



## Scientific Facts on Ecosystem Change

**Source document:**  
MA (2005)

**Summary & Details:**  
GreenFacts

**Context** - Human well-being is highly dependent on ecosystems and the benefits they provide such as food and drinkable water. Over the past 50 years, however, humans have had a tremendous impact on their environment.

To better understand the consequences of current changes to ecosystems and to evaluate scenarios for the future, UN Secretary General Kofi Annan has launched a comprehensive scientific study, the Millennium Ecosystem Assessment.

What actions could be taken to limit harmful consequences of ecosystem degradation?

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

The full Digest is available at: <https://www.greenfacts.org/en/ecosystems/>

**i** This PDF Document is the Level 1 of a GreenFacts Digest. GreenFacts Digests are published in several languages as questions and answers, in a copyrighted user-friendly Three-Level Structure of increasing detail:

- 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. How have ecosystems changed?

1.1 Virtually all of Earth's ecosystems have been significantly transformed through human actions. Changes have been especially rapid in the last 50 years and today the fastest changes are taking place in developing countries. Ecosystems are particularly affected by large-scale fishing, freshwater use, and agriculture.



Land cover change  
[see Annex 1, p. 7]

1.2 Ecosystems depend on fundamental environmental cycles such as the continuous circulation of water, carbon, and other nutrients. Human activities have modified these cycles, especially during the last 50 years, through increases in freshwater use, carbon dioxide emissions, and fertilizer use. This in turn has affected the ability of ecosystems to provide benefits to humans.

1.3 Many animal and plant populations have declined in numbers, geographical spread, or both. For instance, a quarter of mammal species are currently threatened by extinction. Human activity has caused between 50 and 1000 times more extinctions in the last 100 years than would have happened due to natural processes. Increasingly, the same species are found at different locations on the planet and the overall biodiversity is decreasing, because some rare species are lost and common ones spread to new areas.



See also GreenFacts' digest on Biodiversity [see <https://www.greenfacts.org/en/biodiversity/index.htm>]

Overall, the range of genetic differences within species has declined, particularly for crops and livestock.

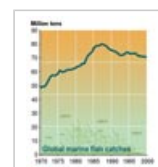
## 2. How have ecosystem services and their uses changed?

2.1 Ecosystem services are the multiple benefits provided by ecosystems to humans.

2.2 Human use of all ecosystem services is increasing:

- The use of **resources** such as food, water, and timber has increased rapidly, and continues to grow, sometimes unsustainably.
- Human interventions have led to changes in the **regulation** of climate, disease, and other ecosystem processes.
- The use of ecosystems for recreation, spiritual enrichment, and other **cultural** purposes is growing. However, the capacity of ecosystems to provide these services has declined significantly.

2.3 In the past, increases in the supply of resources were often achieved despite local limitations by shifting production and harvest to new, less exploited regions. These options are diminishing, and developing substitutes for services can be expensive.



Global fish catch  
[see Annex 2, p. 7]

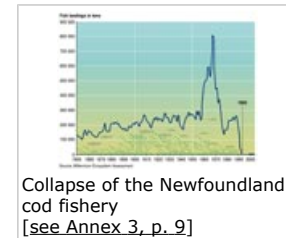
2.4 Biodiversity reflects the number, variety and variability of living organisms in an ecosystem. Changes in biodiversity at a particular location affect the ability of the ecosystem to supply services and to recover from disturbances.

2.5 When humans modify an ecosystem to gain something, it often has negative effects on other components of ecosystems, leading to trade-offs. For instance, increased food production tends to bring about reductions in biodiversity. However, conserving or enhancing particular components of an ecosystem, for instance creating an urban park, can also lead to positive synergies improving a variety of services.

### 3. How have ecosystem changes affected human well-being and poverty alleviation?

3.1 Human well-being depends on material welfare, health, good social relations, security, and freedom. All of these are affected by changes in ecosystem services.

3.2 Ecosystem services, particularly food production, timber and fisheries, are important for employment and economic activity. 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. If the full economic value of ecosystems were taken into account in decision-making, their degradation could be significantly slowed down or even reversed.



3.3 Levels of poverty remain high, and over one billion people have an income of less than \$1 per day. Most of these people are very dependent on ecosystems, because they support themselves mainly through agriculture, grazing, and hunting. The regions facing the greatest developmental challenges tend to be those having the greatest ecosystem-related problems. These include some parts of Africa, Asia and Latin America.

3.4 Some ecosystem changes such as increased food production have helped hundreds of millions of people out of poverty, but also have negative effects. Degradation of ecosystem services is harming many of the world's poorest and most vulnerable people, and is sometimes the main factor causing poverty. Poverty in turn tends to increase dependence on ecosystem services. This can lead to additional pressure on ecosystems and a downward spiral of poverty and ecosystem degradation.

### 4. What are the most critical factors causing ecosystem changes?

4.1 Natural or human-induced factors that change ecosystems are called drivers. Habitat change and overexploitation, for instance, are direct drivers that influence ecosystem processes explicitly. Indirect drivers affect ecosystems by influencing the direct drivers.

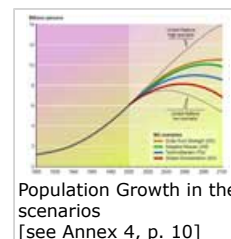
4.2 The main indirect drivers are changes in human population, economic activity, and technology, as well as socio-political and cultural factors. For example, world population has doubled in the past forty years, with most of the growth taking place in developing countries. Pressures on ecosystems have grown in absolute terms, but the growth has been slower than GDP growth. This is due to changing economic structures, increased efficiency, and use of substitutes for ecosystem services.

4.3 Important direct drivers include: habitat change, climate change, invasive species, overexploitation, and pollution. Habitat change occurs, for instance, when the area of land used for agriculture or cities is expanded. World climate has already changed and continues to change, affecting temperature, rainfall, and sea levels. Commercially exploited fish stocks are probably at a historical low. Intensive use of fertilizers has polluted ecosystems with excessive amounts of nutrients. Most direct drivers of degradation are currently staying constant or growing in intensity.

## 5. How might ecosystems and their services change in the future under various plausible scenarios?

5.1 In this assessment, four plausible scenarios were developed to explore the future of ecosystems and human well-being. The different scenarios are based on either increased globalization or increased regionalization, and an either reactive or proactive way of addressing ecosystem problems.

5.2 According to the scenarios, the indirect and direct drivers that will affect ecosystems over the next 50 years will be mostly the same ones as today. However, the relative importance of different drivers will change. Climate change and high nutrient levels in water will become increasing problems, whereas population growth will become relatively less important.



5.3 The scenarios predict that the rapid conversion of ecosystems for use in agriculture, cities, and infrastructure will continue. Moreover, habitat loss will lead to a significant loss of biodiversity by 2050.

5.4 Three of the four scenarios predict improvements in at least some ecosystem services. In many cases, however, human uses of ecosystems will increase substantially. This will deteriorate ecosystems, particularly if they are used unsustainably. Overall, human health is expected to improve in the future in most scenarios. Only the scenario which combines regionalization with reactive ecosystem management might lead to a negative spiral of poverty, declining health, and degraded ecosystems in developing countries.

5.5 In the scenarios, proactive management of ecosystems is generally beneficial, particularly when conditions are changing. However, both proactive and reactive approaches have costs and benefits.

## 6. Why are both global and sub-global assessments of ecosystem change useful?

The importance of ecosystem services for human well-being around the world was investigated at local, national, and regional levels. Overall, the global and sub-global assessments gave similar results on the present state of ecosystems. However, local conditions were sometimes better or worse than expected from the global assessment, for instance for water resources or biodiversity. The assessments identified an imbalance in the distribution of the benefits and costs of ecosystem change, since these are often displaced or postponed.



Some ecosystem problems have been reduced by innovative local responses. However, the "threats" observed at a global level may be difficult to estimate from a more local perspective. Moreover, consequences of actions that go beyond the actor's immediate perspective are often overlooked. Therefore, institutions are needed at multiple levels to strengthen the adaptive capacity and effectiveness of sub-national and local responses.

## 7. How do ecosystems change over time?

7.1 The impacts of human actions on ecosystems are often slow to become apparent. In general, people manage ecosystems in such ways that short-term benefits are increased, while long-term costs go unnoticed or are ignored. This can transfer the costs of current changes to future generations.

Different drivers of ecosystem change take more or less time to react to changes. For example, some species might become extinct quickly when they lose their habitat, but for others, like trees, it can take centuries. This delay provides opportunities for restoring habitats and rescuing species.

7.2 Most changes in ecosystems are gradual and, in principle, detectable and predictable. Other changes are more difficult to predict, because they are gradual only until they reach a certain threshold, at which large changes occur suddenly. Examples of abrupt changes include the start of epidemics, the collapse of a fish population, and bursts of algae growth.

7.3 Human interventions in ecosystems make abrupt changes more likely. Loss of biodiversity, for instance, makes it more difficult for ecosystems to recover from damage. Once an ecosystem has undergone an abrupt change, recovery to the original state is slow, costly, and sometimes even impossible.

## 8. What options exist to manage ecosystems sustainably?

8.1 Reversing the degradation of ecosystems while meeting increasing demands for their services is a major challenge. Changes in policy can decrease many of the negative consequences of growing pressures on ecosystems. However, the actions needed for this are much larger than those currently taken. Most ecosystem services have already suffered, but the damage would have been even greater without the conservation actions taken so far.

8.2 The assessments identified many types of positive actions that would bring long-term benefits for both ecosystems and human well-being. Examples of actions include: increasing international coordination, developing and diffusing technology, and improving the use of information.

8.3 Decision-making processes and their effects on ecosystems and human well-being can be improved by a series of elements such as transparency and public participation.

## 9. What are the most important uncertainties hindering decision-making concerning ecosystems?

Reducing some important uncertainties about ecosystems and their services could significantly improve the ability of assessments to provide the information needed by policy-makers. Better theories and models are needed to understand the links between ecosystem change and impacts on human well-being and to assess the economic consequences of ecosystem change.

9.1 Conditions and trends in ecosystems are difficult to assess because of gaps in information, due for instance to incomplete monitoring systems, inventories of species, and models.

9.2 Better models could provide decision-makers with detailed information that directly links local, national, regional, and global projections on the future of ecosystem services.

9.3 There is limited information on the costs and benefits of alternative policy options in terms of total economic value (including non-marketed ecosystem services). Moreover, not enough is known about the importance placed by different cultures on cultural services, how this changes over time, and how it influences trade-offs and decisions.

## 10. Conclusions: main findings

Four main findings on the links between ecosystems and human well-being:

*10.1* Over the past 50 years, **humans have changed ecosystems** faster and more extensively than in any period in human history. This has been due largely to rapidly growing demands for food, freshwater, timber, fiber, and fuel. The result has been a substantial and largely irreversible loss in the diversity of life on Earth.

*10.2* The changes made to ecosystems have contributed to **substantial gains in human well-being** and economic development, but these gains have been achieved **at growing costs**. These costs include the degradation of many ecosystem services, increased risks of abrupt changes, and increased poverty for some groups of people. These problems, unless addressed, will substantially reduce the benefits that future generations get from ecosystems.

*10.3* This **degradation of ecosystem services could get significantly worse** during the next 50 years. It is a barrier to the achievement of the Millennium Development Goals.

*10.4* **Reversing the degradation of ecosystems** while meeting increasing demands for their services is a challenge. This challenge can be partially met in the future under scenarios involving significant changes to policies, institutions, and practices. However, these required actions will have to be substantial when compared to the actions currently taken.

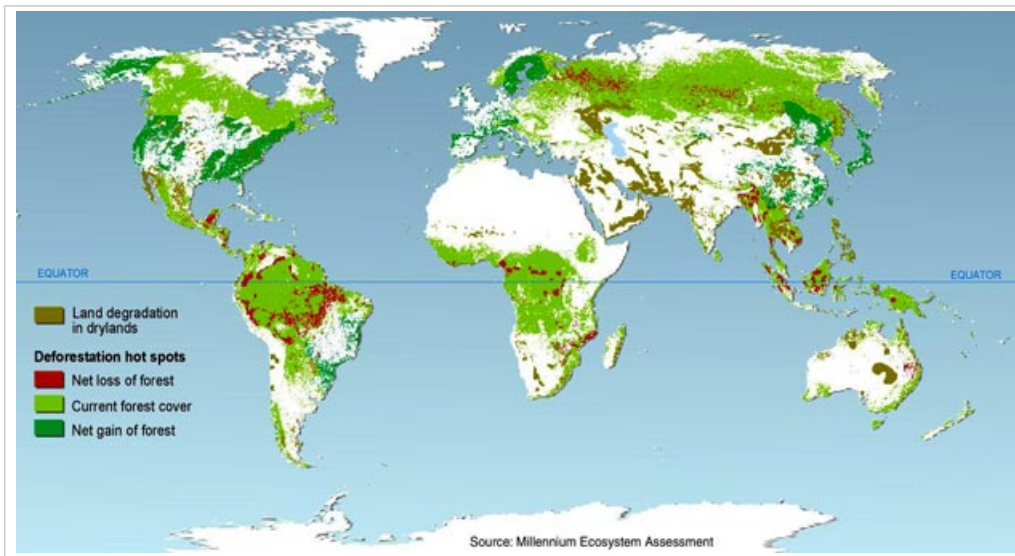


## Annex

### Annex 1:

#### Figure 1.4. Locations reported by various studies as undergoing high rates of land cover change in the past few decades.

"In the case of forest cover change, the studies refer to the period 1980-2000, and are based on national statistics, remote sensing, and to a limited degree expert opinion. In the case of *land cover* change resulting from degradation in drylands [see Annex 6, p. 11] (desertification), the period is unspecified but inferred to be within the last half-century, and the major study was entirely based on expert opinion, with associated low certainty. Change in cultivated area is not shown."

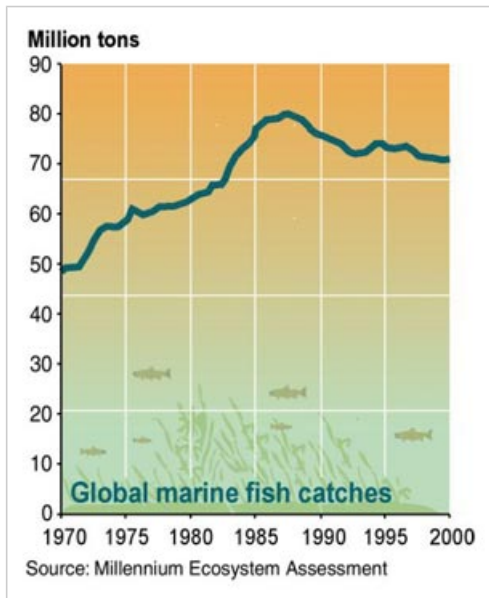


Source: *Millennium Ecosystem Assessment Synthesis Report* [see <http://www.millenniumassessment.org/en/Products.Synthesis.aspx>] (2005), Chapter 1, p.33

### Annex 2:

#### Figure 2.1. Estimated Global Marine Fish Catch, 1950-2001.

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



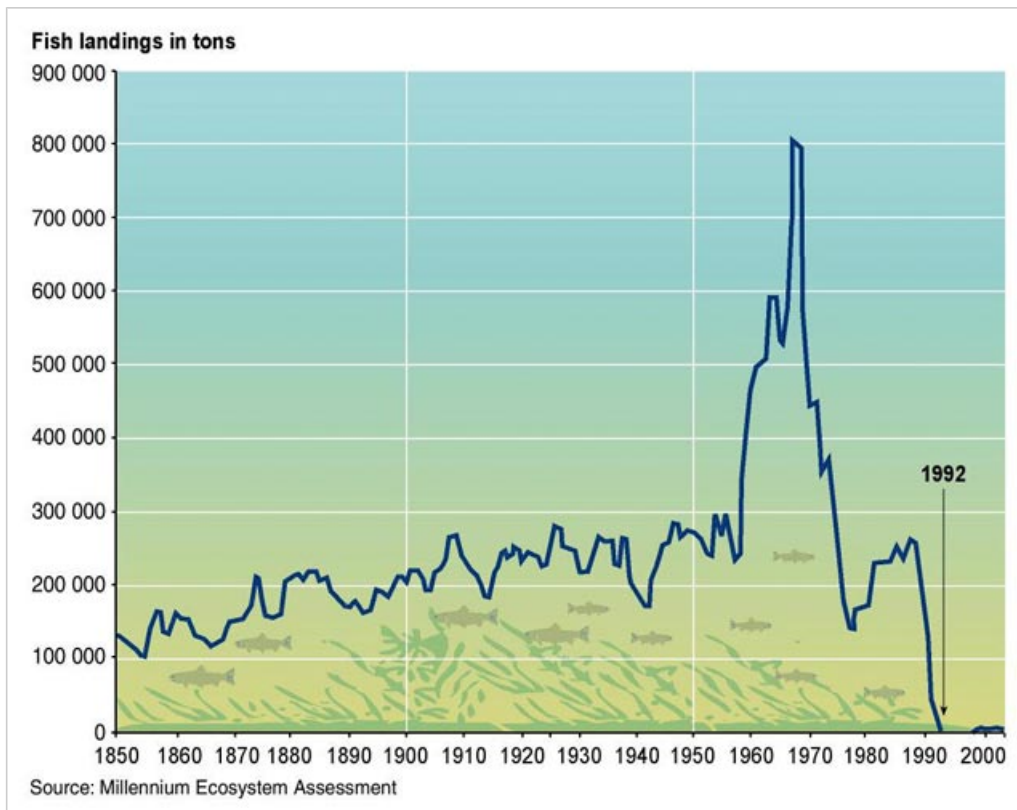
Source & © Millennium Ecosystem Assessment  
Synthesis Report [see <http://www.millenniumassessment.org/en/Products.Synthesis.aspx>] (2005), Chapter 2, p.39  
(Conditions and Trends Working Group Report, C18 Marine Systems, Fig C18.3)



### Annex 3:

#### Figure 3.4. Collapse of Atlantic Cod Stocks Off the East Coast of Newfoundland in 1992

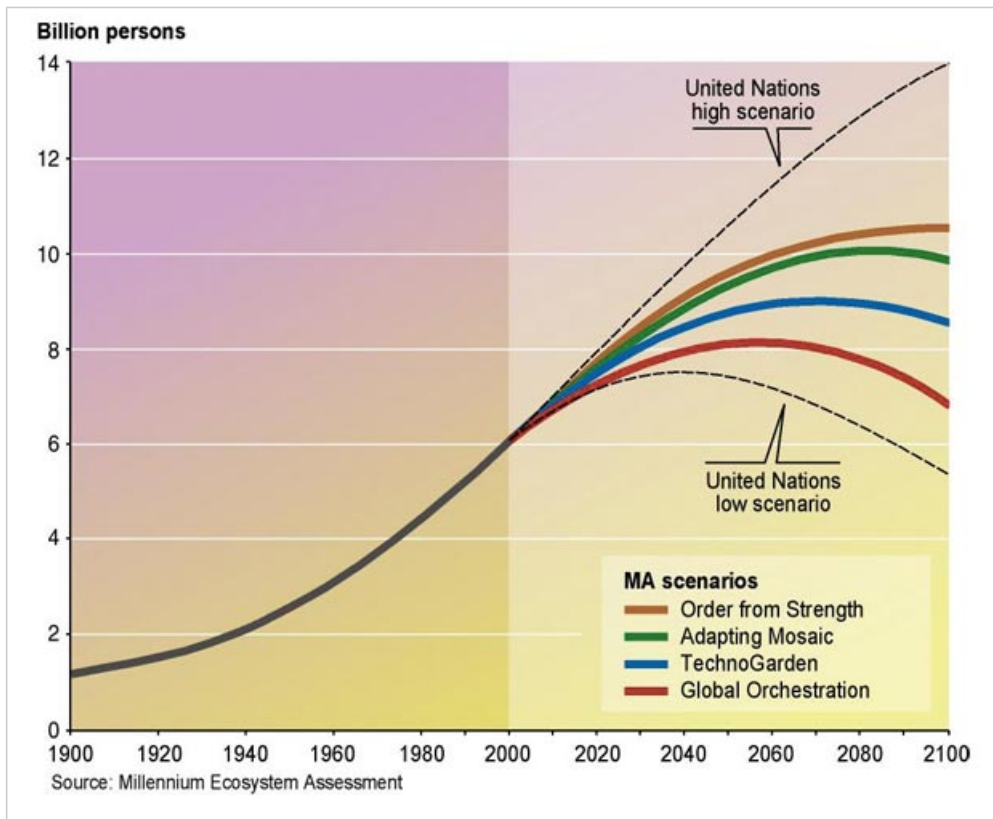
"This collapse forced the closure of the fishery after hundreds of years of exploitation. Until the late 1950s, the fishery was exploited by migratory seasonal fleets and resident inshore small-scale fishers. From the late 1950s, offshore bottom trawlers began exploiting the deeper part of the stock, leading to a large catch increase and a strong decline in the underlying biomass. Internationally agreed quotas in the early 1970s and, following the declaration by Canada of an Exclusive Fishing Zone in 1977, national quota systems ultimately failed to arrest and reverse the decline. The stock collapsed to extremely low levels in the late 1980s and early 1990s, and a moratorium on commercial fishing was declared in June 1992. A small commercial inshore fishery was reintroduced in 1998, but catch rates declined and the fishery was closed indefinitely in 2003."



Source: Millennium Ecosystem Assessment  
Synthesis Report [see <http://www.millenniumassessment.org/en/Products.Synthesis.aspx>] (2005),  
Chapter 3, p.58  
(Conceptual Framework, Box 2.4)

## Annex 4:

### Figure 5.1. MA World Population Scenarios

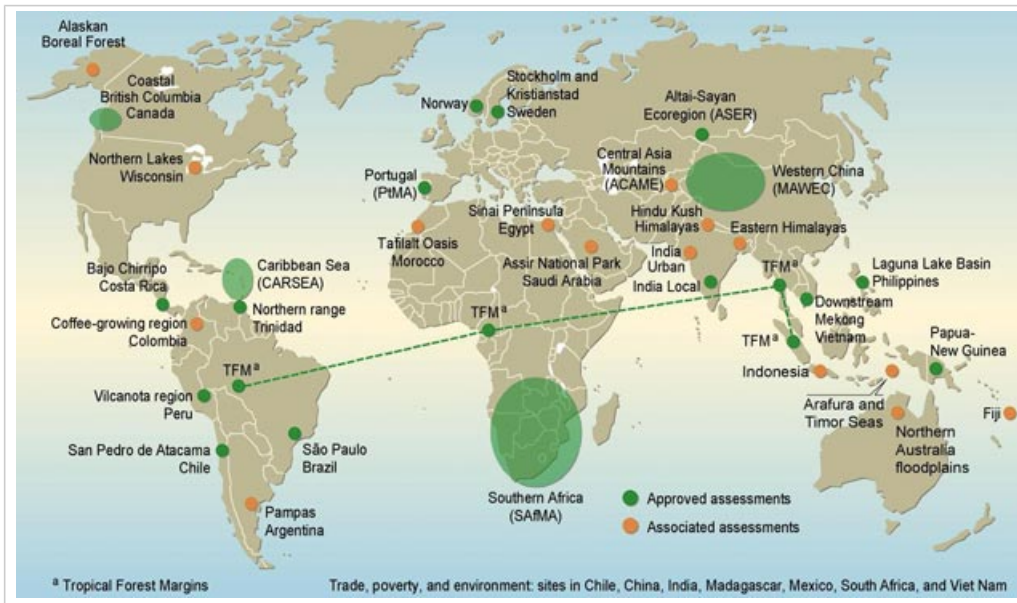


Source: Millennium Ecosystem Assessment  
Synthesis Report [see <http://www.millenniumassessment.org/en/Products.Synthesis.aspx>] (2005), Chapter 5, p.74  
(Sub-Global Working Group Report, S7 Drivers of Ecosystem Change, Fig 7.2)

## Annex 5:

### Figure 6.1. MA Sub-Global Assessments

"Eighteen assessments were approved as components of the MA. Any institution or country was able to undertake an assessment as part of the MA if it agreed to use the MA Conceptual Framework, to centrally involve the intended users as stakeholders and partners, and to meet a set of procedural requirements related to peer review, metadata, transparency, and intellectual property rights. The MA assessments were largely self-funded, although planning grants and some core grants were provided to support some assessments. The MA also drew on information from 15 other sub-global assessments affiliated with the MA that met a subset of these criteria or were at earlier stages in development."

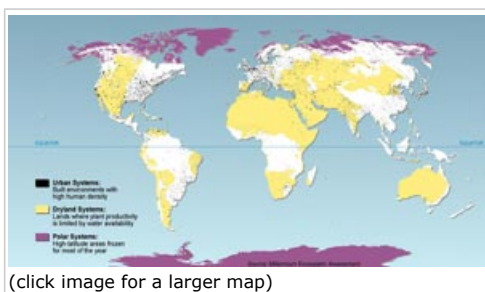


Source: Millennium Ecosystem Assessment Synthesis Report [see <http://www.millenniumassessment.org/en/Products.Synthesis.aspx>] (2005), Chapter 6, p.85

More information on the sub-global assessments can be found on Millennium Ecosystem Assessment website at: [see <http://www.millenniumassessment.org/en/subglobal.overview.aspx?>]

## Annex 6:

### Urban, Dryland and Polar systems



"**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*