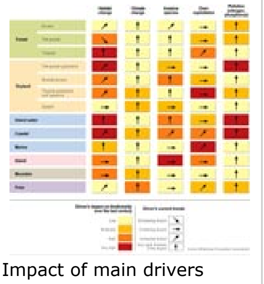
The costs and risks associated with biodiversity loss are expected to increase, and to affect disproportionately the poor who depend more heavily on local ecosystem service.

New tools exist to better quantify the different values people place on biodiversity and ecosystem services. However, the value of some ecosystem services is difficult to quantify, and often not taken into account in decision making.

8.4 What are the causes of biodiversity loss, and how are they changing?

Finding 4. Direct and indirect drivers will continue to cause biodiversity loss and changes in ecosystem services, either steadily or even increasingly.

The main indirect drivers are changes in human population, economic activity, and technology, as well as socio-political and cultural factors.



Impact of main drivers
[see Annex 17, p. 40]

The main factors directly driving biodiversity loss are: habitat change, such as fragmentation of forests; invasive alien species that establish and spread outside their normal distribution; overexploitation of natural resources; excessive fertilizer use leading to excessive levels of nutrients in soil and water and other forms of pollution; and climate change

8.5 What actions can be taken?

Finding 5. Many of the actions that have been taken to conserve biodiversity and promote its sustainable use have been successful in limiting biodiversity loss. Rates of loss are now lower than they would have been in the absence of such actions. Less biodiversity would exist today had not communities, NGOs, governments, and, to a growing extent, business and industry taken actions to conserve biodiversity, mitigate its loss, and support its sustainable use. To achieve greater progress toward biodiversity conservation, it will be necessary (but not sufficient) to strengthen a series of actions that focus primarily on conservation and sustainable use of biodiversity and ecosystem services.

Actions that focus primarily on **conservation** include: protected areas; species protection and recovery measures for threatened species; conservation of genetic diversity; both on and off sites (such as in gene banks); and ecosystem restoration.

Actions that focus primarily on sustainable use include: providing economic incentives; incorporating biodiversity considerations into management practices (for instance in agriculture, forestry, and fisheries); ensuring that local communities benefit from biodiversity.

Actions that address both conservation and sustainable use include: increasing coordination between international agreements that affect biodiversity and resource use; increasing public awareness, communication, and education; improving our capacity to assess the consequences of ecosystem change for human well-being; and increasing the integration between different policy areas.

However, many of all the above actions will not be sufficient unless other indirect and direct drivers of change are addressed and certain enabling conditions are met.

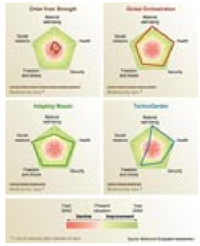
8.6 What are the prospects for reducing the rate of biodiversity loss by 2010?

Finding 6. Unprecedented additional efforts would be needed to achieve, by 2010, a significant reduction in the rate of biodiversity loss at all levels.

Indeed, the challenge is great, as it can take many years for human institutions to act and for positive and negative impacts of human actions on biodiversity and ecosystem to become apparent.

Given appropriate actions, it is possible to achieve, by 2010, a reduction in the rate of biodiversity loss for certain aspects of biodiversity and in certain regions. The rate of habitat loss, for instance, is now slowing in some regions, though this may not necessarily translate into lower overall rates of species loss.

Decision-making at all levels could be improved through a better understanding of the impacts of drivers on biodiversity, ecosystem functioning, and ecosystem services. Since changes take place over different time frames, longer-term goals and targets - say, for 2050 - are needed in addition to short-term targets to guide policy and actions.



Trade-offs between human well-being and biodiversity loss [see Annex 39, p. 61]

While biodiversity makes important contributions to human well-being, many of the actions needed to promote economic development and reduce hunger and poverty are likely to reduce biodiversity. Thus, the 2015 targets of the Millennium Development Goals of poverty alleviation and the 2010 target of reducing the rate of biodiversity loss need to be addressed jointly.

People and decision-makers today still have the power to choose among a very wide array of possible approaches, and these choices will have different implications for biodiversity and human well-being of current and future generations.

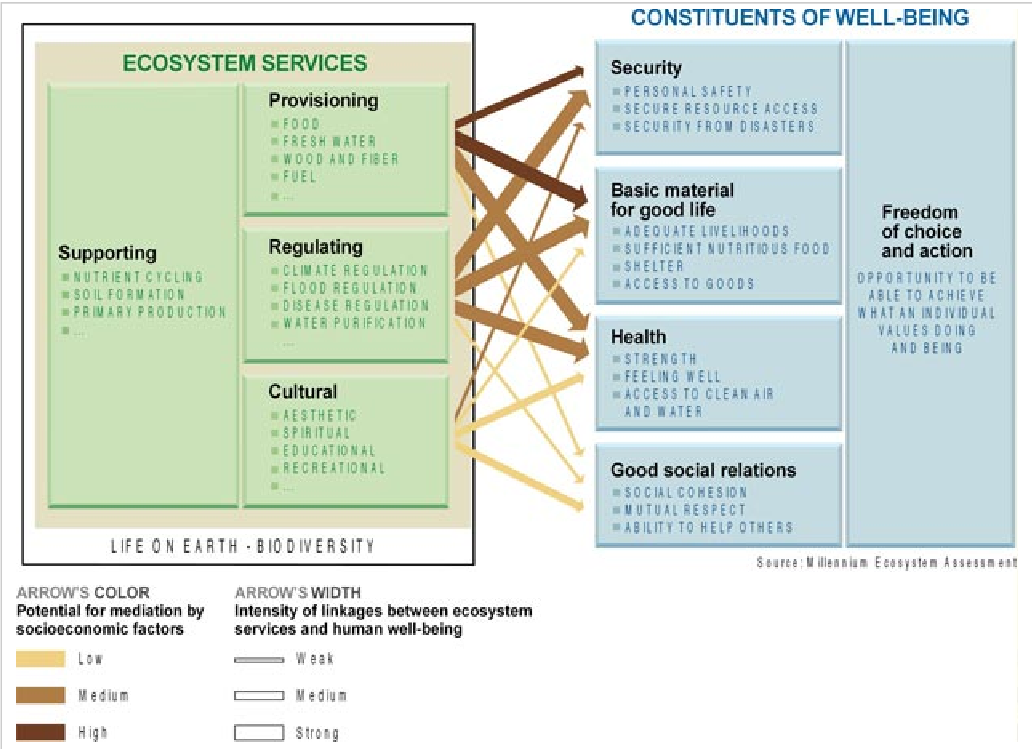
Depending on the path that will be taken, the world in 2100 could still have a substantial biodiversity or be relatively homogenized with relatively low levels of diversity.

Annex

Annex 1:

Box 1.1. Linkages among Biodiversity, Ecosystem Services, and Human Well-being

Biodiversity represents the foundation of ecosystems that, through the services they provide, affect human well-being. These include provisioning services such as food, water, timber, and fiber; regulating services such as the regulation of climate, floods, disease, wastes, and water quality; cultural services such as recreation, aesthetic enjoyment, and spiritual fulfillment; and supporting services such as soil formation, photosynthesis, and nutrient cycling (CF2). The MA considers human well-being to consist of five main components: the basic material needs for a good life, health, good social relations, security, and freedom of choice and action. Human well-being is the result of many factors, many directly or indirectly linked to biodiversity and ecosystem services while others are independent of these.



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005),
Chapter 4, p.64

Annex 2:

Box 1.2. Measuring and Estimating Biodiversity: More than Species Richness

Measurements of biodiversity seldom capture all its dimensions, and the most common measure—species richness—is no exception. While this can serve as a valuable surrogate measure for other dimensions that are difficult to quantify, there are several limitations associated with an emphasis on species. First, what constitutes a species is not often well defined. Second, although native species richness and ecosystem functioning correlate well, there is considerable variability surrounding this relationship. Third, species may be taxonomically similar (in the same genus) but ecologically quite distinct. Fourth, species vary extraordinarily in abundance; for most biological communities, only a few are dominant, while many are rare.

Simply counting the number of species in an ecosystem does not take into consideration how variable each species might be or its contribution to ecosystem properties. For every species, several properties other than its taxonomy are more valuable for assessment and monitoring. These properties include measures of genetic and ecological variability, distribution and its role in ecosystem processes, dynamics, trophic position, and functional traits.

In practice, however, variability, dynamics, trophic position, and functional attributes of many species are poorly known. Thus it is both necessary and useful to use surrogate, proxy, or indicator measures based on the taxonomy or genetic information. Important attributes missed by species or taxon-based measures of diversity include:

- abundance—how much there is of any one type. For many provisioning services (such as food, fresh water, fiber), abundance matters more than the presence of a range of genetic varieties, species, or ecosystem types.
- variation—the number of different types over space and time. For understanding population persistence, the number of different varieties or races in a species or variation in genetic composition among individuals in a population provide more insight than species richness.
- distribution—where quantity or variation in biodiversity occurs. For many purposes, distribution and quantity are closely related and are therefore generally treated together under the heading of quantity. However, quantity may not always be sufficient for services: the location, and in particular its availability to the people that need it, will frequently be more critical than the absolute volume or biomass of a component of biodiversity.Finally, the importance of variability and quantity varies, depending on the level of biodiversity measured. (See Table.)

Level	Importance of Variability	Importance of Quantity and Distribution
Genes	adaptive variability for production and resilience to environmental change, pathogens, and so on	local resistance and resilience
Populations	different populations retain local adaptation	local provisioning and regulating services, food, fresh water
Species	the ultimate reservoir of adaptive variability, representing option values	community and ecosystem interactions are enabled through the co-occurrence of species
Ecosystems	different ecosystems deliver a diversity of roles	the quantity and quality of service delivery depend on distribution and location

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.20

Annex 3:
Box 1.3. Ecological Indicators and Biodiversity

The National Research Council in the United States identified three categories of ecological indicators, none of which adequately assesses the many dimensions of biodiversity:

- Ecosystem extent and status (such as land cover and land use) indicates the coverage of ecosystems and their ecological attributes.
- Ecological capital, further divided into biotic raw material (such as total species richness) and abiotic raw materials (such as soil nutrients), indicates the amount of resources available for providing services.
- Ecological functioning (such as lake trophic status) measures the performance of ecosystems.

Care must therefore be taken not to apply ecological indicators to uses they were not intended for, especially when assessing biodiversity. For example, biotic raw ecological capital measures the amount and variability of species within a defined area (C2 [see Annex 4, p. 29] .2.4). This may seem related to biodiversity, but it measures only taxonomic diversity. As such, this indicator does not necessarily capture many important aspects of biodiversity that are significant for the delivery of ecosystem services.

The most common ecological indicator, total species richness, is a case in point. TSR only partially captures ecosystem services. It does not differentiate among species in terms of sensitivity or resilience to change, nor does it distinguish between species that fulfill significant roles in the ecosystem (such as pollinators and decomposers) and those that play lesser roles. That is, all species are weighted equally, which can lead assigning equal values to areas that have quite different biota. Moreover, the value of TSR depends on the definition of the area over which it was measured and may scale neither to smaller nor to larger areas. Finally, TSR does not differentiate between native and non-native species, and the latter often include exotic, introduced, or invasive species that frequently disrupt key ecosystem services. Ecosystem degradation by human activities may temporarily increase species richness in the limited area of the impact due to an increase in exotic or weedy species, but this is not a relevant increase in biodiversity (C2 [see Annex 4, p. 29] .2.4).

Given the limitations of ecological indicators to serve as adequate indicators of biodiversity, work is urgently needed to develop a broader set of biodiversity indicators that are aligned against valued aspects of biodiversity. With the exception of diversity indices based on taxonomic or population measures, little attention has been paid to the development of indicators that capture all the dimensions of biodiversity (C4 [see Annex 4, p. 29] .5.1), although see Key Question 6 and C4 [see Annex 4, p. 29] .5.2 for more on indicators for the “2010 biodiversity target.”

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.21

Annex 4:

Direct cross-links to the Global Assessment Reports of the Millennium Assessment

Note that text references to CF, CWG, SWG, RWG, or SGWG refer to the entire Working Group report. ES refers to the Main Messages in a chapter.

CF: Ecosystems and Human Well-being: A Framework for Assessment [see http://www.millenniumassessment.org/en/Framework.aspx]	
CF.1 Introduction and Conceptual Framework CF.2 Ecosystems and Their Services CF.3 Ecosystems and Human Well-being CF.4 Drivers of Change in Ecosystems and Their Services CF.5 Dealing with Scale CF.6 Concepts of Ecosystem Value and Valuation Approaches CF.7 Analytical Approaches CF.8 Strategic Interventions, Response Options, and Decision-making	This book offers an overview of the project, describing the conceptual framework that is being used, defining its scope, and providing a baseline of understanding that all participants need to move forward.
C (or CWG): Current State and Trends: Findings of the Condition and Trends Working Group [see http://www.millenniumassessment.org/en/Condition.aspx]	
SDM Summary C.1 MA Conceptual Framework C.2 Analytical Approaches for Assessing Ecosystem Conditions and Human Well-being C.3 Drivers of Change C.4 Biodiversity C.5 Ecosystem Conditions and Human Well-being C.6 Vulnerable Peoples and Places C.7 Fresh Water C.8 Food C.9 Timber, Fuel, and Fiber C.10 New Products and Industries from Biodiversity C.11 Biological Regulation of Ecosystem Services C.12 Nutrient Cycling C.13 Climate and Air Quality C.14 Human Health: Ecosystem Regulation of Infectious Diseases C.15 Waste Processing and Detoxi.cation C.16 Regulation of Natural Hazards: Floods and Fires C.17 Cultural and Amenity Services C.18 Marine Fisheries Systems C.19 Coastal Systems C.20 Inland Water Systems C.21 Forest and Woodland Systems C.22 Dryland Systems C.23 Island Systems C.24 Mountain Systems C.25 Polar Systems C.26 Cultivated Systems C.27 Urban Systems C.28 Synthesis	Richly illustrated with maps and graphs, Current State and Trends presents an assessment of Earth's ability to provide twenty-four distinct services essential to human well-being. These include food, fiber, and other materials; the regulation of the climate and fresh water systems, underlying support systems such as nutrient cycling, and the fulfillment of cultural, spiritual, and aesthetic values. The volume pays particular attention to the current health of key ecosystems, including inland waters, forests, oceans, croplands, and dryland systems, among others. It will be an indispensable reference for scientists, environmentalists, agency professionals, and students.
S (or SWG): Scenarios: Findings of the Scenarios Working Group [see http://www.millenniumassessment.org/en/Scenarios.aspx]	
SDM Summary S.1 MA Conceptual Framework S.2 Global Scenarios in Historical Perspective S.3 Ecology in Global Scenarios S.4 State of Art in Simulating Future Changes in Ecosystem Services S.5 Scenarios for Ecosystem Services: Rationale and Overview S.6 Methodology for Developing the MA Scenarios S.7 Drivers of Change in Ecosystem Condition and Services S.8 Four Scenarios S.9 Changes in Ecosystem Services & Their Drivers across the Scenarios S.10 Biodiversity across Scenarios S.11 Human Well-being across Scenarios S.12 Interactions among Ecosystem Services S.13 Lessons Learned for Scenario Analysis S.14 Policy Synthesis for Key Stakeholders	This second volume of the Millennium Ecosystem Assessment series explores the implications of four different approaches for managing ecosystem services in the face of growing human demand for them. The Scenarios volume will help decision-makers and managers identify development paths that better maintain the resilience of ecosystems, and can reduce the risk of damage to human well-being and the environment.
R (or RWG): Policy Responses: Findings of the Responses Working Group SDM Summary [see http://www.millenniumassessment.org/en/Responses.aspx]	
R.1 MA Conceptual Framework R.2 Typology of Responses R.3 Assessing Responses R.4 Recognizing Uncertainties in Evaluating Responses R.5 Biodiversity R.6 Food and Ecosystems R.7 Freshwater Ecosystem Services R.8 Wood, Fuelwood, and Non-wood Forest Products R.9 Nutrient Management R.10 Waste Management, Processing, and Detoxi.cation R.11 Flood and Storm Control R.12 Ecosystems and Vector-borne Disease Control R.13 Climate Change R.14 Cultural Services R.15 Integrated Responses R.16 Consequences and Options for Human Health R.17 Consequences of Responses on Human Well-being and Poverty Reduction R.18 Choosing Responses R.19 Implications for Achieving the Millennium Development Goals	With the knowledge of possible outcomes, what kind of actions should we take? The Millennium Ecosystem Assessment scored more than 70 response options for ecosystem services, biodiversity, and drivers such as climate change and nutrient loading. This third volume in the Millennium Ecosystem Assessment series presents policy options, analyzing the track record of past policies and the potential of new ones.

SG (or SGWG): Multiscale Assessments: Findings of the Sub-global Assessments Working Group [see http://www.millenniumassessment.org/en/Multiscale.aspx]	
SDM Summary SG.1 MA Conceptual Framework SG.2 Overview of the MA Sub-global Assessments SG.3 Linking Ecosystem Services and Human Well-being SG.4 The Multiscale Approach SG.5 Using Multiple Knowledge Systems: Benefits and Challenges SG.6 Assessment Process SG.7 Drivers of Ecosystem Change SG.8 Condition and Trends of Ecosystem Services and Biodiversity SG.9 Responses to Ecosystem Change and their Impacts on Human Well-being SG.10 Sub-global Scenarios SG.11 Communities, Ecosystems, and Livelihoods SG.12 Reflections and Lessons Learned	Representing the baseline and framework for ongoing assessments of ecosystems and human well-being on a variety of scales around the world, Multiscale Assessments provides students, researchers, and policy-makers with the most comprehensive methodology for assessing ecosystems at local, national, and regional scales.

Source: MA Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.85

Annex 5:
Box 1.4. Criteria for Effective Ecological Indicators

An effective ecological indicator should:

- Provide information about changes in important processes
- Be sensitive enough to detect important changes but not so sensitive that signals are masked by natural variability
- Be able to detect changes at the appropriate temporal and spatial scale without being overwhelmed by variability
- Be based on well-understood and generally accepted conceptual models of the system to which it is applied
- Be based on reliable data that are available to assess trends and are collected in a relatively straightforward process
- Be based on data for which monitoring systems are in place
- Be easily understood by policy-makers

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.21

Annex 6:
Box 2.1. Social Consequences of Biodiversity Degradation (SG-SAfMA)

The basic needs of the AmaXhosa people in South Africa are met by ecosystem services, including fuelwood, medicinal plants, building materials, cultural species, food supplements, and species of economic value. When asked by researchers about their relationship with the natural environment, a local responded “I am entirely dependent on the environment. Everything that I need comes from this environment” and “[the environment] will be important forever because if you have something from the environment it does encourage you to love the environment.”

Respondents often described positive emotional and physical symptoms when the environment is healthy: “When the environment is healthy, my body and spirit is also happy.” And when describing people’s feelings toward a healthy environment, a respondent stated that “people love such an environment. They really adore it. Such an environment makes them feel free.” In addition, respondents described the feelings of peace when walking in the bush and how they would go into the natural environment to pray.

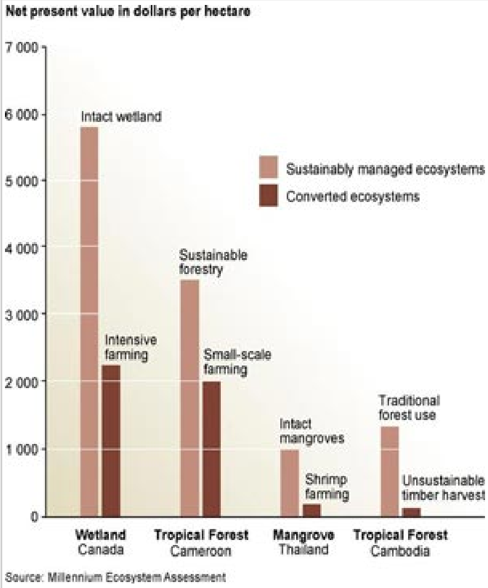
The beliefs and traditions of the AmaXhosa play an important role in guiding resource use and management and encouraging values to be place-centered. The ancestors are central to this cosmology, where the very identity of a Xhosa person is based on performing traditions and rituals for ancestors. The majority of respondents stated that practicing traditions and thus communicating with ancestors is what is of value to a Xhosa person.

A number of sites and species are fundamental to the performance of rituals and maintaining a relationship with the ancestors. When respondents were asked what would happen if these sites were to be destroyed, they replied “It means that the ancestors would be homeless.” “That can’t happen here at this village because our health depends entirely on these sites,” and “it means that our culture is dead.”

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.31

Annex 7:
Box 2.2. Economic Costs and Benefits of Ecosystem Conversion

Relatively few studies have compared the total economic value of ecosystems under alternate management regimes. The results of several that attempted to do so are shown in the Figure. In each case where the total economic value of sustainable management practices was compared with management regimes involving conversion of the ecosystem or unsustainable practices, the benefit of managing the ecosystem more sustainably exceeded that of the converted ecosystem even though the private benefits—that is, the actual monetary benefits captured from the services entering the market—would favor conversion or unsustainable management. These studies are consistent with the understanding that market failures associated with ecosystem services lead to greater conversion of ecosystems than is economically justified. However, this finding would not hold at all locations. For example, the value of conversion of an ecosystem in areas of prime agricultural land or in urban regions often exceeds the total economic value of the intact ecosystem (although even in dense urban areas, the TEV of maintaining some "green space" can be greater than development of these sites) (C5 [see Annex 4, p. 29]).



Economic Benefits under Alternate Management Practices

- Conversion of tropical forest to small-scale agriculture or plantations (Mount Cameroon, Cameroon). Maintenance of the forest with low-impact logging provided social benefits (NWFPs, sedimentation control, and flood prevention) and global benefits (carbon storage plus option, bequest, and existence values) across the five study sites totaling some $3,400 per hectare. Conversion to small-scale agriculture yielded the greatest private benefits (food production), of about $2,000 per hectare. Across four of the sites, conversion to oil palm and rubber plantations resulted in average net costs (negative benefits) of $1,000 per hectare. Private benefits from cash crops were only realized in this case because of market distortions.
- Conversion of a mangrove system to aquaculture (Thailand). Although conversion for aquaculture made sense in terms of short-term private benefits, it did not once external costs were factored in. The global benefits of carbon sequestration were considered to be similar in intact and degraded systems. However, the substantial social benefits associated with the original mangrove cover—from timber, charcoal, NWFPs, offshore fisheries, and storm protection—fell to almost zero following conversion. Summing all measured goods and services, the TEV of intact mangroves was a minimum of $1,000 and possibly as high as $36,000 per hectare, compared with the TEV of shrimp farming, which was about $200 per hectare.
- Draining freshwater marshes for agriculture (Canada). Draining freshwater marshes in one of Canada's most productive agricultural areas yielded net private benefits in large part because of substantial drainage subsidies. However, the social benefits of retaining wetlands arising from sustainable hunting, angling, and trapping greatly exceeded agricultural gains. Consequently, for all three marsh types considered, TEV was on average $5,800 per hectare, compared with $2,400 per hectare for converted wetlands.
- Use of forests for commercial timber extraction (Cambodia). Use of forest areas for swidden agriculture and extraction of non-wood forest products (including fuelwood, rattan and bamboo, wildlife, malva nuts, and medicine) as well as ecological and environmental functions such as watershed, biodiversity, and carbon storage provided a TEV ranging of $1,300–4,500 per hectare (environmental services accounted for $590 of that while NWFPs provided $700–3,900 per hectare). However, the private benefits associated with unsustainable timber harvest practices exceeded private benefits of NWFP collection. Private benefits for timber harvest ranged from $400 to $1,700 per hectare, but after accounting for lost services the total benefits were from $150 to $1,100 per hectare, significantly less than the TEV of more sustainable uses.

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005),
Chapter 2, p.39

Annex 8:

Box 2.3. Concepts and Measures of Poverty

Relative poverty is the state of deprivation defined by social standards. It is fixed by a contrast with others in the society who are not considered poor. Poverty is then seen as lack of equal opportunities. It is based on subjective measures of poverty.

Depth of poverty is a measure of the average income gap of the poor in relation to a certain threshold. It defines how poor the poor are. It gives the amount of resources needed to bring all poor people to the poverty-line level.

Temporary poverty is characterized by a short-term deprivation, usually seasonal, of water or food.

Monetary poverty is an insufficiency of income or monetary resources. Most indicators like the U.S. dollar a day indicator or national poverty lines are defined in those terms.

Multidimensional poverty is conceived as a group of irreducible deprivations that cannot be adequately expressed as income insufficiency. It combines basic constituents of well-being in a composite measure, such as the Human Poverty Index.

Other characteristics of poverty commonly used in the literature include rural and urban poverty, extreme poverty (or destitution), female poverty (to indicate gender discrimination), and food-ratio poverty lines (with calorie-income elasticities). Other indices such as the FGT (Foster, Greer, and Thorbecke) or the Sen Index, which combine both dimensions of incidence and depth of poverty, are also widely used. The type of poverty experienced by individuals will therefore differ for different rates and levels of biodiversity and ecosystem services loss and if the loss is transitory or permanent.

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005),
Chapter 2, p.40

Annex 9:

Box 2.4. Conflicts Between the Mining Sector and Local Communities in Chile

The Salar de Atacama, Chile, is a salty wetland within the driest desert in the world. Surface water is limited. The present major concern is over groundwater usage and the extent to which the exploitation is sustainable. The economic activities in this region include mining, agriculture, and tourism, all of which depend on the quantity and quality of available water. The Salar de Atacama holds over 40% of world lithium reserves; mining provides 12% of local employment and two thirds of the regional GDP. It also consumes 65% of the water used in the region. Tourism is the second largest source of employment and income, and tourist facilities need fresh water. Local communities rely on water for subsistence agriculture and livestock raising. Most subsistence farmers do not have enough resources to buy water rights when bidding against the mining companies. Hence the shortage of water is generating major conflicts over access and ownership rights among competing users (SG.SDM [see Annex 4, p. 29]).

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005),
Chapter 2, p.41

Annex 10:

Box 3.1. Direct Drivers: Example from Southern African Sub-global Assessment

(SG-SAfMA [see Annex 4, p. 29])

The direct drivers of biodiversity loss in southern Africa include the impacts of land use change, alien invasives, overgrazing, and overharvesting— all of which have already had a large impact on the region's biodiversity, ecosystem services, and human well-being, and all of which are likely to spread in the absence of interventions.

The dominant direct driver of ecosystem change in southern Africa is considered to be widespread land use change that in some cases has led to degradation. Forests and woodlands are being converted to croplands and pastures at a rate somewhat slower than in Southeast Asia and the Amazon during the 1990s, but nevertheless sufficiently fast to endanger ecosystem services at a local scale. Half of the region consists of drylands, where overgrazing is the main cause of desertification.

In the first half of the twenty-first century, climate change is a real threat to water supplies, human health, and biodiversity in southern Africa. The threats arise partly because the projected warming may, over large areas, be accompanied by a drying trend, and partly because of the low state of human welfare and weak governance, which increases vulnerability of humans to climate change. Although some of these threats have slowed in some regions (afforestation with monocultures of alien species in South Africa has decreased, for example), some have accelerated elsewhere (afforestation with alien species in Mozambique has increased, for instance, due to favorable growing conditions and weak regulation). Thus, the region's biodiversity remains vulnerable to land use change. In addition, the more subtle problem of land degradation is considered a bigger threat in the region.

Several studies indicate that the biodiversity of southern Africa is at risk. There is now evidence, for example, that it is declining in the northern part of its range, but stable in the southern part, as predicted by the global change models. In addition, there is experimental evidence that the recorded expansion of woody invasions into grasslands and savannas may be driven by rising global CO_2 concentrations. The ability of species to disperse and survive these pressures will be hampered by a fragmented landscape made inhospitable by human activities. The Assessments of Impacts and Adaptations to Climate Change in Multiple Regions and Sectors project is currently analyzing response options that may conserve biodiversity under future climate and land cover scenarios in southern Africa.

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005),
Chapter 2, p.49

Annex 11:

Box 5.1. Key Factors of Successful Responses to Biodiversity Loss

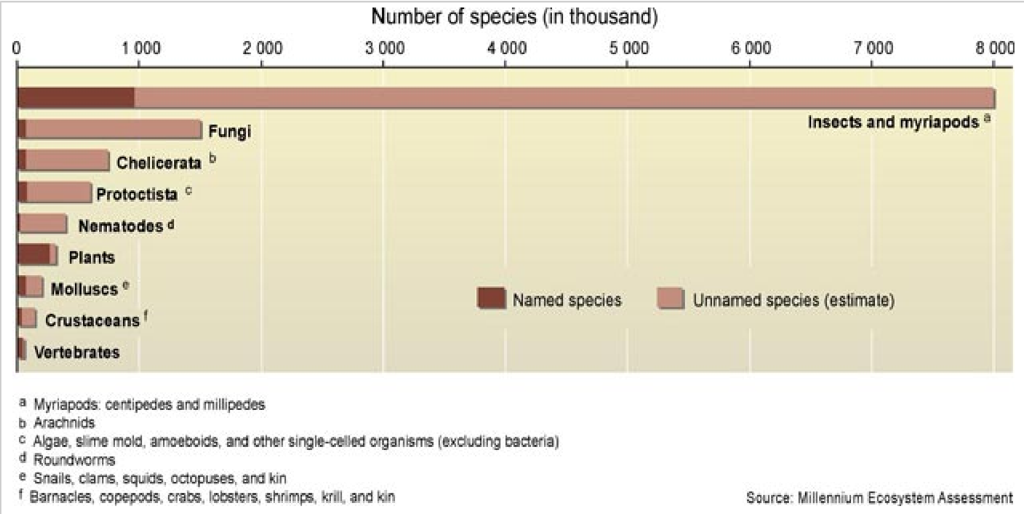
- Mobilize knowledge. Ensure that the available knowledge is presented in ways that can be used by decision-makers.
- Recognize complexity. Responses must serve multiple objectives and sectors; they must be integrated.
- Acknowledge uncertainty. In choosing responses, understand the limits to current knowledge, and expect the unexpected.
- Enable natural feedbacks. Avoid creating artificial feedbacks that are detrimental to system resilience.
- Use an inclusive process. Make information available and understandable to a wide range of affected stakeholders.
- Enhance adaptive capacity. Resilience is increased if institutional frameworks are put in place that allow and promote the capacity to learn from past responses and adapt accordingly.
- Establish supporting instrumental freedoms. Responses do not work in a vacuum, and it is therefore critical to build necessary supporting instrumental freedoms—enabling conditions like transparency, markets, education—needed in order for the responses to work efficiently and equitably.
- Establish legal frameworks. A legally binding agreement is generally likely to have a much stronger effect than a soft law agreement.
- Have clear definitions. Agreements with clear definitions and unambiguous language will be easier to implement.
- Establish principles. Clear principles can help guide the parties to reach future agreement and guide the implementation of an agreement.
- Elaborate obligations and appropriate rights. An agreement with a clear elaboration of obligations and rights is more likely to be implemented.
- Provide financial resources. Availability of financial resources increases the opportunities for implementation.
- Provide mechanisms for implementation. Where financial resources are not sufficient, market mechanisms may increase the potential for implementation.
- Establish implementing and monitoring agencies. The establishment of subsidiary bodies with authority and resources to undertake specific activities to enhance the implementation of the agreements is vital to ensure continuity, preparation, and follow-up to complex issues.
- Establish good links with scientific bodies. As ecological issues become more complex, it becomes increasingly important to establish good institutional links between the legal process and the scientific community.
- Integrate traditional and scientific knowledge. Identify opportunities for incorporating traditional and local knowledge in designing responses.

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005),
p.74

Annex 12:

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

(C4 [see Annex 4, p. 29] .2.3)

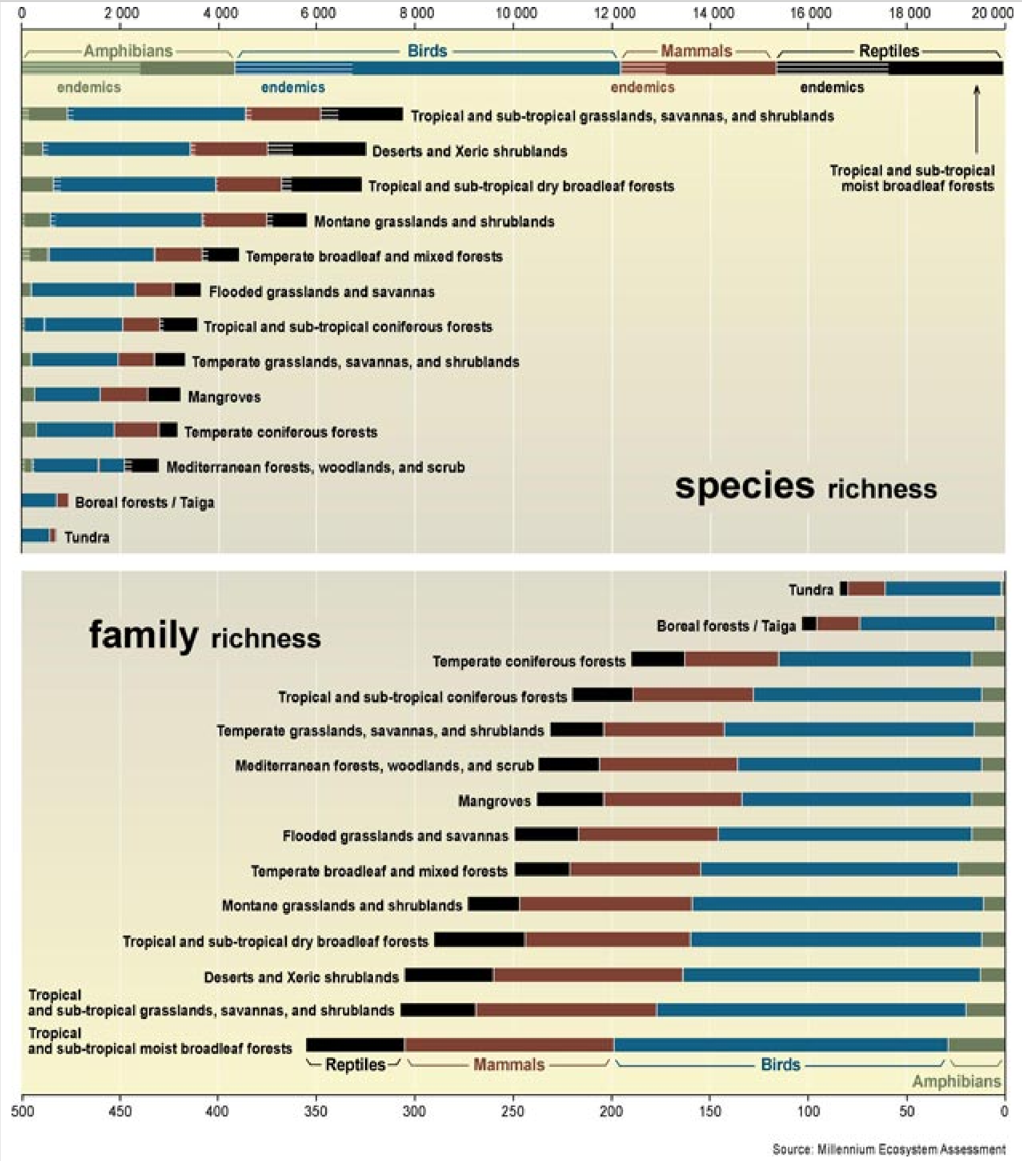


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see https://www.greenfacts.org/en/biodiversity/about-biodiversity.htm] , p.22

Annex 13:

Figure 1.2. Comparisons for the 14 Terrestrial Biomes of the World in Terms of Species Richness, Family Richness, and Endemic Species

(C4 [see Annex 4, p. 29] .Fig 4.7)

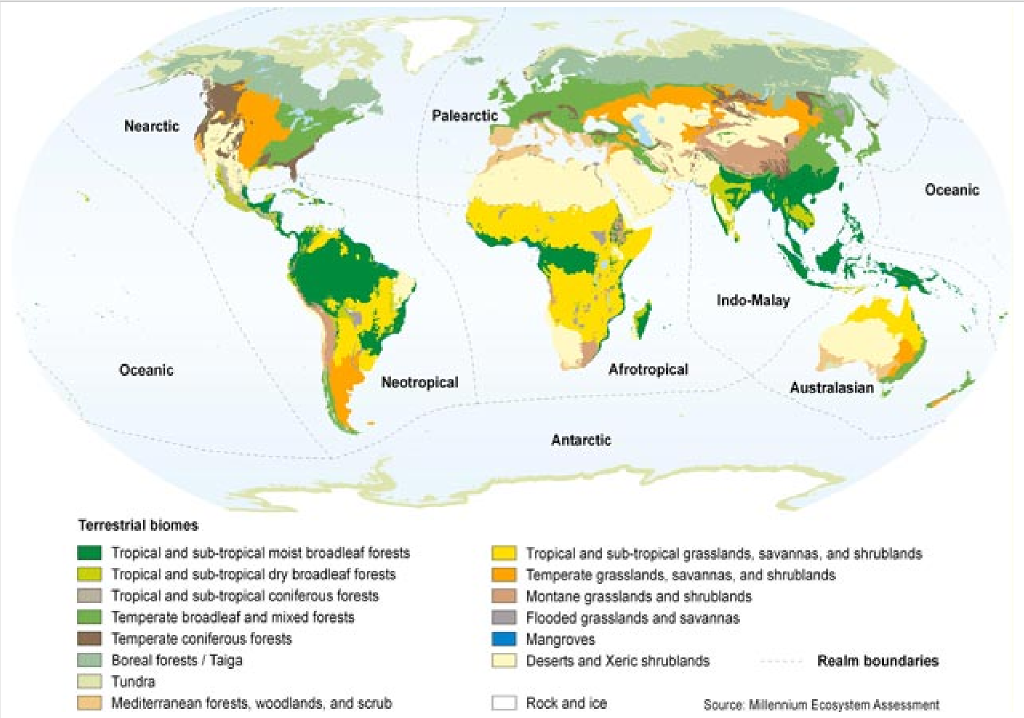


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.23

Annex 14:
Figure 1.3. The 8 Biogeographical Realms and 14 Biomes Used in the MA

(C4 [see Annex 4, p. 29] .Figure C4.3)

Biogeographic realms are large spatial regions within which ecosystems share a broadly similar biological evolutionary history. Eight terrestrial biogeographic realms are typically recognized, corresponding roughly to continents. Although similar ecosystems (such as tropical moist forests) share similar processes and major vegetation types wherever they are found, their species composition varies markedly depending on the biogeographic realm in which they are found. Assessing biodiversity at the level of biogeographic realms is important because the realms display substantial variation in the extent of change, they face different drivers of change, and there may be differences in the options for mitigating or managing the drivers. Terrestrial biogeographic realms reflect freshwater biodiversity patterns reasonably well, but marine biogeographic realms are poorly known and largely undefined (C4.2.1).

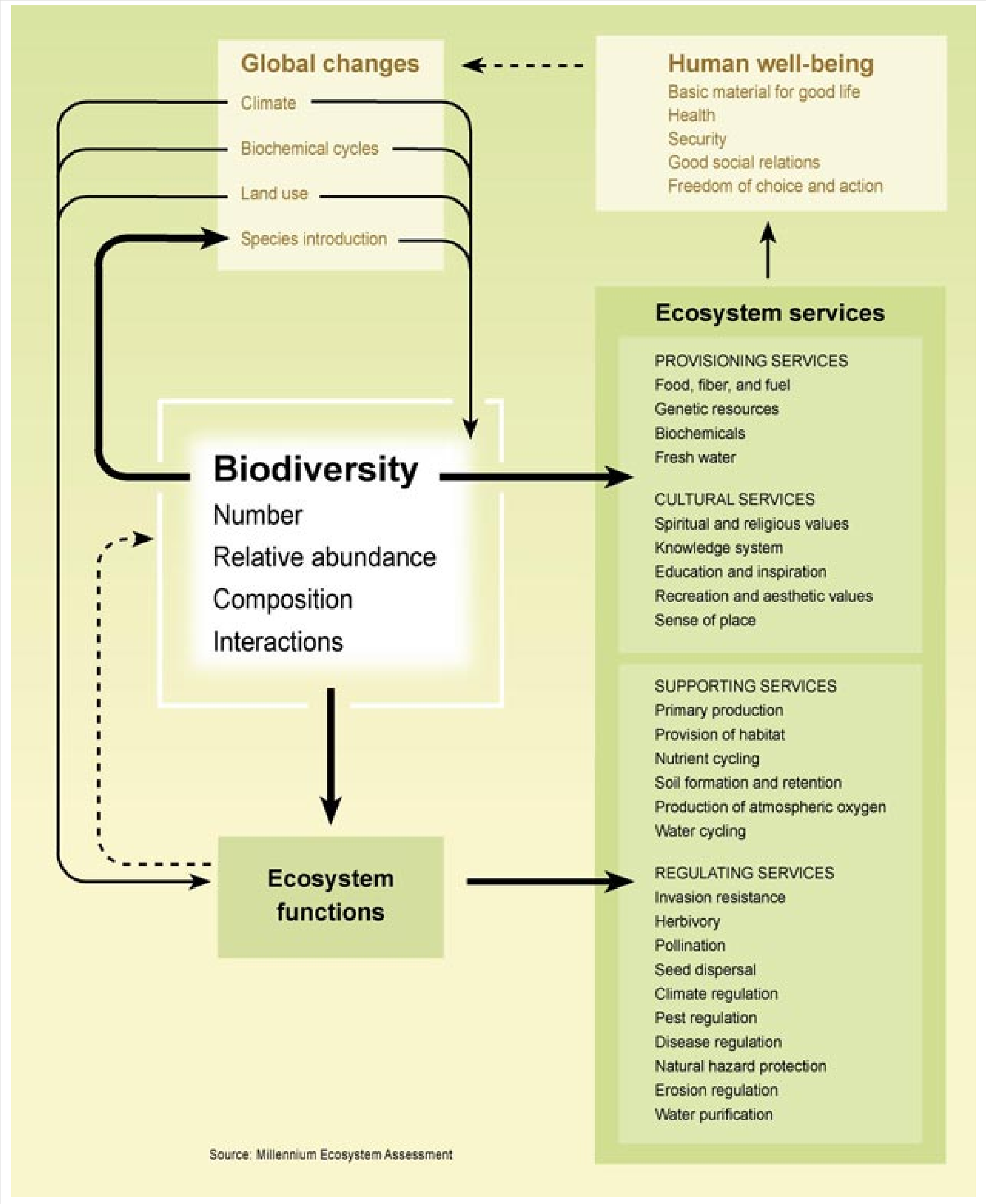


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.24

Annex 15:
Figure 1.4. Biodiversity, Ecosystem Functioning, and Ecosystem Services

(C11 [see Annex 4, p. 29] .Figure 11.1)

Biodiversity is both a response variable affected by global change drivers and a factor modifying ecosystem processes and services and human well-being. Solid arrows indicate the links that are the focus of Chapter C11.

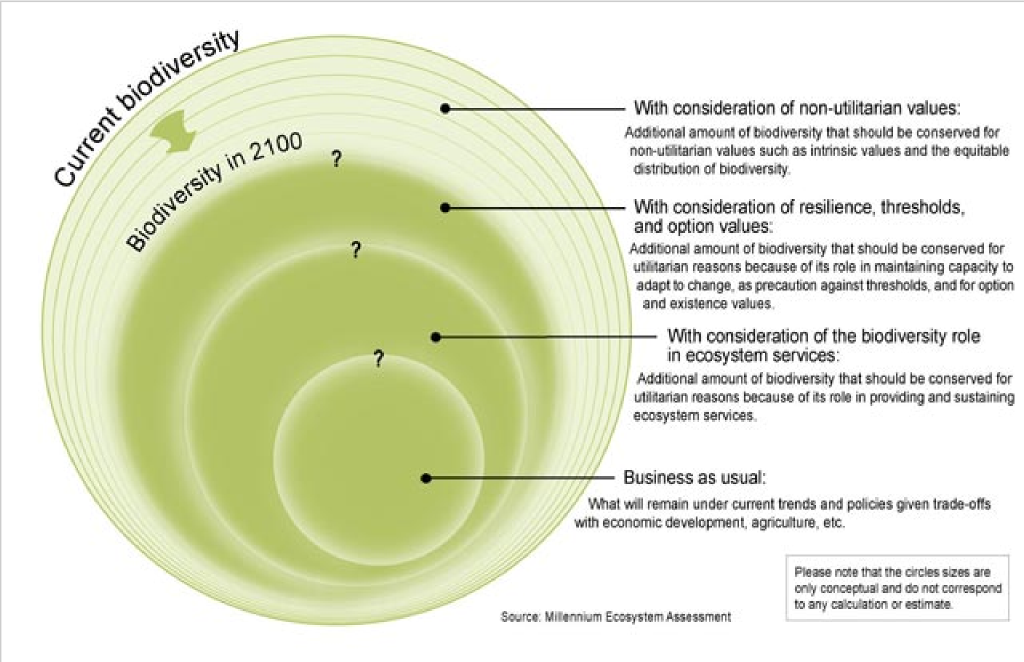


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.28

Annex 16:

Figure 2. How Much Biodiversity Will Remain a Century from Now under Different Value Frameworks?

The outer circle in the Figure represents the present level of global biodiversity. Each inner circle represents the level of biodiversity under different value frameworks. Question marks indicate the uncertainties over where the boundaries exist, and therefore the appropriate size of each circle under different value frameworks.

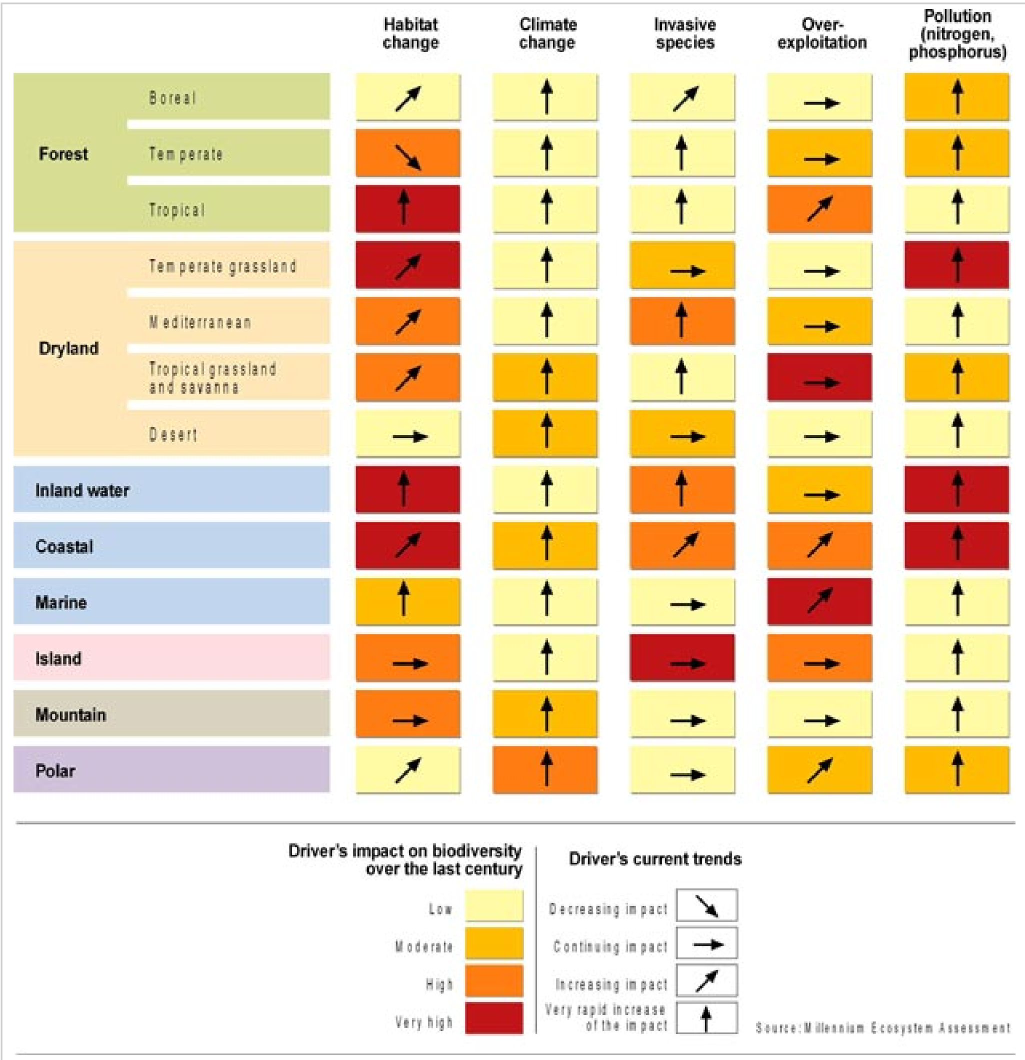


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.7

Annex 17:

Figure 3. Main Direct Drivers

The cell color indicates the impact to date of each driver on biodiversity in each biome over the past 50–100 years. The arrows indicate the trend in the impact of the driver on biodiversity. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively increasing trends in impact. This Figure is based on expert opinion consistent with and based on the analysis of drivers of change in various chapters of the assessment report of the Condition and Trends Working Group. This Figure presents global impacts and trends that may be different from those in specific regions.

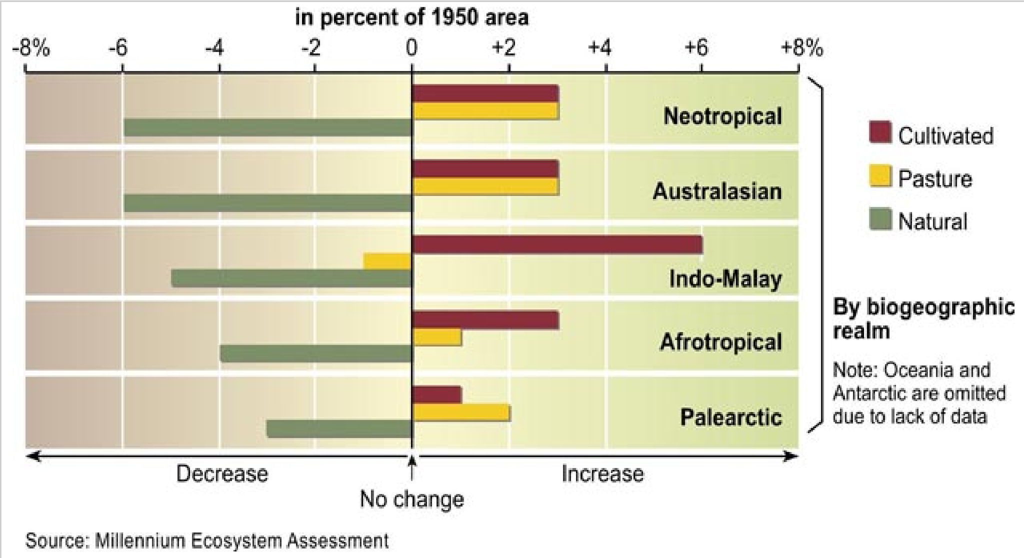


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.9

Annex 18:

Figure 3.1. Percentage Change 1950–90 in Land Area of Biogeographic Realms Remaining in Natural Condition or under Cultivation and Pasture

Two biogeographic realms are omitted due to lack of data: Oceania and Antarctic. In the Nearctic, the amount of land under cultivation and pasture has stabilized, with no net change in cover since 1950.

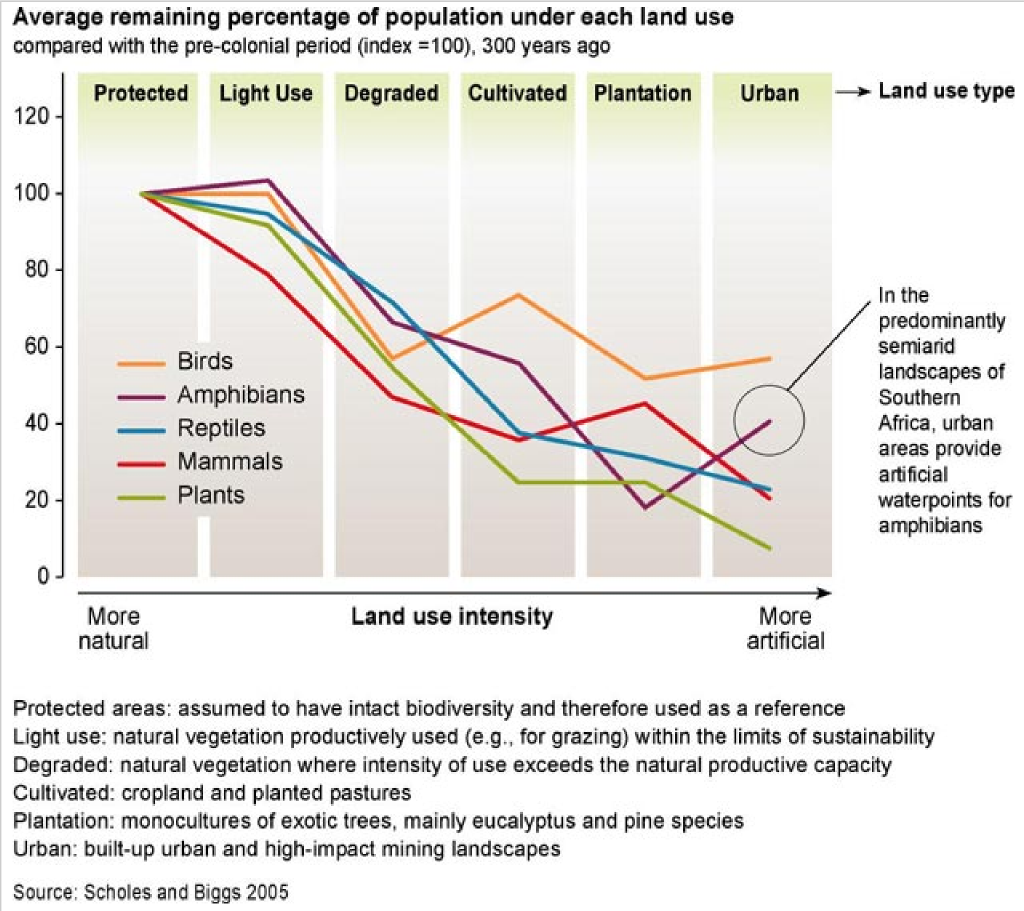


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.38

Annex 19:

Figure 3.11. Effect of Increasing Land Use Intensity on the Fraction of Inferred Population 300 Years Ago of Different Taxa that Remain

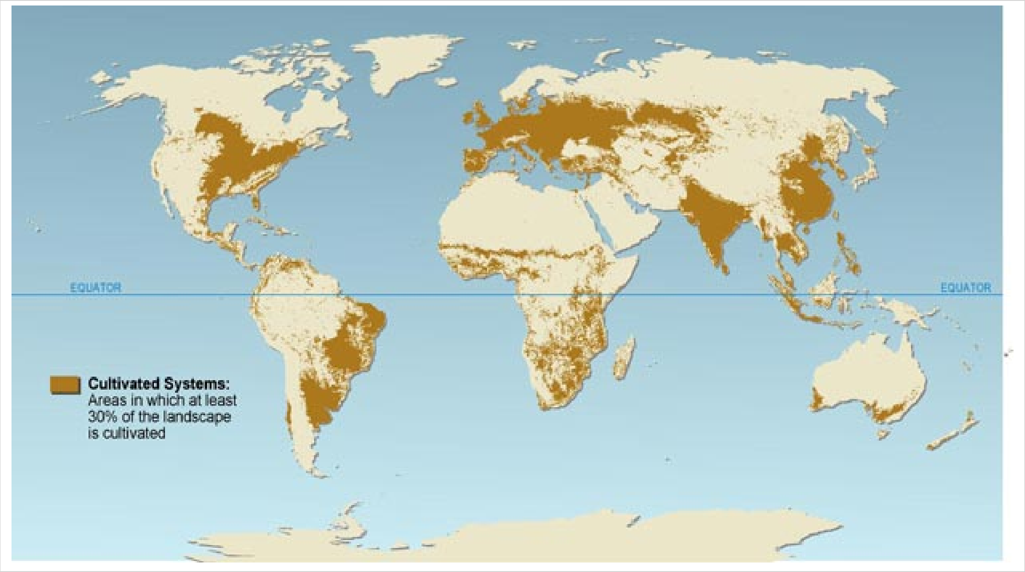
The vertical axis percentages refer to the share of southern Africa under the respective land uses. Human landscape modifications can also lead to increases of populations under conditions of light use (see amphibians).



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.51

Annex 20:
Figure 3.12. Extent of Cultivated Systems, 2000

(C26 [see Annex 4, p. 29])

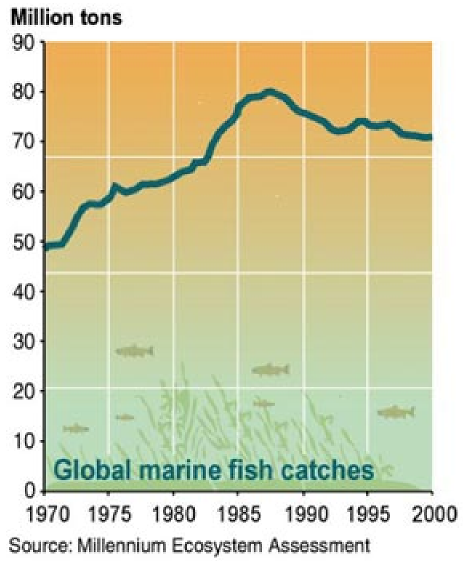


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.52

Annex 21:
Figure 3.14. Estimated Global Marine Fish Catch, 1950–2001

(C18 [see Annex 4, p. 29] Fig 18.3)

In this Figure, the catch reported by governments is in some cases adjusted to correct for likely errors in data.

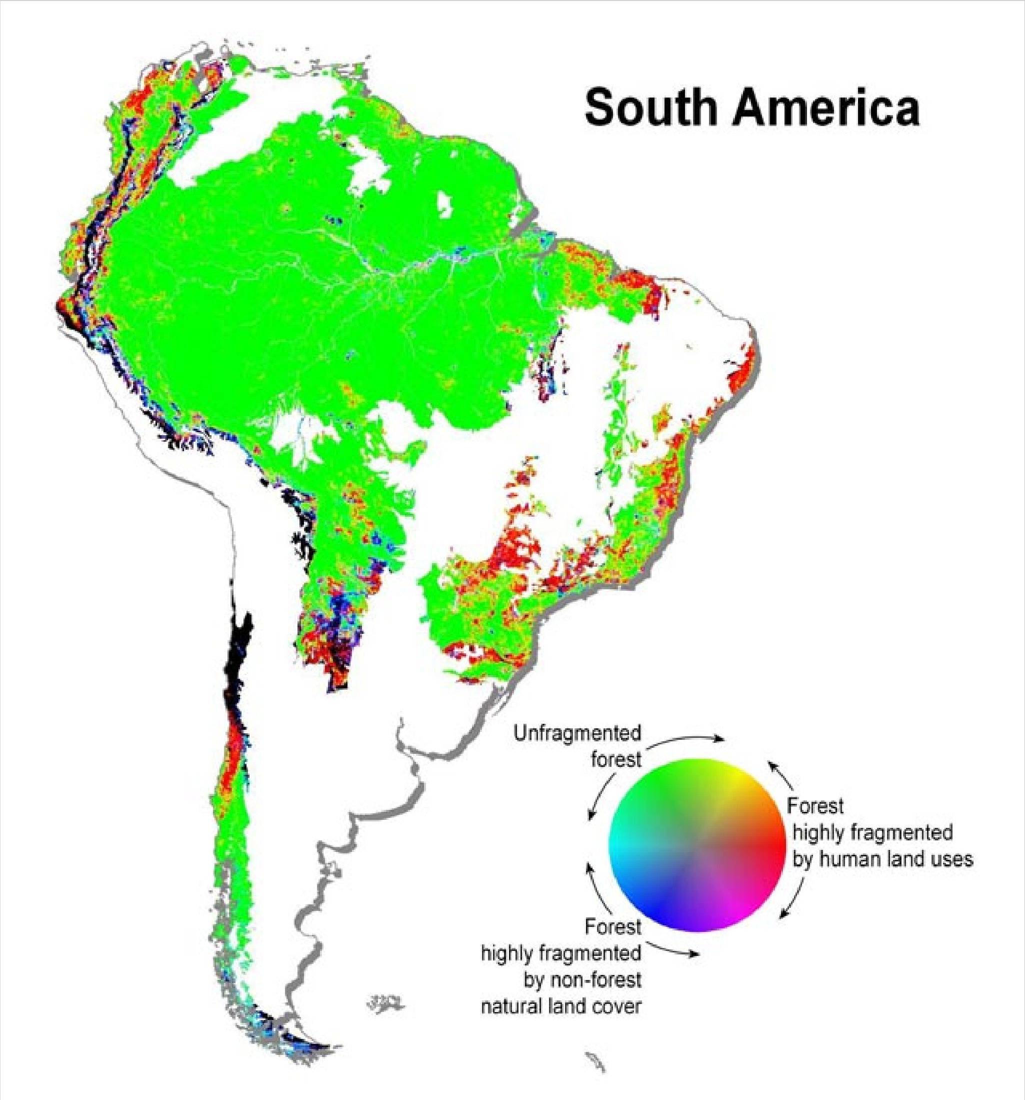


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.53

Annex 22:

Figure 3.15. Estimates of Forest Fragmentation due to Anthropogenic Causes

(C4 [see Annex 4, p. 29])

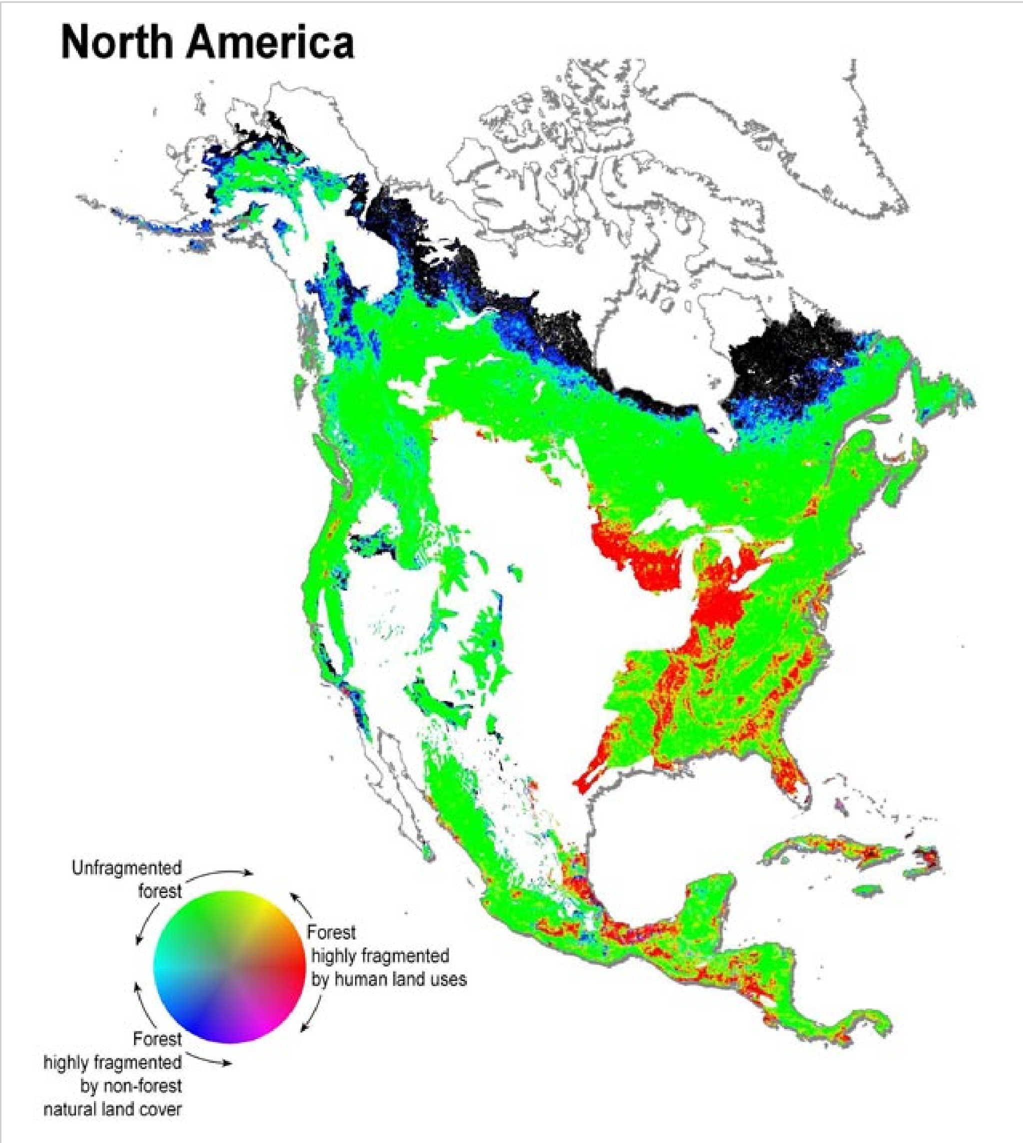


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.54

Annex 23:

Figure 3.15. Estimates of Forest Fragmentation due to Anthropogenic Causes

(C4 [see Annex 4, p. 29])

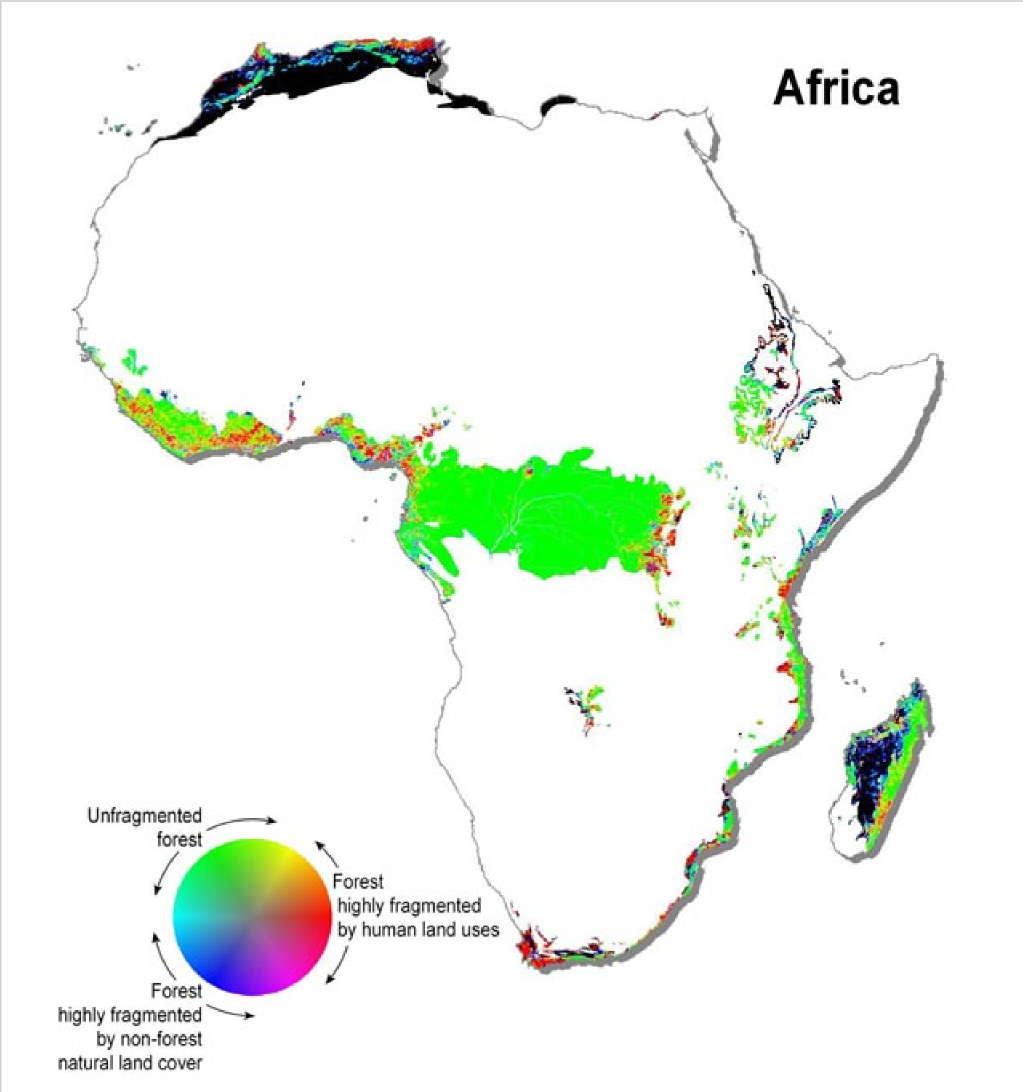


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.54

Annex 24:

Figure 3.15. Estimates of Forest Fragmentation due to Anthropogenic Causes

(C4 [see Annex 4, p. 29])

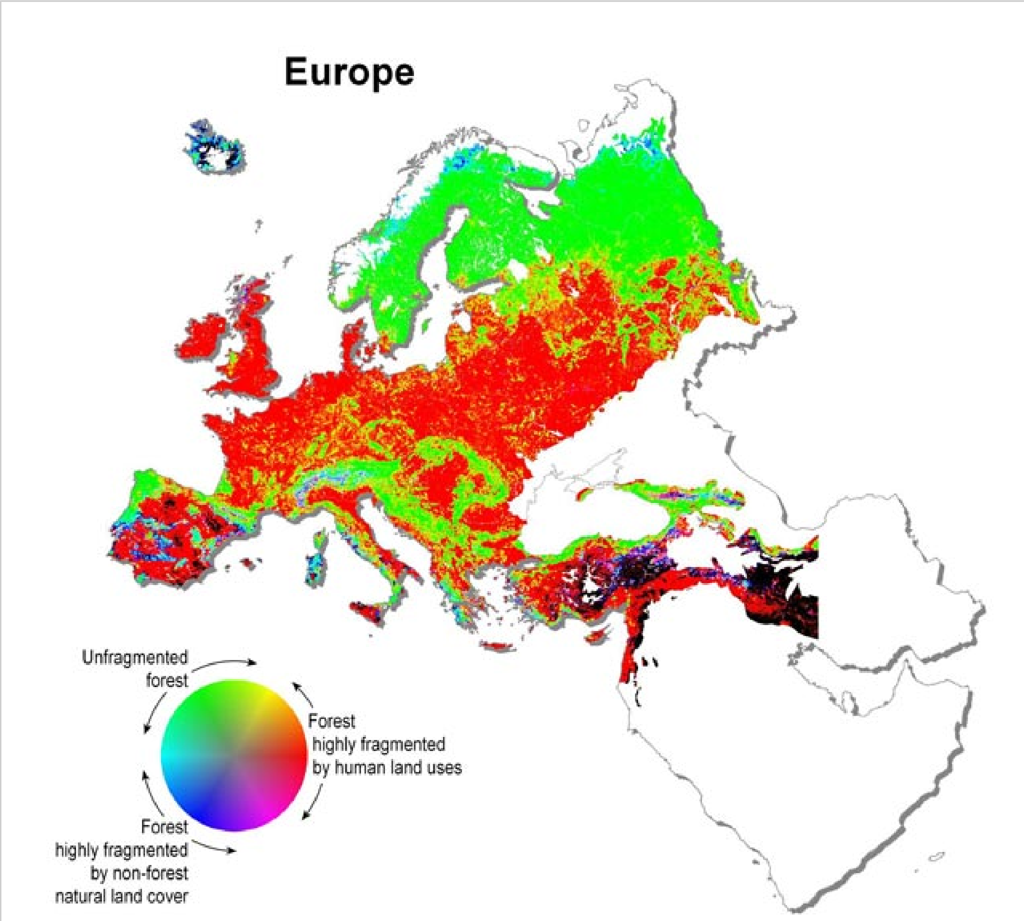


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.54

Annex 25:

Figure 3.15. Estimates of Forest Fragmentation due to Anthropogenic Causes

(C4 [see Annex 4, p. 29])

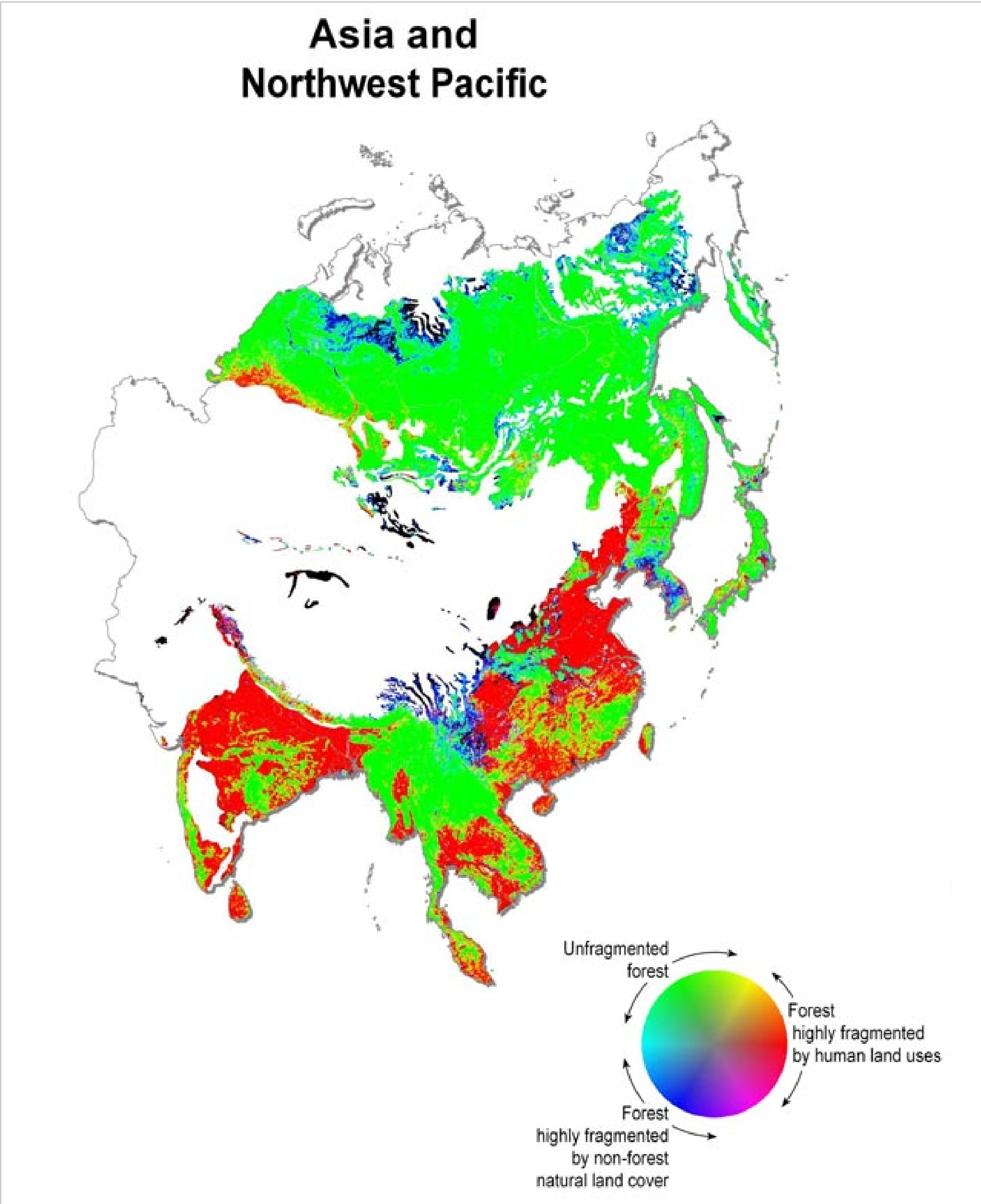


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.54

Annex 26:

Figure 3.15. Estimates of Forest Fragmentation due to Anthropogenic Causes

(C4 [see Annex 4, p. 29])

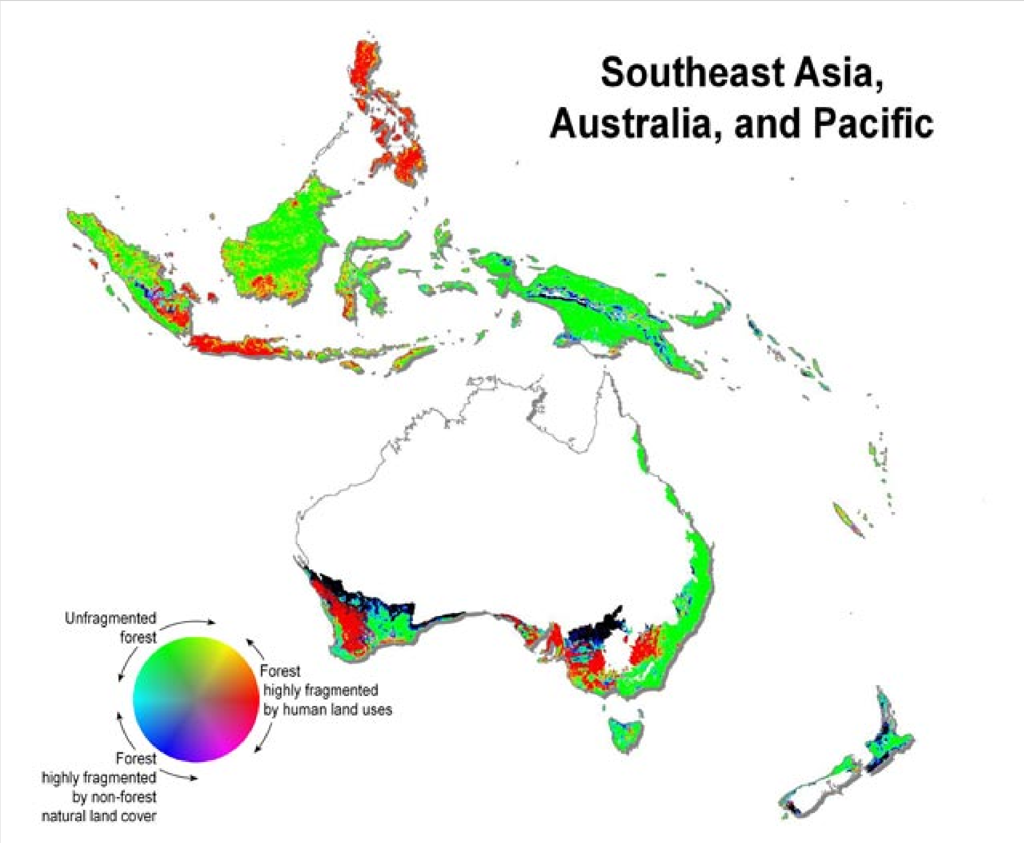


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.54

Annex 27:

Figure 3.15. Estimates of Forest Fragmentation due to Anthropogenic Causes

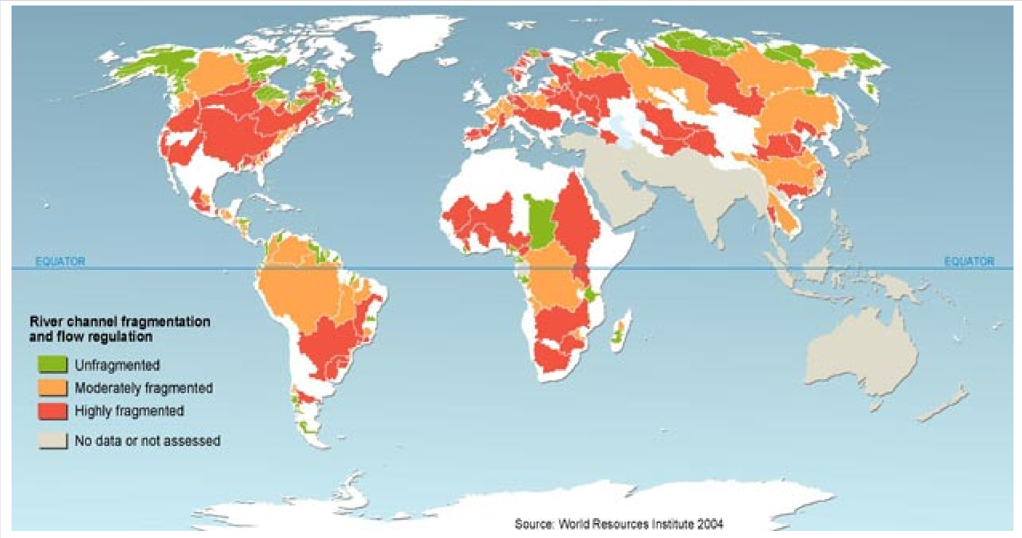
(C4 [see Annex 4, p. 29])



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.54

Annex 28:
Figure 3.16. Fragmentation and Flow in Major Rivers

(C20 [see Annex 4, p. 29])

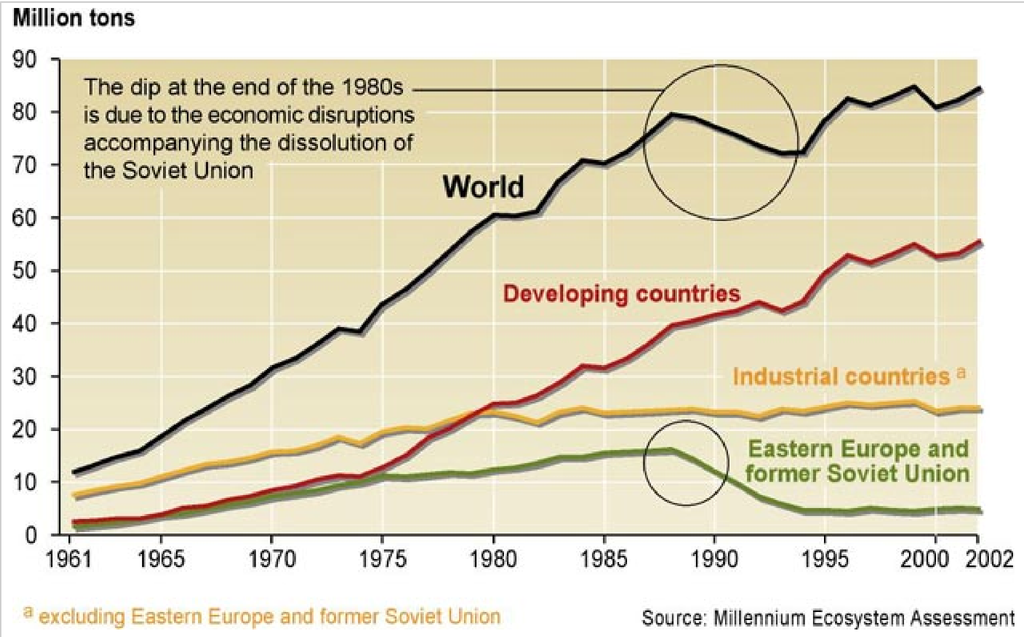


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.56

Annex 29:

Figure 3.17 Trends in Global Use of Nitrogen Fertilizer, 1961–2001 (million tons)

(S7 [see Annex 4, p. 29] Fig 7.16)



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.57

Annex 30:

Figure 3.18 Trends in Global Use of Phosphate Fertilizer, 1961–2001 (million tons)

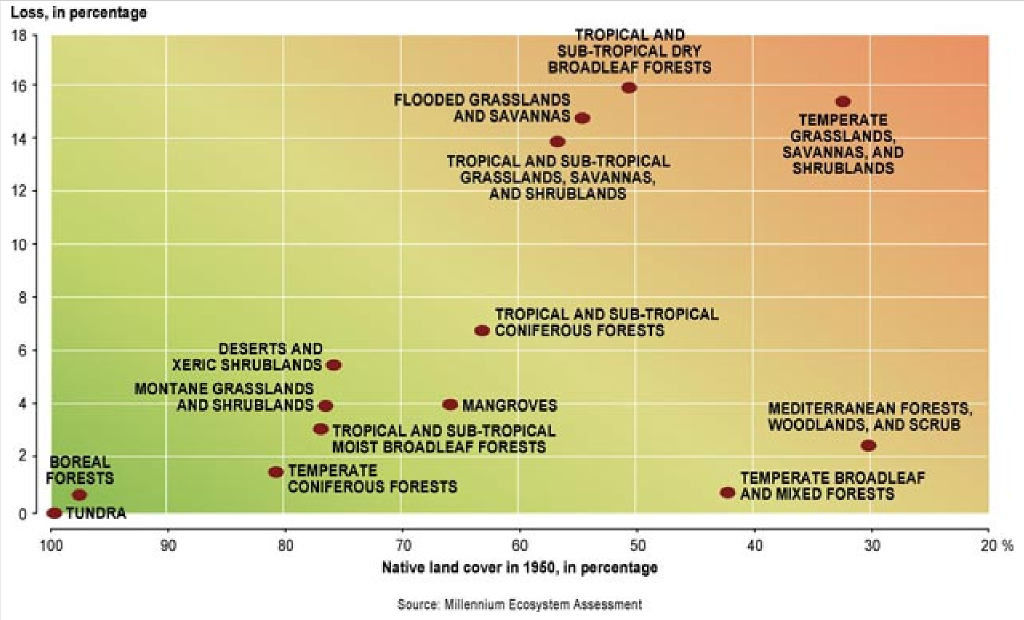
(S7 [see Annex 4, p. 29] Fig 7.18)

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.57

Annex 31:

Figure 3.2. Relationship between Native Habitat Loss by 1950 and Additional Losses between 1950 and 1990

(C4 [see Annex 4, p. 29] Fig 4.26)

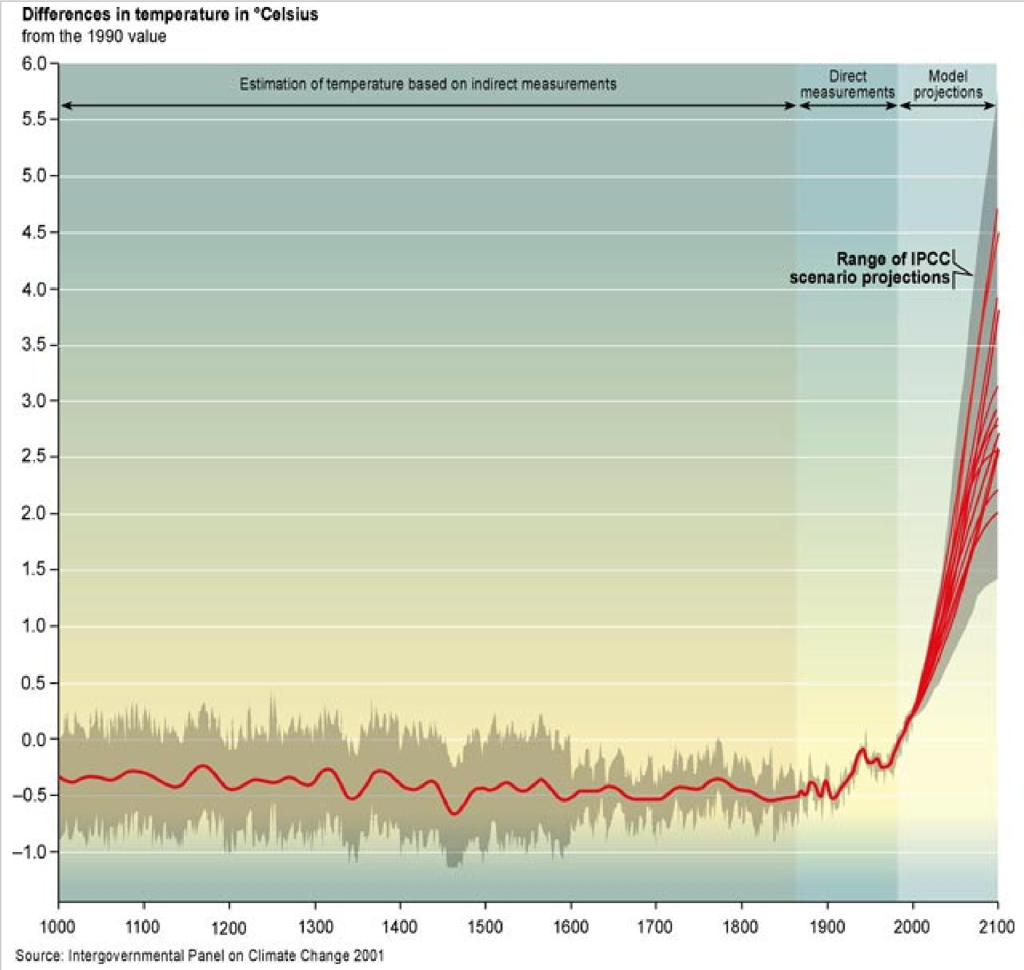


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.43

Annex 32:

Figure 3.20. Historical and Projected Variations in Earth's Surface Temperature

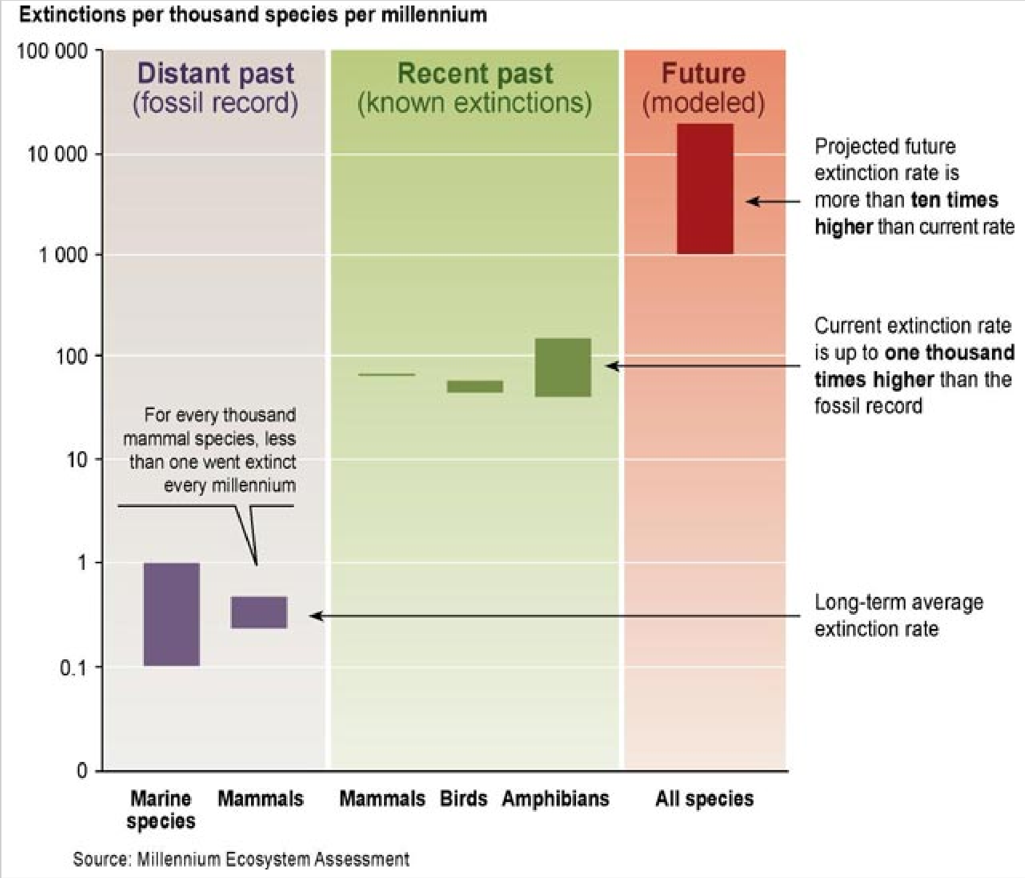
Estimated global temperature averages for the past 1,000 years, with projections to 2100 depending on various plausible scenarios for future human behavior



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.59

Annex 33:
Figure 3.3. Species Extinction Rates

(Adapted from C4 [see Annex 4, p. 29] Fig 4.22)



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.44

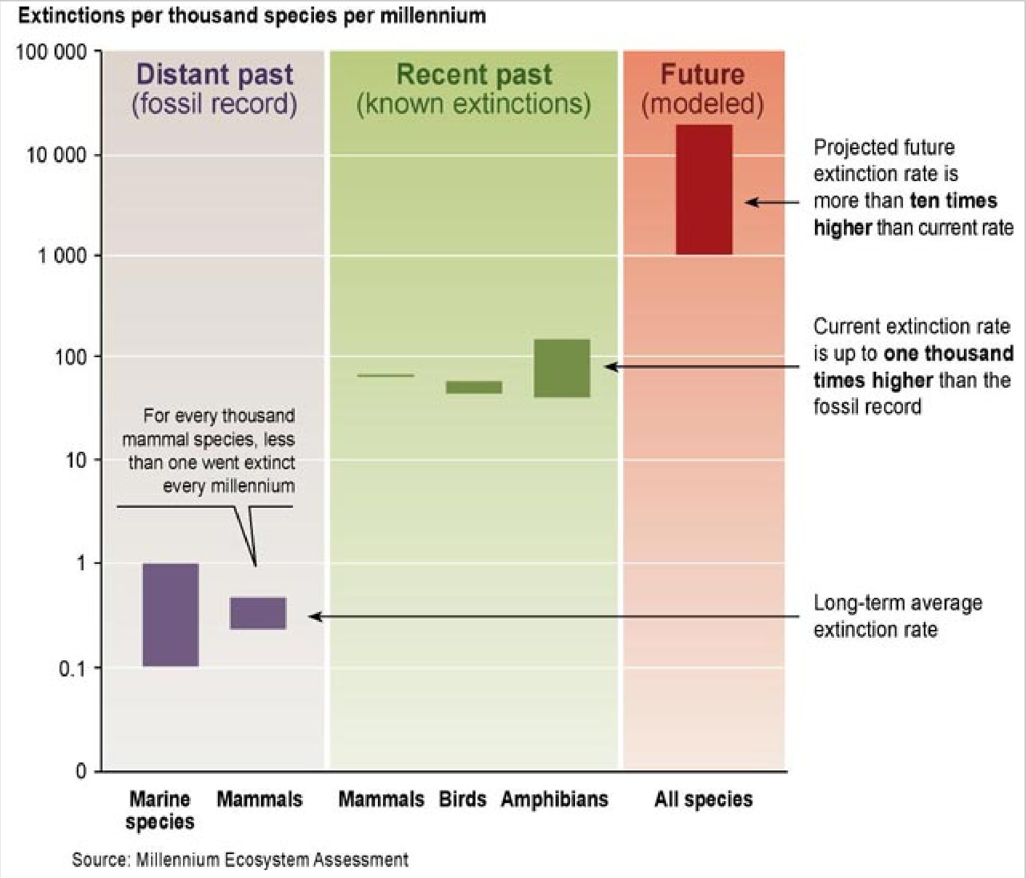
Annex 34:
Figure 3.3. Species Extinction Rates

(Adapted from C4 [see Annex 4, p. 29] Fig 4.22)

"Distant past" refers to average extinction rates as calculated from the fossil record.

"Recent past" refers to extinction rates calculated from known extinctions of species (lower estimate) or known extinctions plus "possibly extinct" species (upper bound). A species is considered to be "possibly extinct" if it is believed to be extinct by experts but extensive surveys have not yet been undertaken to confirm its disappearance.

"Future" extinctions are model-derived estimates using a variety of techniques, including species-area models, rates at which species are shifting to increasingly more threatened categories, extinction probabilities associated with the IUCN categories of threat, impacts of projected habitat loss on species currently threatened with habitat loss, and correlation of species loss with energy consumption. The time frame and species groups involved differ among the "future" estimates, but in general refer to either future loss of species based on the level of threat that exists today or current and future loss of species as a result of habitat changes taking place roughly from 1970 to 2050. Estimates based on the fossil record are low certainty. The lower-bound estimates for known extinctions are high certainty, while the upper-bound estimates are medium certainty; lower-bound estimates for modeled extinctions are low certainty, and upper-bound estimates are speculative.

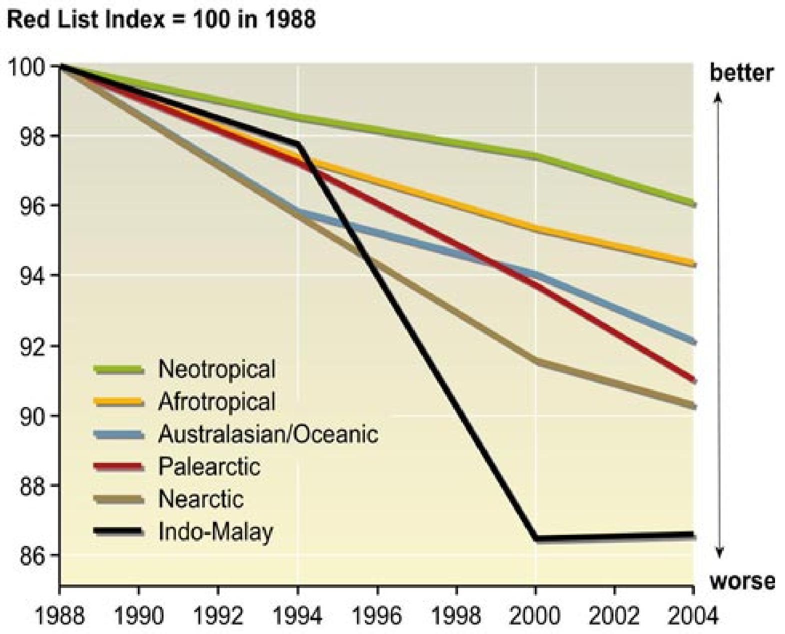


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.44

Annex 35:

Figure 3.4. Red List Indices for Birds, 1988–2004, in Different Biogeographic Realms

(C4 [see Annex 4, p. 29])



The Red List Index illustrates the relative rate at which sets of species change in overall threat status (i.e., projected relative extinction risk), based on population, range size, and trends as quantified by categories on the IUCN Red List.

Source: Butchart et al. 2005

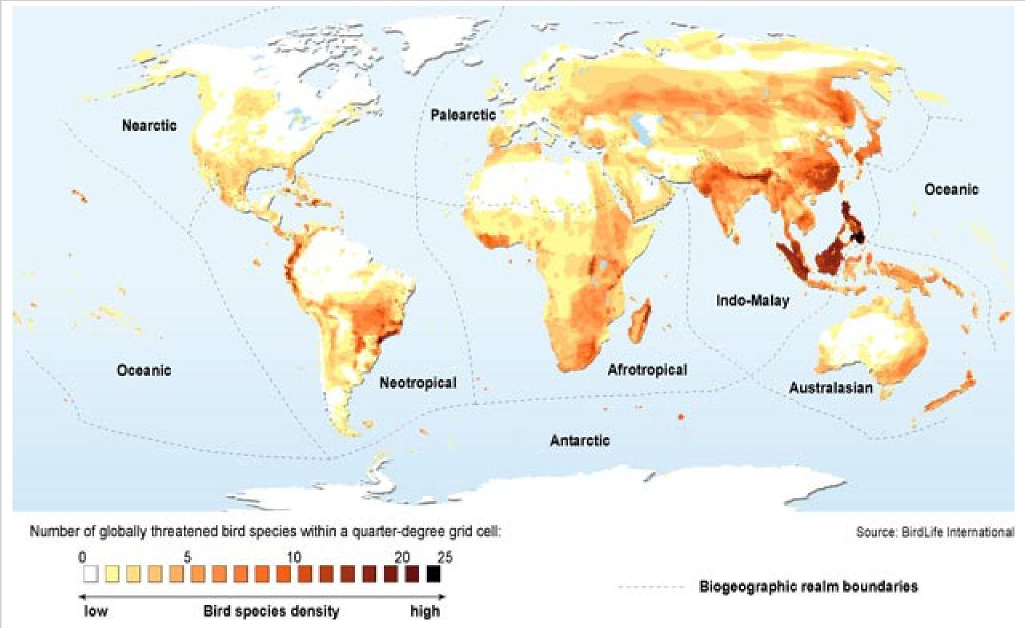
Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.44

Annex 36:

Figure 3.5. Density Distribution Map of Globally Threatened Bird Species Mapped at a Resolution of Quarter-degree Grid Cell

(C4 [see Annex 4, p. 29] Fig 4.25)

Dark orange colors correspond to higher richness, dark blue to lowest. (n=1,213)

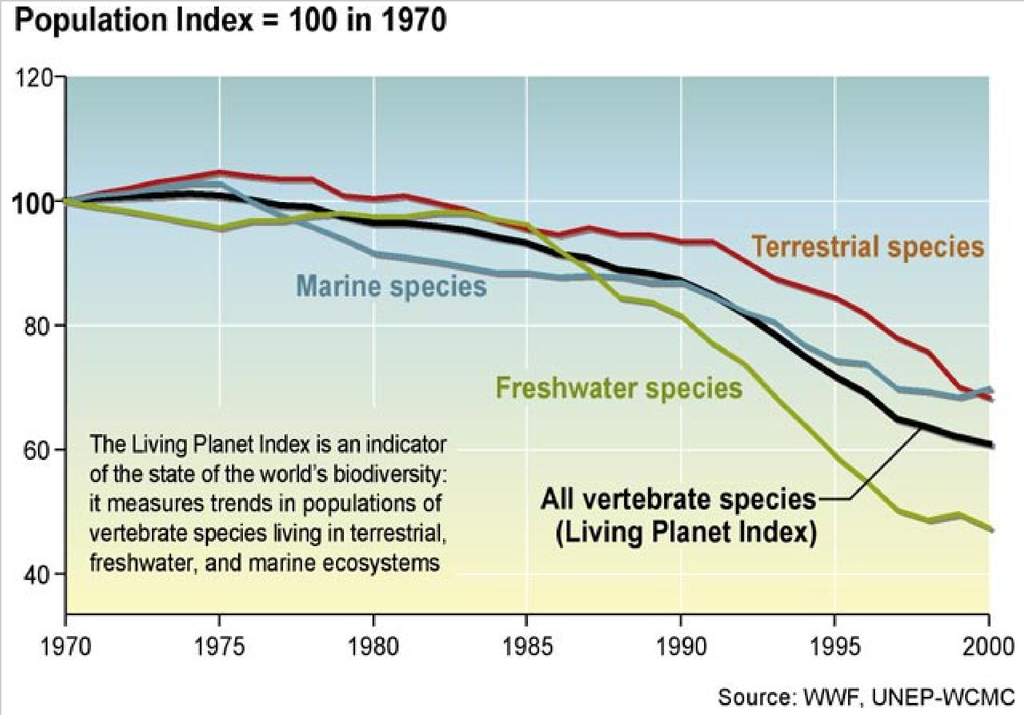


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.45

Annex 37:

Figure 3.7. The Living Planet Index, 1970–2000

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

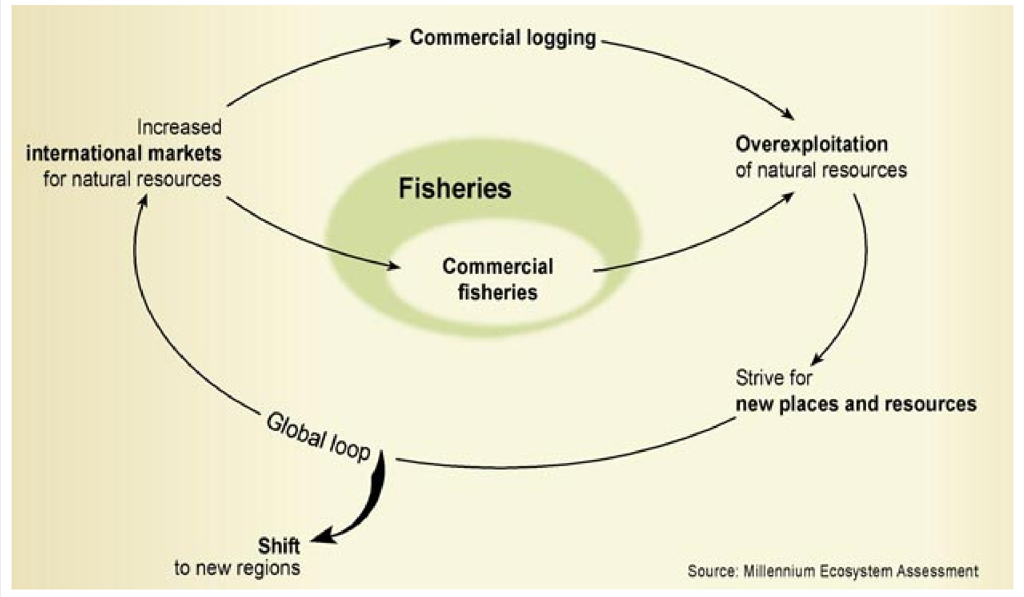


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.47

Annex 38:

Figure 3.9. Summary of Interactions among Drivers Associated with the Overexploitation of Natural Resources

(Adapted from SG7 [see Annex 4, p. 29] Fig 7.7)

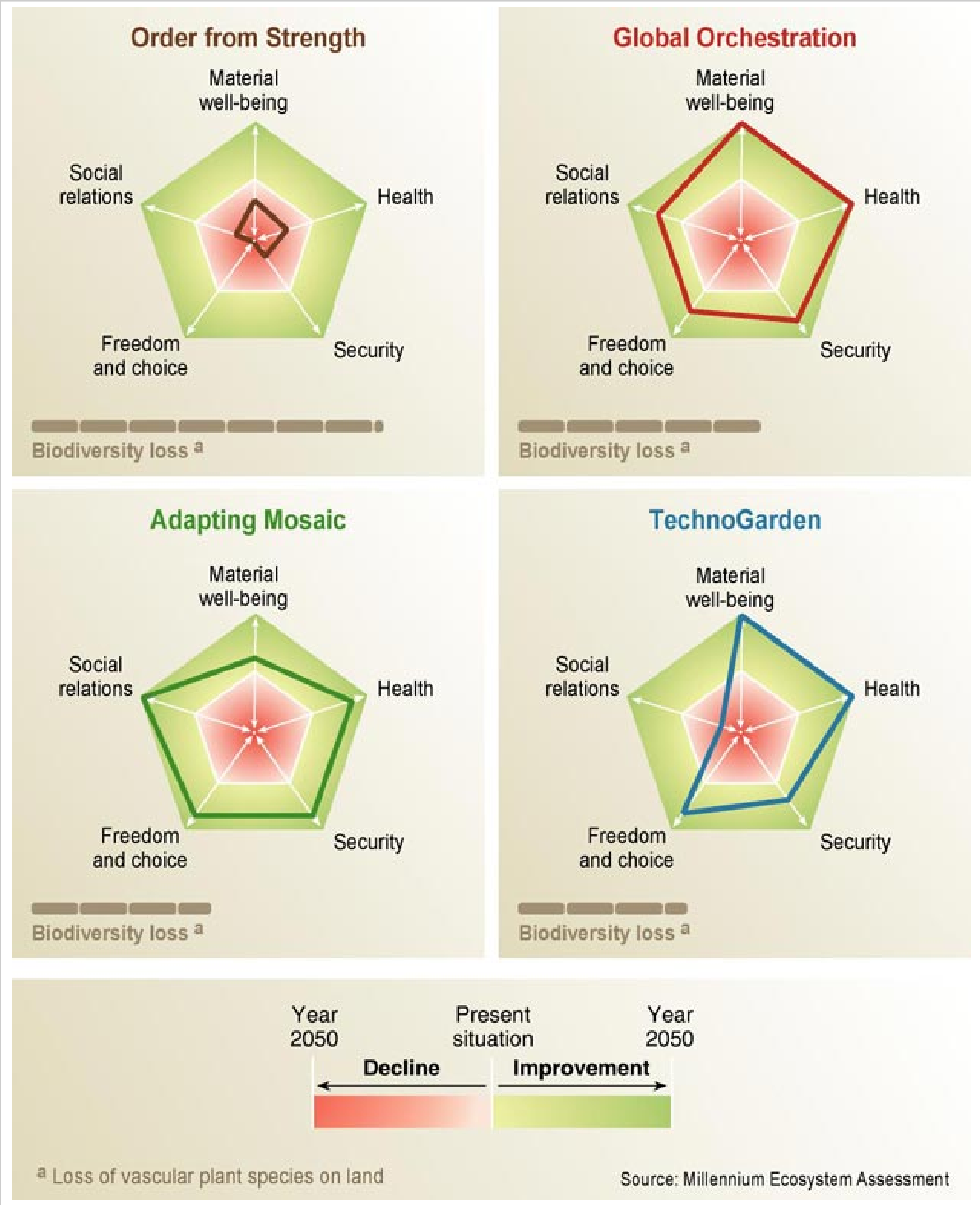


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.48

Annex 39:

Figure 4. Trade-offs between Biodiversity and Human Well-being under the Four MA Scenarios

Loss of biodiversity is least in the two scenarios that feature a proactive approach to environmental management (TechnoGarden [see Annex 50, p. 71] and Adapting Mosaic [see Annex 47, p. 68]). The MA scenario with the worst impacts on biodiversity (high rates of habitat loss and species extinction) is also the one with the worst impacts on human well-being (Order from Strength [see Annex 49, p. 70]). A scenario with relatively positive implications for human well-being (Global Orchestration [see Annex 48, p. 69]) had the second worst implications for biodiversity.



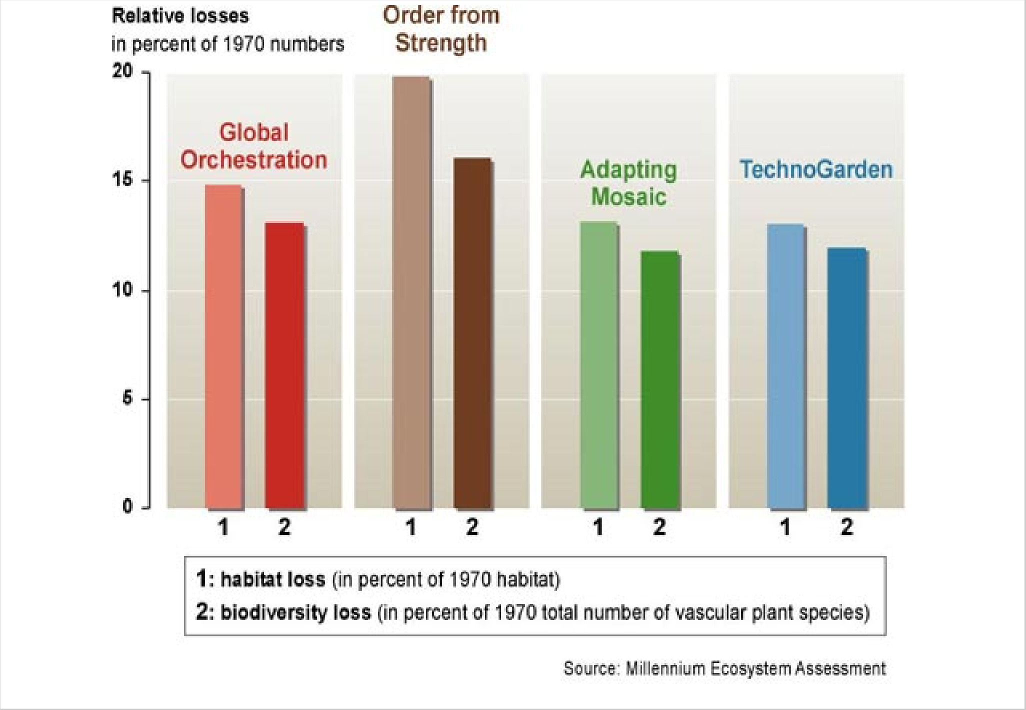
Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.15

Annex 40:

Figure 4.1. Losses of Habitat as a Result of Land Use Change between 1970 and 2050 and Reduction in the Equilibrium Number of Vascular Plant Species under the MA Scenarios

(S10.2 [see Annex 4, p. 29])

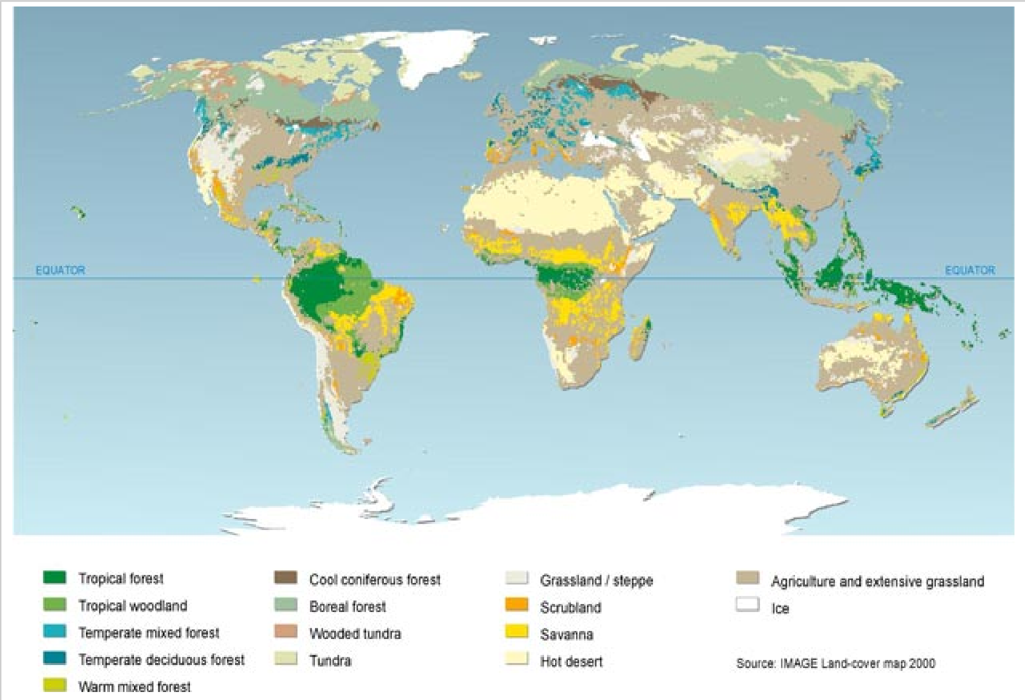
Extinctions of vascular plants will occur between now and sometime after 2050, when populations reach equilibrium with the remaining habitat.



Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.61

Annex 41:
Figure 4.3. Land-cover Map for the Year 2000

(S6 [see Annex 4, p. 29])

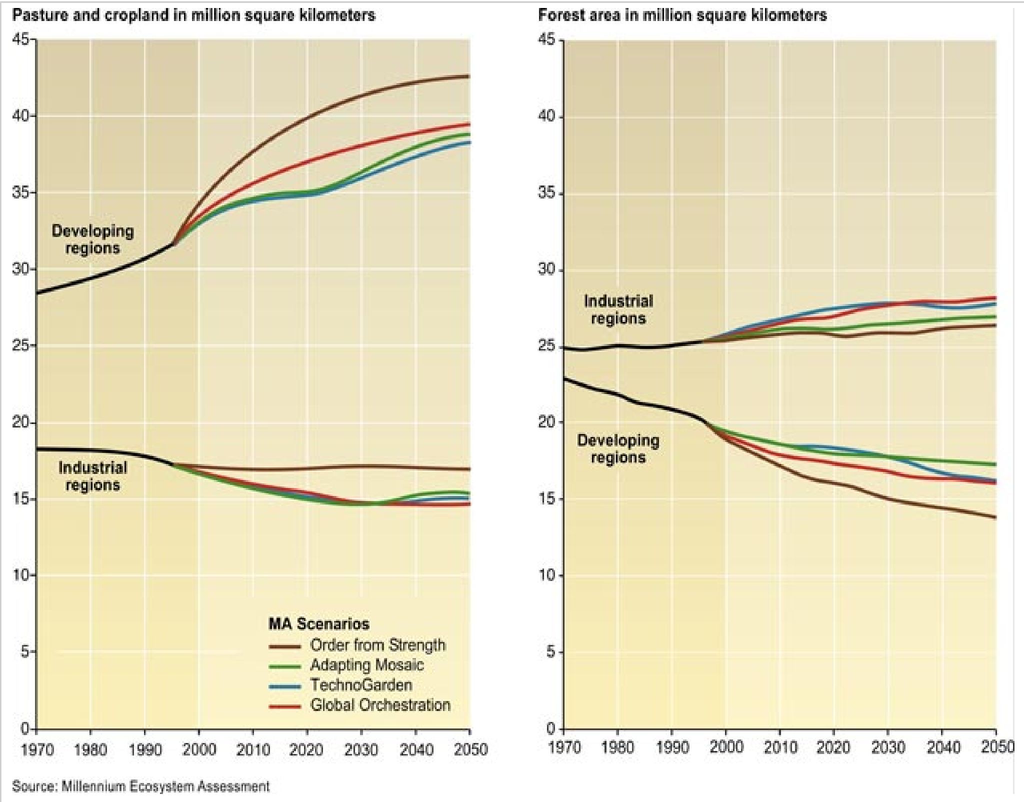


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.63

Annex 42:

Figure 4.5. Forest and Cropland/Pasture in Industrial and Developing Regions under the MA Scenarios

(S9 [see Annex 4, p. 29] Fig 9.15)

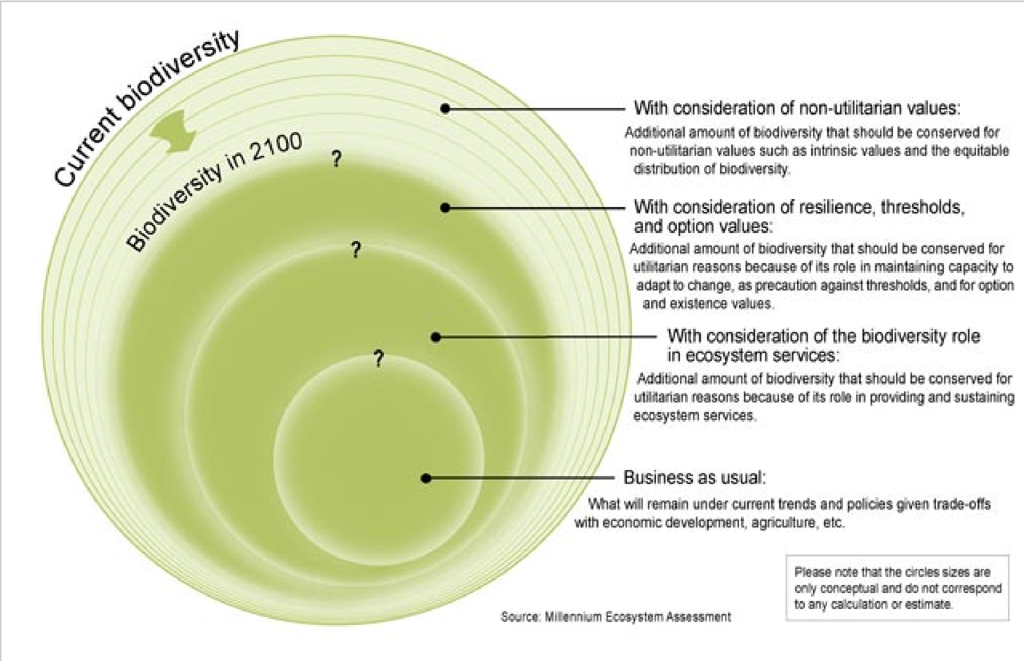


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.65

Annex 43:

Figure 6.1. How Much Biodiversity Will Remain a Century from Now under Different Value Frameworks?

The outer circle in the Figure represents the present level of global biodiversity. Each inner circle represents the level of biodiversity under different value frameworks. Question marks indicate the uncertainties over where the boundaries exist, and therefore the appropriate size of each circle under different value frameworks.

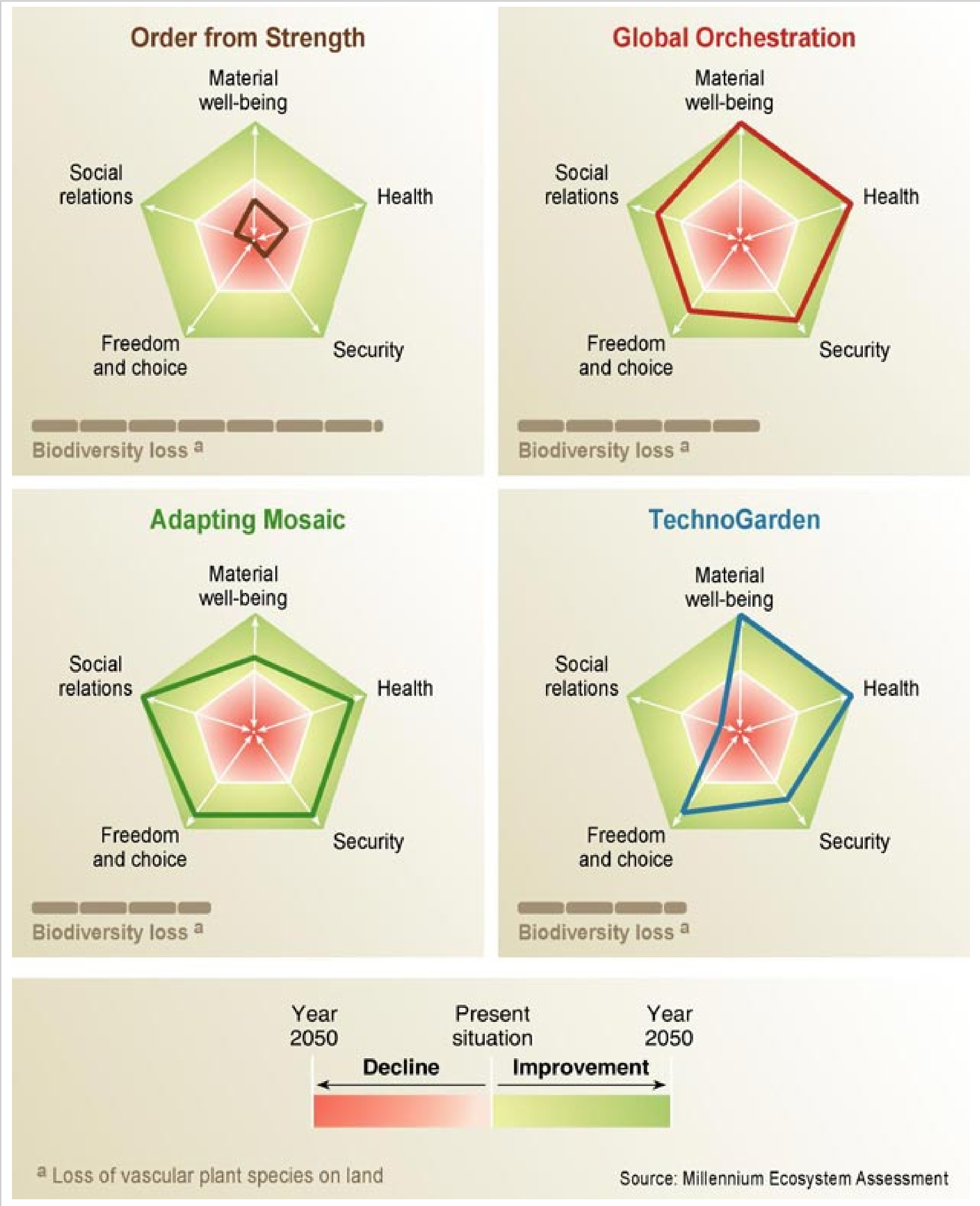


Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.81

Annex 44:

Figure 6.2. Trade-offs between Biodiversity and Human Well-being under the Four MA Scenarios

Loss of biodiversity is least in the two scenarios that feature a proactive approach to environmental management (TechnoGarden [see Annex 50, p. 71] and Adapting Mosaic [see Annex 47, p. 68]). The MA scenario with the worst impacts on biodiversity (high rates of habitat loss and species extinction) is also the one with the worst impacts on human well-being (Order from Strength [see Annex 49, p. 70]). A scenario with relatively positive implications for human well-being (Global Orchestration [see Annex 48, p. 69]) had the second worst implications for biodiversity.



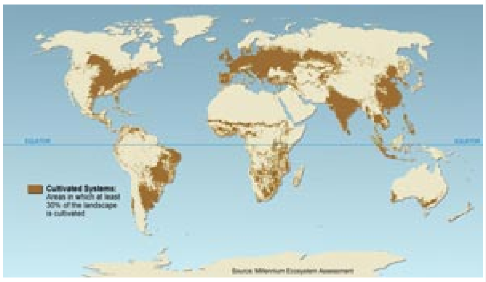
Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis (2005) [see http://www.millenniumassessment.org/proxy/Document.354.aspx] , p.82

Annex 45:

Forest and Cultivated systems

(click image for a larger map of **Forest systems**)
[see Annex 28, p. 51]

"**Forest systems** are lands dominated by trees; they are often used for timber, fuelwood, and non-timber forest products. The map shows areas with a canopy cover of at least 40% by woody plants taller than 5 meters. Forests include temporarily cut-over forests and plantations but exclude orchards and agroforests where the main products are food crops. The global area of forest systems has been reduced by one half over the past three centuries. Forests have effectively disappeared in 25 countries, and another 29 have lost more than 90% of their forest cover. Forest systems are associated with the regulation of 57% of total water runoff. About 4.6 billion people depend for all or some of their water on supplies from forest systems. From 1990 to 2000, the global area of temperate forest increased by almost 3 million hectares per year, while deforestation in the tropics occurred at an average rate exceeding 12 million hectares per year over the past two decades.

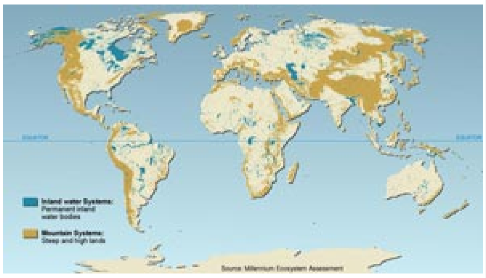


(click image for a larger map of **Cultivated systems**)
[see Annex 12, p. 35]

Cultivated systems are lands dominated by domesticated species and used for and substantially changed by crop, agroforestry, or aquaculture production. The map shows areas in which at least 30% by area of the landscape comes under cultivation in any particular year. Cultivated systems, including croplands, shifting cultivation, confined livestock production, and freshwater aquaculture, cover approximately 24% of total land area. In the last two decades, the major areas of cropland expansion were located in Southeast Asia, parts of South Asia, the Great Lakes region of eastern Africa, the Amazon Basin, and the U.S. Great Plains. The major decreases of cropland occurred in the southeastern United States, eastern China, and parts of Brazil and Argentina. Most of the increase in food demand of the past 50 years has been met by intensification of crop, livestock, and aquaculture systems rather than expansion of production area. In developing countries, over the period 1961–99 expansion of harvested land contributed only 29% to growth in crop production, although in sub-Saharan Africa expansion accounted for two thirds of growth in production. Increased yields of crop production systems have reduced the pressure to convert natural ecosystems into cropland, but intensification has increased pressure on inland water ecosystems, generally reduced biodiversity within agricultural landscapes, and it requires higher energy inputs in the form of mechanization and the production of chemical fertilizers. Cultivated systems provide only 16% of global runoff, although their close proximity to humans means that about 5 billion people depend for all or some of their water on supplies from cultivated systems. Such proximity is associated with nutrient and industrial water pollution."

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 1, pp.29-30

Annex 46:
Inland waters and Mountain systems



(click image for a larger map) [see Annex 29, p. 52]

"**Inland water systems** are permanent water bodies inland from the coastal zone and areas whose properties and use are dominated by the permanent, seasonal, or intermittent occurrence of flooded conditions. Inland waters include rivers, lakes, floodplains, reservoirs, wetlands, and inland saline systems. (Note that the wetlands definition used by the Ramsar Convention includes the MA inland water and coastal system categories.) The biodiversity of inland waters appears to be in a worse condition than that of any other system, driven by declines in both the area of wetlands and the water quality in inland waters. It is speculated that 50% of inland water area (excluding large lakes) has been lost globally. Dams and other infrastructure fragment 60% of the large river systems in the world.

Mountain systems are steep and high lands. The map is based on elevation and, at lower elevations, a combination of elevation, slope, and local topography. Some 20% (or 1.2 billion) of the world's people live in mountains or at their edges, and half of humankind depends, directly or indirectly, on mountain resources (largely water). Nearly all—90%—of the 1.2 billion people in mountains live in countries with developing or transition economies. In these countries, 7% of the total mountain area is currently classified as cropland, and people are often highly dependent on local agriculture or livestock production. About 4 billion people depend for all or some of their water on supplies from mountain systems. Some 90 million mountain people—almost all those living above 2,500 meters—live in poverty and are considered especially vulnerable to food insecurity."

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 1, p.30

Annex 47:
MA Scenarios - Adapting Mosaic

The MA developed four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services, and human well-being. These scenarios are :

Ecosystem Management	World Development	
	Globalization	Regionalization
Reactive	Global Orchestration [see Annex 32, p. 54]	Order from Strength [see Annex 33, p. 55]
Proactive	TechnoGarden [see Annex 34, p. 56]	**Adapting Mosaic**

"The **Adapting Mosaic** scenario, regional watershed-scale ecosystems are the focus of political and economic activity. This scenario sees the rise of local ecosystem management strategies, and the strengthening of local institutions. Investments in human and social capital are geared towards improving knowledge about ecosystem functioning and management, which results in a better understanding of resilience, fragility, and local flexibility of ecosystems. There is optimism that we can learn, but humility about preparing for surprises and about our ability to know everything about managing ecosystems.

There is also great variation among nations and regions in styles of governance, including management of ecosystem services. Some regions explore actively adaptive management, investigating alternatives through experimentation. Others employ bureaucratically rigid methods to optimize ecosystem performance. Great diversity exists in the outcome of these approaches: some areas thrive, while others develop severe inequality or experience ecological degradation. Initially, trade barriers for goods and products are increased, but barriers for information nearly disappear (for those who are motivated to use them) due to improving communication technologies and rapidly decreasing costs of access to information.

Eventually, the focus on local governance leads to failures in managing the global commons. Problems like climate change, marine fisheries, and pollution grow worse and global environmental problems intensify. Communities slowly realize that they cannot manage their local areas because global and regional problems are infringing, and they begin to develop networks among communities, regions, and even nations, to better manage the global commons. Solutions that were effective locally are adopted among networks. These networks of regional successes are especially common in situations where there are mutually beneficial opportunities for coordination, such as along river valleys. Sharing good solutions and discarding poor ones eventually improves approaches to a variety of social and environmental problems, ranging from urban poverty to agricultural water pollution. As more knowledge is collected from successes and failures, provision of many services improves. "

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 5, Box 5.1, pp.72-73

Annex 48:
MA Scenarios - Global Orchestration

The MA developed four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services, and human well-being. These scenarios are :

Ecosystem Management	**World Development**	
	Globalization	**Regionalization**
Reactive	**Global Orchestration**	Order from Strength [see Annex 33, p. 55]
Proactive	TechnoGarden [see Annex 34, p. 56]	Adapting Mosaic [see Annex 31, p. 53]

"The **Global Orchestration** scenario depicts a globally-connected society in which policy reforms that focus on global trade and economic liberalization are used to reshape economies and governance, emphasizing the creation of markets that allow equal participation and provide equal access to goods and services. These policies, in combination with large investments in global public health and the improvement of education worldwide, generally succeed in promoting economic expansion and lifting many people out of poverty into an expanding global middle class. Supra national institutions in this globalized scenario are well-placed to deal with global environmental problems such as climate change and fisheries. However, the reactive approach to ecosystem management favored in this scenario makes people vulnerable to surprises arising from delayed action. While the focus is on improving human well-being of all people, environmental problems that threaten human well-being are only considered after they become apparent.

Growing economies, expansion of education, and growth of the middle class leads to demand for cleaner cities, less pollution, and a more beautiful environment. Rising income levels bring about changes in global consumption patterns, boosting demand for ecosystem services, including agricultural products such as meat, fish, and vegetables. Growing demand for these services leads to declines in other services, as forests are converted into cropped area and pasture, and the services formerly provided by forests decline. The problems related to increasing food production, such as loss of wildlands, are not apparent to most people who live in urban areas. These problems therefore receive only limited attention.

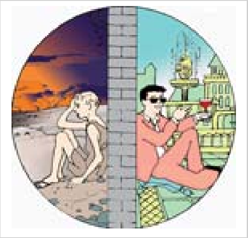
Global economic expansion expropriates or degrades many of the ecosystem services poor people once depended upon for their survival. While economic growth more than compensates for these losses in some regions by increasing our ability to find substitutes for particular ecosystem services, in many other places, it does not. An increasing number of people are impacted by the loss of basic ecosystem services essential for human life. While risks seem manageable in some places, in other places there are sudden, unexpected losses as ecosystems cross thresholds and degrade irreversibly. Loss of potable water supplies, crop failures, floods, species invasions, and outbreaks of environmental pathogens increase in frequency. The expansion of abrupt, unpredictable changes in ecosystems, many with harmful effects on increasingly large numbers of people, is the key challenge facing managers of ecosystem services. "

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 5, Box 5.1, pp.72-73

Annex 49:
MA Scenarios - Order from Strength

The MA developed four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services, and human well-being. These scenarios are :

Ecosystem Management	**World Development**	
	Globalization	**Regionalization**
Reactive	Global Orchestration [see Annex 32, p. 54]	**Order from Strength**
Proactive	TechnoGarden [see Annex 34, p. 56]	Adapting Mosaic [see Annex 31, p. 53]



"The **Order from Strength** scenario represrnts a regionalized and fragmented world, concerned with security and protection, emphasizing primarily regional markets, and paying little attention to common goods. Nations see looking after their own interests as the best defense against economic insecurity, and the movement of goods, people, and information is strongly regulated and policed. The role of government expands as oil companies, water systems, and other strategic businesses are either nationalized or subjected to more state oversight. Trade is restricted, large amounts of money are invested in security systems, and technological change slows due to restrictions on the flow of goods and information. Regionalization exacerbates global inequality.

Treaties on global climate change, international fisheries, and the trade in endangered species are only weakly and haphazardly implemented, resulting in degradation of the global commons. Local problems often go unresolved, but major problems are sometimes handled by rapid disaster relief to at least temporarily resolve the immediate crisis. Many powerful countries cope with local problems by shifting burdens to other, less powerful countries, increasing the gap between rich and poor. In particular, natural resource-intensive industries are moved from wealthier nations to poorer and less powerful ones. Inequality increases considerably within countries as well.

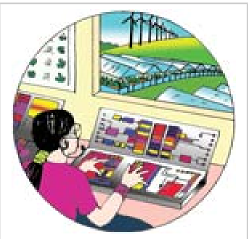
Ecosystem services become more vulnerable, fragile, and variable in Order from Strength. For example, parks and reserves exist within fixed boundaries, but climate changes around them, leading to the unintended extirpation of many species. Conditions for crops are often suboptimal, and the ability of societies to import alternative foods is diminished by trade barriers. As a result, there are frequent shortages of food and water, particularly in poor regions. Low levels of trade tend to restrict the number of invasions by exotic species; however, ecosystems are less resilient and invaders are therefore more often successful when they arrive."

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Cahpter 5, Box 5.1, pp.72-73

Annex 50:
MA Scenarios - TechnoGarden

The MA developed four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services, and human well-being. These scenarios are :

Ecosystem Management	World Development	
	Globalization	Regionalization
Reactive	Global Orchestration [see Annex 32, p. 54]	Order from Strength [see Annex 33, p. 55]
Proactive	**TechnoGarden**	Adapting Mosaic [see Annex 31, p. 53]



"The **TechnoGarden** scenario depicts a globally connected world relying strongly on technology and highly managed, often engineered ecosystems, to deliver ecosystem services. Overall efficiency of ecosystem service provision improves, but is shadowed by the risks inherent in large-scale human-made solutions and rigid control of ecosystems. Technology and market-oriented institutional reform are used to achieve solutions to environmental problems. These solutions are designed to benefit both the economy and the environment. These changes co-develop with the expansion of property rights to ecosystem services, such as requiring people to pay for pollution they create or paying people for providing key ecosystem services through actions such as preservation of key watersheds.

Interest in maintaining, and even increasing, the economic value of these property rights, combined with an interest in learning and information, leads to a flowering of ecological engineering approaches for managing ecosystem services. Investment in green technology is accompanied by a significant focus on economic development and education, improving people's lives and helping them understand how ecosystems make their livelihoods possible.

A variety of problems in global agriculture are addressed by focusing on the multifunctional aspects of agriculture and a global reduction of agricultural subsidies and trade barriers. Recognition of the role of agricultural diversification encourages farms to produce a variety of ecological services, rather than simply maximizing food production. The combination of these movements stimulates the growth of new markets for ecosystem services, such as tradable nutrient runoff permits, and the development of technology for increasingly sophisticated ecosystem management. Gradually, environmental entrepreneurship expands as new property rights and technologies co-evolve to stimulate the growth of companies and cooperatives providing reliable ecosystem services to cities, towns, and individual property owners.

Innovative capacity expands quickly in developing nations. The reliable provision of ecosystem services, as a component of economic growth, together with enhanced uptake of technology due to rising income levels, lifts many of the world's poor into a global middle class. Elements of human well-being associated with social relations decline in this scenario due to great loss of local culture, customs, and traditional knowledge that occurs and due to the weakening of civil society institutions as an increasing share of interactions take place over the Internet. While the provision of basic ecosystem services improves the well-being of the world's poor, the reliability of the services, especially in urban areas, is increasingly critical and increasingly difficult to ensure. Not every problem has succumbed to technological innovation. Reliance on technological solutions sometimes creates new problems and vulnerabilities. In some cases, we seem to be barely ahead of the next threat to ecosystem services. In such cases new problems often seem to emerge from the last solution, and the costs of managing the environment are continually rising. Environmental breakdowns that impact large numbers of people become more common. Sometimes new problems seem to emerge faster than solutions. The challenge for the future will be to learn how to organize social-ecological systems so that ecosystem services are maintained without taxing society's ability to implement solutions to novel, emergent problems. "

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 5, Box 5.1, pp.72-73

Annex 51:
MA Systems

Findings of the Millennium Ecosystem Assessment (MA) reports findings for 10 categories of the land and marine surface, which are refered to as “systems”:

- forest systems [see Annex 27, p. 50] ,
- cultivated systems [see Annex 27, p. 50] ,
- dryland systems [see Annex 51, p. 72] ,
- coastland systems [see Annex 36, p. 58] ,
- marine systems [see Annex 36, p. 58] ,
- urban systems [see Annex 51, p. 72] ,
- polar systems [see Annex 51, p. 72] ,
- inland water systems [see Annex 30, p. 52] (which include freshwater systems),
- island systems [see Annex 36, p. 58] and
- mountain systems [see Annex 30, p. 52] .

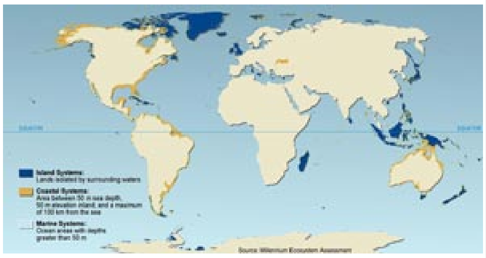
"Each category contains a number of ecosystems. However, ecosystems within each category share a suite of biological, climatic, and social factors that tend to be similar within categories and differ across categories.

The MA reporting categories are not spatially exclusive; their areas often overlap. For example, transition zones between forest and cultivated lands are included in both the forest system and cultivated system reporting categories.

These reporting categories were selected because they correspond to the regions of responsibility of different government ministries (such as agriculture, water, forestry, and so forth) and because they are the categories used within the Convention on Biological Diversity."

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 5, Box 1.1, pp.27-30

Annex 52:
Marine, Coastal and Island systems



(click image for a larger map) [see Annex 37, p. 59]

"**Marine systems** are the world's oceans. For mapping purposes, the map shows ocean areas where the depth is greater than 50 meters. Global fishery catches from marine systems peaked in the late 1980s and are now declining despite increasing fishing effort.

Coastal systems refer to the interface between ocean and land, extending seawards to about the middle of the continental shelf and inland to include all areas strongly influenced by proximity to the ocean. The map shows the area between 50 meters below mean sea level and 50 meters above the high tide level or extending landward to a distance 100 kilometers from shore. Coastal systems include coral reefs, intertidal zones, estuaries, coastal aquaculture and sea grass communities Nearly half of the world's major cities (having more than 500,000 people) are located within 50 kilometers of the coast, and coastal population densities are 2.6 times larger than the density of inland areas. By all commonly used measures, the human well-being of coastal inhabitants is on average much higher than that of inland communities.

Islands are lands (both continental and oceanic) isolated by surrounding water and with a high proportion of coast to hinterland. For mapping purposes, the MA uses the ESRI ArcWorld Country Boundary dataset, which contains nearly 12,000 islands. Islands smaller than 1.5 hectares are not mapped or included in the statistics. The largest island included is Greenland. The map above includes islands within 2km of the mainland (e.g., Long Island in the United States) but the statistics provided for island systems in this report exclude these islands. Island states together with their exclusive economic zones cover 40% of the world's oceans. Island systems are especially sensitive to disturbances, and the majority of recorded extinctions have occurred on island systems, although this pattern is changing, and over the past 20 years as many extinctions have occurred on continents as on islands."

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005),
Chapter 1, p.27

Annex 53:

Table 1.1. Ecological Surprises Caused by Complex Interactions

Voluntary or involuntary introductions or deletions of species often trigger unexpected alterations in the normal provision of ecosystem services by terrestrial, freshwater, and marine ecosystems. In all cases, the community and ecosystem alterations have been the consequence of indirect interactions among three or more species (C11 [see Annex 4, p. 29] , Table 11.2).

Study Case	Nature of the Interaction Involved	Ecosystem Service Consequences
Introductions		
Top predators		
Introduction of brown trout (*Salmo trutta*) in New Zealand for angling	trophic cascade, predator increased primary producers by decreasing herbivores	**negative—** increased eutrophication
Introduction of bass (*Cichla ocellaris*) in Gatun Lake, Panama	trophic cascade, top predator decreased control by predators of mosquito larvae	**negative—** decreased control of malaria vector
IIntroduction of pine marten (*Martes martes*) in the Balearic Islands, Spain	predator of frugivorous lizards (main seed dipersers)	**negative—** decreased diversity of frugivorous lizards due to extinction of native lizards on some islands; changes in dominant shrub (*Cneorum tricoccon*) distribution because marten replaced the frugivorous-dispersing role
Intraguild predators		
Egg parasitoid (*Anastatus kashmirensis*) to control gypsy moth (*Lymantria dispar*)	hyperparasitism (parasitoids that use parasitoids as hosts)	**negative—** disruption of biological control of pests; introduced parasitoid poses risk of hyperparasitism to other pest-regulating native parasitoids
Gambusia and *Lepomis* fish in rice fields to combat mosquitoes	intraguild predator (adult fish feed on juveniles as well as on mosquito larvae)	**opposed to goal—** decreased control of disease vector (mosquito)
Intraguild preys		
Opossum shrimp (*Mysis relicta*) in Canadian lakes to increase fish production	intraguild prey depletes shared zooplankton prey	**opposed to goal—** decreased salmonid fish production
Apparent competitors		
Rats (*Rattus spp*) and cats (*Felis catus*) in Steward Island, New Zealand	rats induced high cat densities and increased predation on endangered flightless parrot (*Strigops habroptilus*)	**negative—** reduced diversity
Herbivores		
Zebra mussel (*Dreissena polymorpha*) in Great Lakes, United States	zebra mussel reduced phytoplankton and outcompeted native bivalves	**negative—** reduced diversity **positive—** increased water quality
Mutualists		
Myna bird (*Acridotheres tristis*) for worm pest control in Hawaiian sugarcane plantations	myna engaged in the dispersal of the exotic woody weed *Lantana camara*	**negative—** increased invasion by *Lantana* produced impenetrable thorny thickets; reduced agricultural crops and pasture carrying capacity and sometimes increased fire risk; displaced habitat of native birds
Ecosystem engineers		
Earthworm (*Pontoscolex corethrurus*)in Amazonian tropical forests converted to pasture	dramatically reduces soil macroporosity and gas exchange capacity	**negative—** reduces soil macrofaunal diversity and increases soil methane emissions
C_4 perennial grasses *Schizachyrium condesatum, Melinis minutiflora* in Hawaii for pasture improvement	increased fuel loads, fuel distribution, and flammability	**negative—** increases fire frequency, affecting fire-sensitive plants; reduced plant diversity; positive feedback for further invasion of flammable exotic species on burned areas
Nitrogen-fixing firetree (*Myrica faya*) in Hawaii	increases soil nitrogen levels in newly formed nitrogen-poor volcanic soils	**negative—** increased fertility, increased invasion by other exotics, reduced regeneration of native *Metrosideros* tree, alteration of successional patterns
Deletions/Harvesting		
Top predators		
Selective harvesting of piscivorous fishes in Canadian lakes	piscivorus fishes promote *Daphnia* that effectively suppresses primary (algal) production	**negative—** shifts from net carbon sinks in piscivorous-dominated to equilibrium or net carbon sources in planktivorous-dominated lake
Sea otter (*Enhydra lutris*) harvesting near extinction in southern California	cascading effects produced reductions of kelp forests and the kelp-dependent community	**negative—** loss of biodiversity of kelp habitat users
Pollution-induced reductions in predators of nematodes in forest soils	heavy metal bioaccumulation produced reductions nematophagous predators and increased herbivorous nematodes	**negative—** disruption of forest soil food webs; increases in belowground herbivory; decrease in forest productivity
Intraguild predators		
Declining populations of coyote (*Canis latrans*) in southern California	releases in raccoons (*Procyon lotor*) and feral house cats	**negative—** threat to native bird populations
Overhavesting of seals and sea lions in Alaska	diet shifts of killer whales increased predation on sea otters	**negative—** conflict with other restoration programs; failure of reintroduction of sea otters to restore kelp forest ecosystems
Keystone predators		
Harvesting of triggerfish (*Balistaphus*) in Kenyan coral reefs	triggerfish declines release sea urchins, which outcompete herbivorous fish	**negative—** increased bioerosion of coral substrates; reduced calcium carbonate deposition

Study Case	Nature of the Interaction Involved	Ecosystem Service Consequences
Herbivores		
Voluntary removal of sheep and cattle in Santa Cruz Island, United States, for restoration	release of the exotic plant component from top-down control	**opposite to goal—** explosive increases in exotic herbs and forbs and little recovery of native plant species
Overhavesting of seals and sea lions in Alaska	lack of fish grazers allowed macroalgae to outcompete coral following disturbances	**negative—** coral cover was reduced from 52% to 3%, and macroalgae increased from 4% to 92%
Ecosystem engineers		
Voluntary removal of exotic tamarisk (*Tamariscus* sp.) for restoration of riparian habitats in Mediterranean deserts	long-established tamarisk has replaced riparian vegetation and serves as habitat to endangered birds	**opposite to goal—** reduction in biodiversity; structural changes in riparian habitats

Source: Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.26-27

Annex 54:

Table 2.1. Percentage of Households Dependent on Indigenous Plant-based Coping Mechanisms at Kenyan and Tanzanian Site

(C6 [see Annex 4, p. 29] Table 6.4)

Activities that Involve Use of Indigenous Plants	Share of Households, Kenya site	Share of Households, Tanzania site
	(percent)	(percent)
All use	94	94
Food use	69	54
Non-food use	40	42

Source: MA Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.26-27

Annex 55:

Table 2.2. Trends in the Human Use of Ecosystem Services and Enhancement or Degradation of the Service Around the Year 2000 - Provisioning services

Legend

↑	= Increasing (for Human Use column) or enhanced (for Enhanced or Degraded column)
↓	= Decreasing (for Human Use column) or degraded (for Enhanced or Degraded column)
+/-	= Mixed (trend increases and decreases over past 50 years or some components/regions increase while others decrease

Click on the links below for similar tables on:

Regulating services [see Annex 56, p. 79]

Cultural services [see Annex 57, p. 81]

Supporting services [see Annex 58, p. 83]

Service	Sub-category	Human Use (a)	Enhanced or Degraded (b)	Notes
Provisioning Services				
Food	Crops	↑	↑	Food provision has grown faster than overall population growth. Primary source of growth from increase in production per unit area but also significant expansion in cropland. Still persistent areas of low productivity and more rapid area expansion, e.g., sub-Saharan Africa and parts of Latin America.
	Livestock	↑	↑	Significant increase in area devoted to livestock in some regions, but major source of growth has been more-intensive, confined production of chicken, pigs, and cattle.
	Capture Fisheries	↓	↓	Marine fish harvest increased until the late 1980s and has been declining since then. Currently, one quarter of marine fish stocks are overexploited or significantly depleted. Freshwater capture fisheries have also declined. Human use of capture fisheries has declined because of the reduced supply, not because of reduced demand.
	Aquaculture	↑	↑	Aquaculture has become a globally significant source of food in the last 50 years and, in 2000, contributed 27% of total fish production. Use of fish feed for carnivorous aquaculture species places an additional burden on capture fisheries.
	Wild plants and animal food products	**NA**	↓	Provision of these food sources is generally declining as natural habitats worldwide are under increasing pressure and as wild populations are exploited for food, particularly by the poor, at unsustainable levels.
Fiber	Timber	↑	+/-	Global timber production has increased by 60% in the last four decades. Plantations provide an increasing volume of harvested roundwood, amounting to 35% of the global harvest in 2000. Roughly 40% of forest area has been lost during the industrial era, and forests continue to be lost in many regions (thus the service is degraded in those regions), although forest is now recovering in some temperate countries and thus this service has been enhanced (from this lower baseline) in these regions in recent decades.
	Cotton, hemp, silk	+/-	+/-	Cotton and silk production have doubled and tripled respectively in the last four decades. Production of other agricultural fibers has declined.
	Wood fuel	+/-	↓	Global consumption of fuelwood appears to have peaked in the 1990s and is now believed to be slowly declining but remains the dominant source of domestic fuel in some regions.
Genetic resources		↑	↓	Traditional crop breeding has relied on a relatively narrow range of germplasm for the major crop species, although molecular genetics and biotechnology provide new tools to quantify and expand genetic diversity in these crops. Use of genetic resources also is growing in connection with new industries based on biotechnology. Genetic resources have been lost through the loss of traditional cultivars of crop species (due in part to the adoption of modern farming practices and varieties) and through species extinctions.
Biochemicals, natural medicines, and pharmaceuticals		↑	↓	Demand for biochemicals and new pharmaceuticals is growing, but new synthetic technologies compete with natural products to meet the demand. For many other natural products (cosmetics, personal care, bioremediation, biomonitoring, ecological restoration), use is growing. Species extinction and overharvesting of medicinal plants is diminishing the availability of these resources.
Ornamental resources		**NA**	**NA**	

Service	Sub-category	Human Use (a)	Enhanced or Degraded (b)	Notes
Freshwater		↑	↓	Human modification to ecosystems (e.g., reservoir creation) has stabilized a substantial fraction of continental river flow, making more fresh water available to people but in dry regions reducing river flows through open water evaporation and support to irrigation that also loses substantial quantities of water. Watershed management and vegetation changes have also had an impact on seasonal river flows. From 5% to possibly 25% of global freshwater use exceeds long-term accessible supplies and requires supplies either through engineered water transfers or overdraft of groundwater supplies. Between 15% and 35% of irrigation withdrawals exceed supply rates. Freshwater flowing in rivers also provides a service in the form of energy that is exploited through hydropower. The construction of dams has not changed the amount of energy, but it has made the energy more available to people. The installed hydroelectric capacity doubled between 1960 and 2000. Pollution and biodiversity loss are defining features of modern inland water systems in many populated parts of the world.

* = Low to medium certainty. All other trends are medium to high certainty.

NA = Not assessed within the MA. In some cases, the service was not addressed at all in the MA (such as ornamental resources), while in other cases the service was included but the information and data available did not allow an assessment of the pattern of human use of the service or the status of the service.

† = The categories of "Human Benefit" and "Enhanced or Degraded" do not apply for supporting services since, by definition, these services are not directly used by people. (Their costs or benefits would be double-counted if the indirect effects were included). Changes in supporting services influence the supply of provisioning, cultural, or regulating services that are then used by people and may be enhanced or degraded.

a For provisioning services, human use increases if the human consumption of the service increases (e.g., greater food consumption); for regulating and cultural services, human use increases if the number of people affected by the service increases. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

b For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating and supporting services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of a regulating and supporting services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., *mangroves* loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, enhancement refers to a change in the ecosystem features that increase the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

Source: MA Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.33-37

Annex 56:

Table 2.2. Trends in the Human Use of Ecosystem Services and Enhancement or Degradation of the Service Around the Year 2000 - Regulating services

Legend

↑	= Increasing (for Human Use column) or enhanced (for Enhanced or Degraded column)
↓	= Decreasing (for Human Use column) or degraded (for Enhanced or Degraded column)
+/-	= Mixed (trend increases and decreases over past 50 years or some components/regions increase while others decrease

Click on the links below for similar tables on:

Provisioning services [see Annex 55, p. 77]

Cultural services [see Annex 57, p. 81]

Supporting services [see Annex 58, p. 83]

Service	Sub-category	Human Use (a)	Enhanced or Degraded (b)	Notes
Regulating Services				
Air quality regulation		↑	↓	The ability of the atmosphere to cleanse itself of pollutants has declined slightly since pre-industrial times but likely not by more than 10%. The net contribution of ecosystems to this change is not known. Ecosystems are also a sink for tropospheric ozone, ammonia, NO_x, SO_2, particulates, and CH_4, but changes in these sinks were not assessed. (C13.ES [see Annex 4, p. 29])
Climate regulation	Global	↑	↑	Terrestrial ecosystems were on average a net source of CO_2 during the nineteenth and early twentieth century, and became a net sink sometime around the middle of the last century. The biophysical effect of historical *land cover* changes (1750 to present) is net cooling on a global scale due to increased albedo, partially offsetting the warming effect of associated CO_2 emissions from land cover change over much of that period. (C13.ES [see Annex 4, p. 29])
	Regional and Local	↑	↓	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. (C13.3, C11.3 [see Annex 4, p. 29])
Water regulation		↑	+/-	The effect of ecosystem change on the timing and magnitude of runoff, flooding, and aquifer recharge depends on the specific change and the specific ecosystem. (C7.4.4 [see Annex 4, p. 29])
Erosion regulation		↑	↓	Land use and crop/soil management practices have exacerbated soil degradation and erosion, although appropriate soil conservation practices that reduce erosion, such as minimum tillage, are increasingly being adopted by farmers in North America and Latin America. (C26 [see Annex 4, p. 29])
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. The capacity of ecosystems to purify such wastes is limited, as evidenced by widespread reports of inland waterway pollution. Loss of wetlands has further decreased the ability of ecosystems to filter and decompose wastes. (C7.2.5, C19 [see Annex 4, p. 29])
Disease regulation		↑	+/-	Ecosystem modifications associated with development have often increased the local incidence of infectious diseases, although major changes in habitats can both increase or decrease the risk of particular infectious diseases. (C14 [see Annex 4, p. 29])
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. In other systems, pest control provided by natural enemies is being used and enhanced through integrated pest management. Crops containing pest-resistant genes can also reduce the need for application of toxic synthetic pesticides. (C11.3 [see Annex 4, p. 29])
Pollination		↑	↓	There is established but incomplete evidence of a global decline in the abundance of pollinators. Pollinator declines have been reported in at least one region or country on every continent except for Antarctica, which has no pollinators. Declines in abundance of pollinators have rarely resulted in complete failure to produce seed or fruit, but more frequently resulted in fewer seeds or in fruit of reduced viability or quantity. Losses in populations of specialized pollinators have directly affected the reproductive ability of some rare plants. (C11 [see Annex 4, p. 29] Box 11.2)

Service	Sub-category	Human Use (a)	Enhanced or Degraded (b)	Notes
Natural hazard regulation				People are increasingly occupying regions and localities that are exposed to extreme events, thereby exacerbating human vulnerability to natural hazards. This trend, along with the decline in the capacity of ecosystems to buffer from extreme events, has led to continuing high loss of life globally and rapidly rising economic losses from natural disasters. (C16,C19 [see Annex 4, p. 29])

* = Low to medium certainty. All other trends are medium to high certainty.

NA = Not assessed within the MA. In some cases, the service was not addressed at all in the MA (such as ornamental resources), while in other cases the service was included but the information and data available did not allow an assessment of the pattern of human use of the service or the status of the service.

† = The categories of “Human Benefit” and “Enhanced or Degraded” do not apply for supporting services since, by definition, these services are not directly used by people. (Their costs or benefits would be double-counted if the indirect effects were included). Changes in supporting services influence the supply of provisioning, cultural, or regulating services that are then used by people and may be enhanced or degraded.

a For provisioning services, human use increases if the human consumption of the service increases (e.g., greater food consumption); for regulating and cultural services, human use increases if the number of people affected by the service increases. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

b For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating and supporting services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of a regulating and supporting services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., *mangroves* loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, enhancement refers to a change in the ecosystem features that increase the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

Source: MA Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.33-37

Annex 57:

Table 2.2. Trends in the Human Use of Ecosystem Services and Enhancement or Degradation of the Service Around the Year 2000 - Cultural services

Legend

↑	= Increasing (for Human Use column) or enhanced (for Enhanced or Degraded column)
↓	= Decreasing (for Human Use column) or degraded (for Enhanced or Degraded column)
+/-	= Mixed (trend increases and decreases over past 50 years or some components/regions increase while others decrease

Click on the links below for similar tables on:

Provisioning services [see Annex 55, p. 77]

Regulating services [see Annex 56, p. 79]

Supporting services [see Annex 58, p. 83]

Service	Human Use (a)	Enhanced or Degraded (b)	Notes
Cultural services			
Cultural diversity	NA	NA	
Spiritual and religious values	↑	↓	There has been a decline in the numbers of sacred groves and other such protected areas. The loss of particular ecosystem attributes (sacred species or sacred forests), combined with social and economic changes, can sometimes weaken the spiritual benefits people obtain from ecosystems. On the other hand, under some circumstances (e.g., where ecosystem attributes are causing significant threats to people), the loss of some attributes may enhance spiritual appreciation for what remains. (C17.2.3 [see Annex 4, p. 29])
Knowledge systems	NA	NA	
Educational values	NA	NA	
Inspiration	NA	NA	
Aesthetic values	↑	↓	The demand for aesthetically pleasing natural landscapes has increased in accordance with increased urbanization. There has been a decline in quantity and quality of areas to meet this demand. A reduction in the availability of and access to natural areas for urban residents may have important detrimental effects on public health and economies. (C17.2.5 [see Annex 4, p. 29])
Social relations	NA	NA	
Sense of place	NA	NA	
Cultural heritage values	NA	NA	
Recreation and ecotourism	↑	+/-	The demand for recreational use of landscapes is increasing, and areas are increasingly being managed to cater for this use, to reflect changing cultural values and perceptions. However, many naturally occurring features of the landscape (e.g., coral reefs) have been degraded as resources for recreation. (C17.2.6, C19.?? [see Annex 4, p. 29])

* = Low to medium certainty. All other trends are medium to high certainty.

NA = Not assessed within the MA. In some cases, the service was not addressed at all in the MA (such as ornamental resources), while in other cases the service was included but the information and data available did not allow an assessment of the pattern of human use of the service or the status of the service.

† = The categories of “Human Benefit” and “Enhanced or Degraded” do not apply for supporting services since, by definition, these services are not directly used by people. (Their costs or benefits would be double-counted if the indirect effects were included). Changes in supporting services influence the supply of provisioning, cultural, or regulating services that are then used by people and may be enhanced or degraded.

a For provisioning services, human use increases if the human consumption of the service increases (e.g., greater food consumption); for regulating and cultural services, human use increases if the number of people affected by the service increases. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

b For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating and supporting services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of a regulating and supporting services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., *mangroves* loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, enhancement refers to a change in the ecosystem features that increase the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

Source: MA Millennium Ecosystem Assessment
Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.33-37

Annex 58:

Table 2.2. Trends in the Human Use of Ecosystem Services and Enhancement or Degradation of the Service Around the Year 2000 - Supporting services

Legend

↑	= Increasing (for Human Use column) or enhanced (for Enhanced or Degraded column)
↓	= Decreasing (for Human Use column) or degraded (for Enhanced or Degraded column)
+/-	= Mixed (trend increases and decreases over past 50 years or some components/regions increase while others decrease

Click on the links below for similar tables on:

Provisioning services [see Annex 55, p. 77]

Regulating services [see Annex 56, p. 79]

Cultural services [see Annex 57, p. 81]

Service	Human Use (a)	Enhanced or Degraded (b)	Notes
Supporting services			
Soil formation	†	†	
Photosynthesis	†	†	
Primary production	†	†	Several global MA systems [see Annex 51, p. 72] , including drylands [see Annex 60, p. 86] , forest, and cultivated systems [see Annex 45, p. 66] , show a trend of NPP increase for the period 1981 to 2000. However, high seasonal and inter-annual variations associated with climate variability occur within this trend on the global scale (C22.2.1 [see Annex 4, p. 29])
Nutrient cycling	†	†	There have been large-scale changes in nutrient cycles in recent decades, mainly due to additional inputs from fertilizers, livestock waste, human wastes, and biomass burning. Inland water and coastal systems have been increasingly affected by eutrophication due to transfer of nutrients from terrestrial to aquatic systems as biological buffers that limit these transfers have been significantly impaired. (C12 [see Annex 4, p. 29] , S7 [see Annex 4, p. 29])
Water cycling	†	†	Humans have made major changes to water cycles through structural changes to rivers, extraction of water from rivers, and, more recently, climate change. (C7 [see Annex 4, p. 29])

* = Low to medium certainty. All other trends are medium to high certainty.

NA = Not assessed within the MA. In some cases, the service was not addressed at all in the MA (such as ornamental resources), while in other cases the service was included but the information and data available did not allow an assessment of the pattern of human use of the service or the status of the service.

† = The categories of “Human Benefit” and “Enhanced or Degraded” do not apply for supporting services since, by definition, these services are not directly used by people. (Their costs or benefits would be double-counted if the indirect effects were included). Changes in supporting services influence the supply of provisioning, cultural, or regulating services that are then used by people and may be enhanced or degraded.

a For provisioning services, human use increases if the human consumption of the service increases (e.g., greater food consumption); for regulating and cultural services, human use increases if the number of people affected by the service increases. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

b For provisioning services, we define enhancement to mean increased production of the service through changes in area over which the service is provided (e.g., spread of agriculture) or increased production per unit area. We judge the production to be degraded if the current use exceeds sustainable levels. For regulating and supporting services, enhancement refers to a change in the service that leads to greater benefits for people (e.g., the service of disease regulation could be improved by eradication of a vector known to transmit a disease to people). Degradation of a regulating and supporting services means a reduction in the benefits obtained from the service, either through a change in the service (e.g., *mangroves* loss reducing the storm protection benefits of an ecosystem) or through human pressures on the service exceeding its limits (e.g., excessive pollution exceeding the capability of ecosystems to maintain water quality). For cultural services, enhancement refers to a change in the ecosystem features that increase the cultural (recreational, aesthetic, spiritual, etc.) benefits provided by the ecosystem. The time frame is in general the past 50 years, although if the trend has changed within that time frame the indicator shows the most recent trend.

Source: MA Millennium Ecosystem Assessment

Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.33-37

Annex 59:

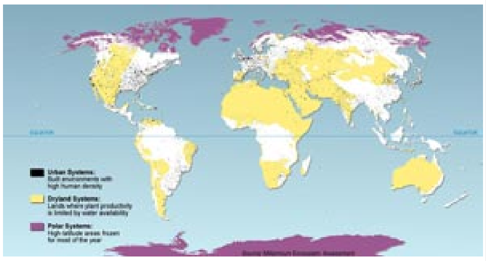
Table 6.1. Prospects for Attaining the 2010 Sub-targets Agreed to under the Convention on Biological Diversity

Goals and Targets	Prospects for Progress by 2010
Protect the components of biodiversity	
Goal 1. Promote the conservation of the biological diversity of ecosystems, habitats, and biomes. Target 1.1: At least 10% of each of the world's ecological regions effectively conserved. Target 1.2: Areas of particular importance to biodiversity protected.	Good prospects for most terrestrial regions. Major challenge to achieve for marine regions. Difficult to provide adequate protection of inland water systems.
Goal 2. Promote the conservation of species diversity. Target 2.1: Restore, maintain, or reduce the decline of populations of species of selected taxonomic groups. Target 2.2: Status of threatened species improved.	Many species will continue to decline in abundance and distribution, but restoration and maintenance of priority species possible. More species will become threatened, but species-based actions will improve status of some.
Goal 3. Promote the conservation of genetic diversity. Target 3.1: Genetic diversity of crops, livestock, and harvested species of trees, .sh, and wildlife and other valuable species conserved, and associated indigenous and local knowledge maintained.	Good prospects for ex situ conservation. Overall, agricultural systems likely to continue to be simplified. Signi.cant losses of fish genetic diversity likely. Genetic resources in situ and traditional knowledge will be protected through some projects, but likely to decline overall.
Promote sustainable use	
Goal 4. Promote sustainable use and consumption. Target 4.1: Biodiversity-based products derived from sources that are sustainably managed, and production areas managed consistent with the conservation of biodiversity. Target 4.2: Unsustainable consumption of biological resources or that has an impact on biodiversity reduced. Target 4.3: No species of wild flora or fauna endangered by international trade.	Progress expected for some components of biodiversity. Sustainable use unlikely to be a large share of total products and production areas. Unsustainable consumption likely to increase. Progress possible, for example through implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora.
Address threats to biodiversity	
Goal 5. Pressures from habitat loss, land use change and degradation, and unsustainable water use reduced. Target 5.1: Rate of loss and degradation of natural habitats decreased.	Unlikely to reduce overall pressures in the most biodiversity-sensitive regions. However, proactive protection of some of the most important sites is possible.
Goal 6. Control threats from invasive alien species. Target 6.1: Pathways for major potential alien invasive species controlled. Target 6.2: Management plans in place for major alien species that threaten ecosystems, habitats, or species.	Pressure is likely to increase (from greater transport, trade, and tourism, especially in *Global Orchestration* [see Annex 48, p. 69] scenario). Measures to address major pathways could be put in place (especially in *Global Orchestration* and *TechnoGarden* [see Annex 50, p. 71] scenarios). Management plans could be developed.
Goal 7. Address challenges to biodiversity from climate change and pollution. Target 7.1: Maintain and enhance resilience of the components of biodiversity to adapt to climate change. Target 7.2: Reduce pollution and its impacts on biodiversity.	Pressures from both climate change and pollution, especially nitrogen deposition, will increase. These increases can be mitigated under UNFCCC for climate change and through agricultural and trade policy, as well as through energy policy for nitrogen pollution. Mitigation measures include carbon sequestration through LULUCF and use of wetlands to sequester or denitrify reactive nitrogen. Proactive measures to reduce impacts on biodiversity possible, but challenging given other pressures.
Maintain goods and services from biodiversity to support human well-being	
Goal 8. Maintain capacity of ecosystems to deliver goods and services and support livelihoods. Target 8.1: Capacity of ecosystems to deliver goods and services maintained. Target 8.2: Biological resources that support sustainable livelihoods, local food security, and health care, especially of poor people, maintained.	Given expected increases in drivers, can probably be achieved only on a selective basis by 2010. Attainment of target 8.2 would contribute to the achievement of the MDG 2015 targets, especially targets 1, 2, and 9.
Protect traditional knowledge, innovations and practices	
Goal 9. Maintain sociocultural diversity of indigenous and local communities. Target 9.1: Protect traditional knowledge, innovations, and practices. Target 9.2: Protect the rights of indigenous and local communities over their traditional knowledge, innovations, and practices, including their rights to bene.t sharing.	It is possible to take measures to protect traditional knowledge and rights, but continued long-term decline in traditional knowledge likely.
Ensure the fair and equitable sharing of benefits arising out of the use of genetic resources	
Goal 10. Ensure the fair and equitable sharing of benefits arising out of the use of genetic resources. Target 10.1: All transfers of genetic resources are in line with the CBD, the International Treaty on Plant Genetic Resources for Food and Agriculture, and other applicable agreements. Target 10.2: Bene.ts arising from the commercial and other utilization of genetic resources shared with the countries providing such resources.	Progress is possible. In the MA scenarios, more equitable outcomes were obtained under the *Global Orchestration* [see Annex 48, p. 69] and *TechnoGarden* [see Annex 50, p. 71] scenarios, but were not achieved under *Order from Strength* [see Annex 49, p. 70] .
Ensure provision of adequate resources	
Goal 11. Parties have improved financial, human, scientific, technical, and technological capacity to implement the Convention. Target 11.1: New and additional financial resources are transferred to developing-country Parties to allow for the effective implementation of their commitments under the Convention, in accordance with Article 20. Target 11.2: Technology is transferred to developing-country Parties to allow for the effective implementation of their commitments under the Convention, in accordance with Article 20.	Progress is possible. In the MA scenarios, this outcome would be more likely under the *Global Orchestration* [see Annex 48, p. 69] and *TechnoGarden* [see Annex 50, p. 71] scenarios, but is less likely to be achieved through *Adapting Mosaic* [see Annex 47, p. 68] and would not be achieved under *Order from Strength* [see Annex 49, p. 70] .

Source: MA Millennium Ecosystem Assessment

Ecosystems and Human Well-being: Biodiversity Synthesis [see http://www.millenniumassessment.org/proxy/Document.354.aspx] (2005), p.26-27

Annex 60:
Urban, Dryland and Polar systems



(click image for a larger map) [see Annex 50, p. 71]

"**Urban systems** are built environments with a high human density. For mapping purposes, the MA uses known human settlements with a population of 5,000 or more, with boundaries delineated by observing persistent night-time lights or by inferring areal extent in the cases where such observations are absent. The world's urban population increased from about 200 million in 1900 to 2.9 billion in 2000, and the number of cities with populations in excess of 1 million increased from 17 in 1900 to 388 in 2000.

Dryland systems are lands where plant production is limited by water availability; the dominant human uses are large mammal herbivory, including livestock grazing, and cultivation. The map shows drylands as defined by the U.N. Convention to Combat Desertification, namely lands where annual precipitation is less than two thirds of potential evapotranspiration—from dry subhumid areas (ratio ranges 0.50–0.65) through semiarid, arid, and hyperarid (ratio < 0.05), but excluding polar areas. Drylands include cultivated lands, scrublands, shrublands, grasslands, savannas, semi-deserts, and true deserts. Dryland systems cover about 41% of Earth's land surface and are inhabited by more than 2 billion people (about one third of the total population). Croplands cover approximately 25% of drylands, and dryland rangelands support approximately 50% of the world's livestock. The current socioeconomic condition of people in dryland systems, of which about 90% are in developing countries, is worse than in other areas. Freshwater availability in drylands is projected to be further reduced from the current average of 1,300 cubic meters per person per year in 2000, which is already below the threshold of 2,000 cubic meters required for minimum human well-being and sustainable development. Approximately 10–20% of the world's drylands are degraded (medium certainty).

Polar systems are high-latitude systems frozen for most of the year, including ice caps, areas underlain by permafrost, tundra, polar deserts, and polar coastal areas. Polar systems do not include high-altitude cold systems in low latitudes. Temperature in polar systems is on average warmer now than at any time in the last 400 years, resulting in widespread thaw of permafrost and reduction of sea ice. Most changes in feedback processes that occur in polar regions magnify trace gas–induced global warming trends and reduce the capacity of polar regions to act as a cooling system for Earth. Tundra constitutes the largest natural wetland in the world."

Source & © Millennium Ecosystem Assessment
Synthesis Report [see http://www.millenniumassessment.org/en/Products.Synthesis.aspx] (2005), Chapter 1, pp.27-29

Partner for this publication

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