The Cost of Policy Inaction

The case of not meeting the 2010 biodiversity target

Executive Summary

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with

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The COPI project

This Summary presents the results of the study of ***"The Cost of Policy Inaction (COPI): The case of not meeting the 2010 biodiversity target***".

In the context of the environment, the cost of policy inaction is defined as: the environmental damage occurring in the absence of additional policy or policy revision. Inaction not only refers to the absence of policies, but it also refers to the failure to correct misguided policies in other areas. The costs of policy inaction may be greater than just the environmental damage, if the same inaction also creates societal and economic problems.

The COPI project is part of the European Commission's commitment - as mentioned in the Biodiversity Communication Action Plan (COM(2006)216; EC, 2006) – to *"Strengthen understanding and communication of values of natural capital and of ecosystem services, and the taking into account of these values in the policy framework, expand incentives for people to safeguard biodiversity"*. The results of this study feed into the process of the Review on the Economics of Biodiversity Loss, which is being prepared under the aegis of the German Presidency of the EU with a view to being presented to the Convention of Biological Diversity (CBD) COP-meeting to be held in May 2008".

The report is available at http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm

The study was conducted by a consortium led by Alterra, Wageningen UR in cooperation with the Institute for European Environmental Policy.

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1. Introduction

The urgency of addressing the loss of biodiversity

Biodiversity is the diversity of species, populations, genes but also communities, and ecosystems. It is both a factor in and an indicator of the health of all ecosystem processes. These processes form the environment on which organisms, including people, depend. Direct benefits of ecosystems to humans such as food, timber, clean water, protection against floods, and aesthetic pleasures all depend on biodiversity, as does the productivity and stability of natural systems. The majority of ecosystems in the world have been seriously modified by humans.

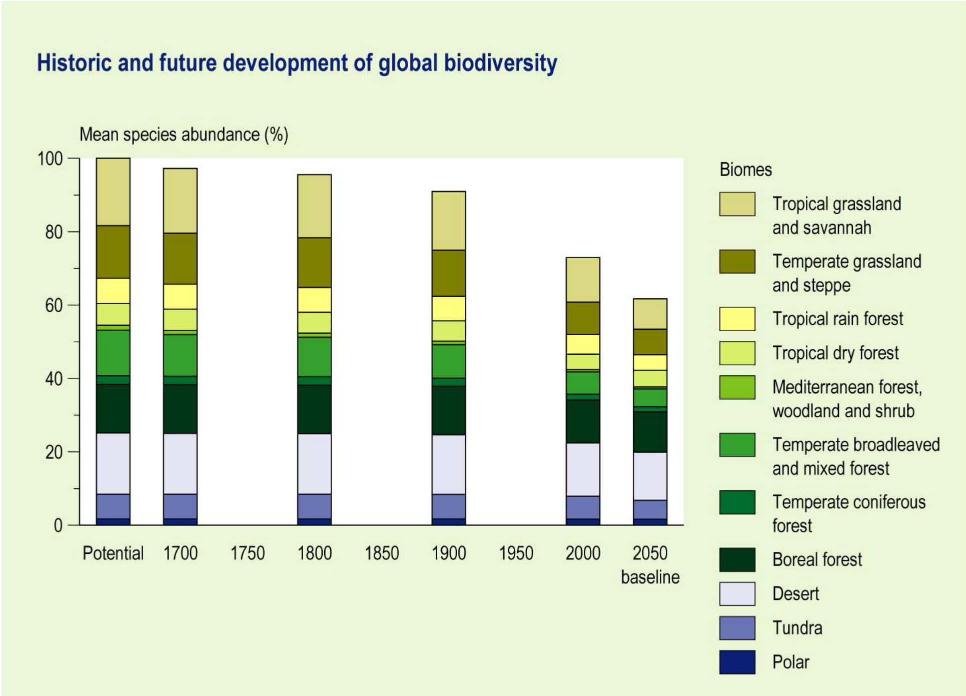


Figure 1 ***Historic and future development of global biodiversity***

The 2010 Biodiversity policy target, as agreed at WSSD (World Summit on Sustainable Development) in 2002 and adopted by the parties to the Convention on Biological Diversity, is an important goal for biodiversity management. The global target is to "*significantly reduce the rate of loss of biodiversity by 2010*". Until a measure of control is achieved on the critical drivers, most declines seem likely to continue at the same or increased rates, although there is evidence that biodiversity loss is slowing or even recovering for some habitats (such as temperate woodlands) and species (birds in the temperate biomes, for example). Some of this positive news can be attributed to the effect of conservation policies.

A large proportion of the world's terrestrial species richness is concentrated in a small area of the world, mostly in the tropics. Homogenization, the process whereby species assemblages become increasingly dominated by a small number of widespread, human-adapted species, represents further losses in biodiversity that are often missed when only considering changes in absolute numbers of species.

The economics of biodiversity loss and the cost of policy inaction

Biodiversity loss implies loss of ecosystem goods and services to the human economy, in other words direct and indirect benefits to human well being. These losses of contributions to the economy have for a large part been the consequence of purposefully converting natural systems to food, timber of fuel producing mono-species ecosystems thereby, to a some extent unintentionally, causing the loss of other ecosystem services, such as climate regulation, water purification and outdoor recreation.

The purpose of estimating the costs of policy inaction is *to highlight the need for action*, prior to the specific development and appraisal of policy instruments. COPI is therefore concerned with problem identification, and with understanding the dynamics of ecosystem change and the associated damage costs in the absence of new or revised policy interventions. In practice, it is valuable to present the costs of policy action in qualitative terms, in quantitative terms and monetary terms – all the while understanding what each of these covers, and therefore presenting the results in context.

Objectives and political context of the COPI study

1. An exhaustive inventory of the economic evaluations of biodiversity so far.
2. To analyse and to present these evaluations in a coherent framework
3. To illustrate the impact of not meeting the 2010 biodiversity target globally
4. To help setting priorities within the field of biodiversity conservation

The Environment Ministers of the G8 countries as well as of Brazil, China, India, Mexico and South Africa, the European Commissioner responsible for the Environment and senior officials from the United Nations and the IUCN (The World Conservation Union) met in Potsdam in March 2007. The meeting resulted in the announcement of a course of action for the conservation of biological diversity and for climate protection: "*The clear message of this meeting is that we must jointly strengthen our endeavours to curb the massive loss of biological diversity. It was agreed that we must no longer delete nature's database, which holds massive potential for economic and social development*" (BMU-Pressedienst No. 077/07; Berlin, 17.03.2007). The so-called "Potsdam Initiative– Biological Diversity 2010" set in motion specific activities for protection and sustainable use of biodiversity.

The COPI study is one of a series of studies being carried out under this initiative, with the aim to contribute to what became the study of The Economics of Ecosystems and Biodiversity (TEEB). The results of COPI feed into the Phase 1 report of the TEEB that is presented at the CBD COP9 in Bonn in May 2009. Furthermore, the methodological insights will help form a basis from which the TEEB phase 2 will build.

2 Methodology

The COPI approach

The key steps of the COPI Analysis are:

1. **Develop projections with the OECD-scenario and IMAGE-GLOBIO-model** of changes in land use, biodiversity and ecosystem services over the period to 2050.
2. **Development of a database of values** of ecosystem services that can be applied to the land use changes.
3. **Development of a spreadsheet model** that allows the combination of the ecosystem service values and the land use changes, and the quality factors based on a measure of biodiversity of the land use types.
4. **Complementary analysis of benefits and losses** across other biomes than the land-biomes in the GLOBIO model.

These steps are complemented by a policy analysis, which puts the OECD- baseline scenario in a policy perspective and helps to clarify the drivers for biodiversity losses.

Step 1. Develop projections with the OECD-scenario and IMAGE-GLOBIO-model

Changes in land use and environmental pressures lead to changes in biodiversity and ecosystem functions which lead to a loss of ecosystem services. All these changes lead to loss of economic value – the cost of policy inaction, the cost of not halting biodiversity loss (*figure 2*).

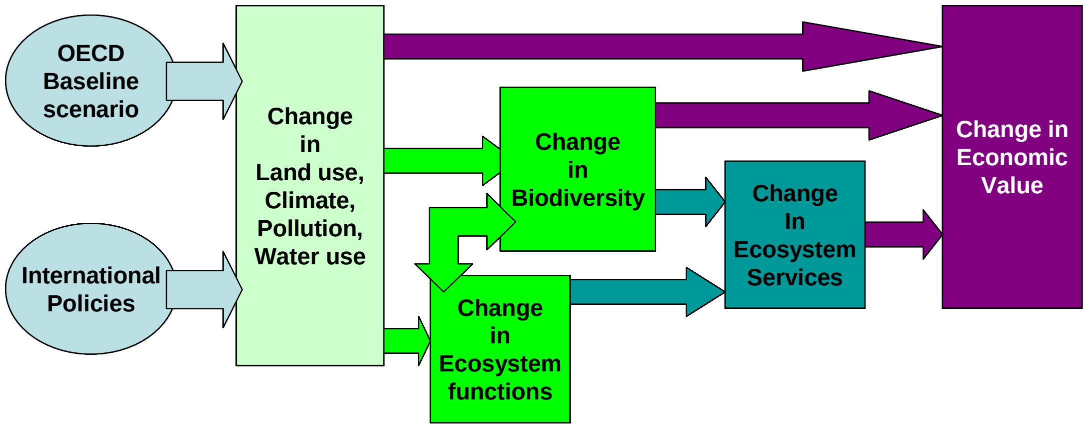


Figure 2 The Conceptual framework of the COPI study

- A Baseline Scenario is used to provide the pathway of economic and social drivers and associated pressures into the future as it is expected to develop without new policies. For this COPI study, the Baseline scenario of the Organisation for Economic Cooperation and Development Outlook to 2030 has been used (OECD, 2008). This scenario is broadly consistent with exercises such as those by the CBD (2006) and UNEP (2007).
- The GLOBIO model, a typical Driver-Pressure-State-Impact framework was used to project changes in terrestrial biodiversity to 2050 (Alkemade et al., 2006). The main indicators are changes in land use and environmental quality and the mean abundance of the original species of an ecosystem (MSA), for all of the world's biomes.
- The Millennium Ecosystem Assessment (MA, 2005a) has created a useful conceptual framework and political commitment to put the value of biodiversity into decision making. It has been a motor for new information on the value of biodiversity and associated ecosystem services; Based on the case material in the MA reports, a set of generalized biodiversity-ecosystem service relationships have been quantified to support the estimation of future monetary values of the services.
- The Total Economic Value framework (e.g. CBD, 2007) has been applied to frame the array of economic valuation case studies, collected and analysed as part of this COPI analysis. The changes in land-use and biodiversity and associated services across the biomes and across the geographic regions of the world were combined with per hectare monetary values for ecosystem services. These values were based on a mixture of literature review and some primary research. A range of benefits transfer and other data gap-filling techniques were used and some developed to have a sufficient range of numbers for an indicative value of the COPI.

Step 2. Development of a database of values

The data in the database are displayed in two parts:
- Part 1 is the core of the database. Estimates have been summarised in a seven-column table, from which the values feed into the monetary biome-land use sheet. *Table 1* represents the core structure of the Valuation Reference Database.
- Part 2 contains all relevant information that characterises each value and the respective study in detail, e.g. the actual location of the case study.

Table 1 Core structure of the Valuation Database

Used in COPI assessment	Useable value	PPP-adjusted usable values	ESS reference	Biome	Landuse type	Geographic region
1 = yes *0 = no*	*EUR/ha in the year 2007*	*EUR/ha adjusted by PPP to feed into matrix*	*# from ESS table to allow sorting (1-19)*	*# ref to allow sorting (1-13)*	*# ref to allow sorting (1-8)*	*# region from Globio (1-14)*

Steps in filling the database:

- **Data gathering:** The search used existing databases, such as the Environmental Valuation Reference Inventory (EVRI) to the extent possible and a literature search of scientific databases (Web of Science, Agricola) for peer-reviewed publications, as well as an internet search for grey literature.
- **Mean values for ecosystem function:** As a first step to reduce the complexity, mean values for different Ecosystem Service-Biome combinations across regions were calculated in Euro for the year 2007 using the Purchase Power Parity/GDP index from the OECD study.
- **Min-max procedure:** To assess the suitability of using the calculated mean values, minimum and maximum values were identified for each combination and compared with the mean. This allowed assessment of representativeness and hence transferability for each ecosystem service-biome combination.
- **Cross-check of single values:** Individual economic evaluation studies and their results may not be representative for a specific biome. This is because these studies are frequently undertaken to highlight the importance of a specific ecosystem service and to raise awareness in the decision-making process. The results of the studies have therefore to be critically assessed by comparing them with related studies using expert judgement. In some cases, non representative "outliers" were taken out before the averages were calculated to avoid undue influence of extreme cases.
- **Filling the gaps:** Two scenarios were created – a partial estimation scenario, where there was a lesser level of gap filling by benefit transfer, and a fuller estimation scenario, where more (but not all) of the gaps were filled. Benefit transfer implies using values of known situations (biome-land use / ecosystem service units) to create values for similar situations.

3. Development of a spreadsheet model

A spreadsheet model was developed to allow computations of economic values across biomes, geographical regions and world totals by combinations of the case study based ecosystem service values with the simulated land use changes, and the quality factors based on a measure of biodiversity of the land use types. Systematic benefit transfers were used to fill gaps. This COPI study has concentrated on the valuation of the "flows" (the ecosystem goods and services) rather than on valuation of the biodiversity "stock", so values per ha, per year are computed. The COPI Value Database contains the basic monetary values needed for the eventual COPI assessment and thus represents the core of the COPI spreadsheet.

4. Complementary analysis of benefits and losses

For the marine biomes a scenario-study for the period 2000-2050 using the EcoOcean model (Alder et al., 2007) was available. The results were added to by literature data, e.g. from the Millennium Ecosystem Assessment (2005b), which was also an important source for the trends in biodiversity, ecosystems services and economic values for coastal and inland water systems. A special study on Invasive Alien species was conducted and an in-depth study of the forest biome. A review of international policies has been used to put the OECD- baseline scenario in a policy perspective and to clarify the drivers for biodiversity losses.

3. The OECD Baseline scenario and international policies

Population development

This COPI study has used the OECD Environmental Outlook to 2030 (OECD, 2008) as the basis for information about future economic and demographic development. The Baseline Scenario assumes that many aspects of today's world remain the same – not frozen in time, but evolving along the same lines as today.

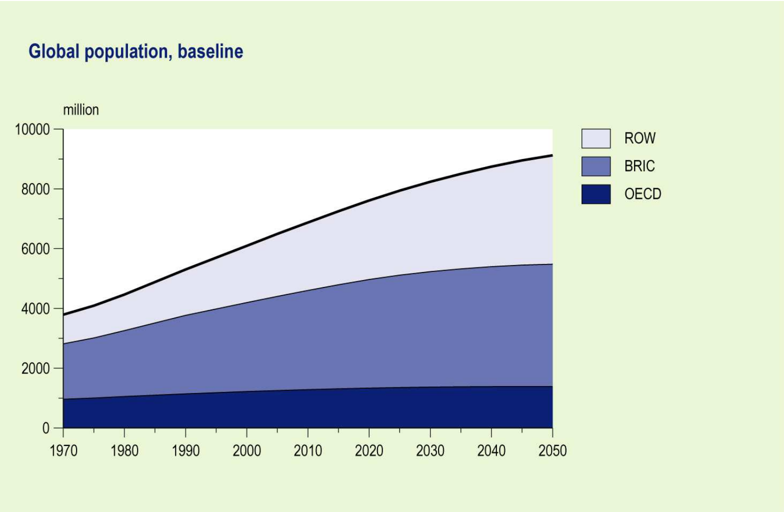


Figure 3 ***Population development 1970 - 2050***

The Baseline uses a so called "medium" population projection of the United Nations, which shows a stabilisation of the world population at around 9.1 billion inhabitants by the middle of this century. Almost all of this increase will be in developing countries. By 2050, world demand for basic needs (food, drinking water, fuel and shelter) based on population increase only, will have increased by about 50% compared to the present. This increase in demand is the direct driver for increase of crop production, capture fisheries, aquaculture, bio-fuel production, cutting and converting pristine forests and intensifying grazing.

Economic development

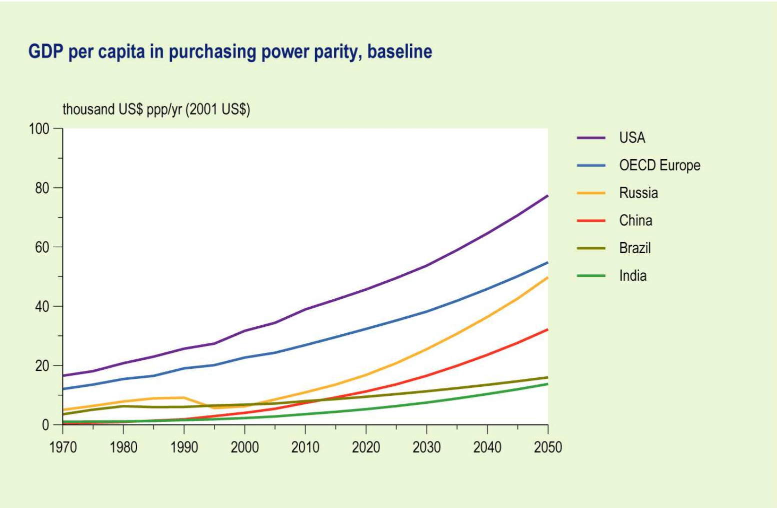


Figure 4 ***Economic development 1970 - 2050***

The economic undercurrents of the Baseline trends combine to produce a modest, but uniformly positive growth in real Gross Domestic Product (GDP) for the world as a whole: the global average is 2.8% per year between 2005 and 2050. China and India would see growth rates of 5 per cent per year averaged over the whole period. As in most economic scenario studies, there is a lack of internal feedback from the impact of the projected annual GDP on the resources, which are the basis to "produce" GDP. Of course, GDP and changes in resource availability have only indirect relationships. Although the modelling for the OECD study is more nuanced than assuming a fixed relation between GDP and pressures on biodiversity, the uncertainty in the Baseline leans to the side of more pressures on biodiversity. Also, in a no-new-policies future, the volume of economic activity can be less, but also much more than projected as Baseline.

Energy
The energy consumption for the OECD Baseline follows more-or-less the 2004 World Energy Outlook scenario of the International Energy Agency, adjusted for small differences in economic growth assumptions and for the higher energy price trajectory adopted from WEO 2006. Final energy consumption increases from 280 EJ in 2000 to ca 600 EJ in 2050. All this must of course be considered in view of the current discussions about depletion of oil reserves and price explosions. All sorts of shifts may happen in the short and medium run, such as real shortages of crude oil, consumer reactions to increasing fuel prices, slowing down of the phasing out of coal etc. This may have serious consequences for efforts in the air quality, CO2, and biofuels area and pricing in the carbon-market.

Food production
It is projected that up to 2030 global agricultural production will need to increase by more than 50% in order to feed a population more than 25% larger and roughly 80% wealthier than today's. Although it is assumed that productivity of land will increase substantially, the global agricultural area will have to increase by about 10% to sustain this production, somewhat like the current agricultural area in the US, Canada and Mexico together. These numbers of the Baseline refer to 2030. For 2050, all this is projected to show further increases. Currently a food price explosion takes place, world wide, which may indicate future problems of mismatches between demand and supply, even though speculation and protective policies are important factors now.

Products from marine and coastal ecosystems are used as luxury food in developed economies but for subsistence in many coastal communities, especially in developing countries, but also as feed for aquaculture, pets and livestock. It is the relatively high prices for these products, combined with subsidies by governments, that make aquaculture a feasible industry. The result is that increasing scarcity of fish, rather than causing less pressure on the remnants of the resource, acts to increase incentives to harvest the remaining individuals. The oceans have long been a crucial resource for many millions of people, especially in developing countries. With the changes in fish stocks of the last few decades, the lack of success in finding new harvestable stocks, and the ever increasing share of fish of lower levels in the marine food chain, the prospect in the "fisheries for food" situation is quite dismal. The recent steep increase in oil prices may make governments reconsider subsidy policies.

The policy landscape
Regarding "protected area" policies for biodiversity, the implicit assumption in the Baseline is that its implementation will not substantially change current trends. Regarding trade in agricultural products the assumption is that there will be no major changes. As to climate change mitigation the Baseline assumes no post-Kyoto regime other than the policies in place and instrumented by 2005. The Baseline further assumes that the EU Common Fisheries Policy and equivalent policies in other world regions, remain in place and continue to be implemented as they are now. The analysis of the current policy landscape indicates clearly that several sector policies still provide substantive incentives to continue and increase short-term economic growth at the expense of long-term environmental sustainability and maintenance of biodiversity.

4. Changes in Biodiversity

Global change of terrestrial biodiversity 2000-2050

By the year 2000, about 73% of the original global biodiversity on land was left. The strongest declines have occurred in the temperate and tropical grasslands and forests, the biomes where human civilizations developed first. By 2050 an additional 11%-points will have been lost. In some regions losses may run up to an additional 20%-points.

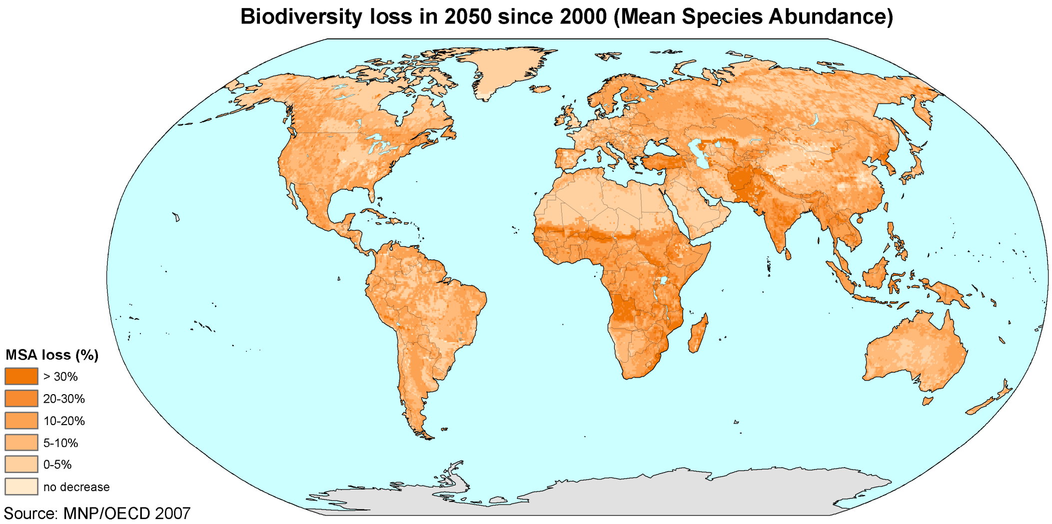


Figure 5 ***Biodiversity (Mean Species Abundance) loss 2000-2050***

Of the remaining biodiversity on land, more than 20% is in polar, tundra and desert regions, providing very little provisioning services, but still important as habitat for many plant and animal species, genetic resources and relevant in the global climate system. So, by 2050, the world will have to make do with about half of the original biodiversity.

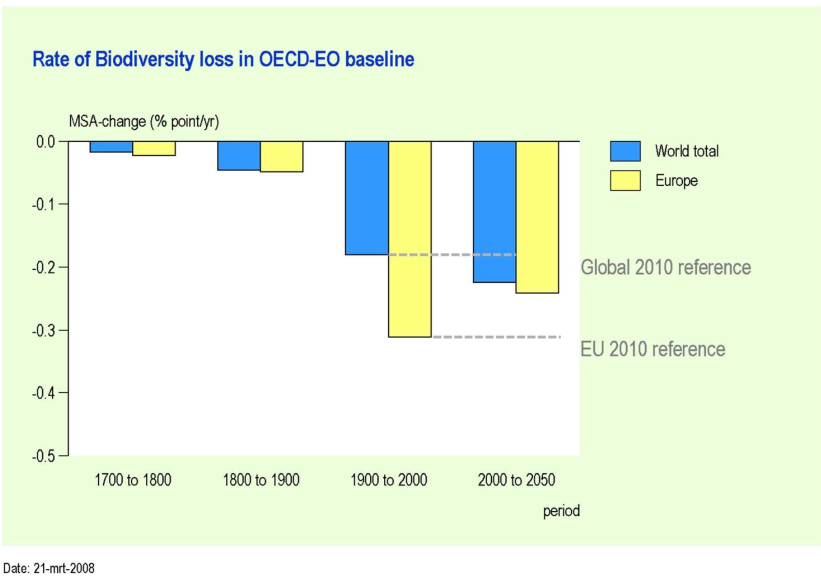


Figure 6 ***Rate of Biodiversity loss 1700 – 2050***

The global annual rate of loss increased dramatically in the twentieth century, and especially in Europe, in comparison to previous centuries. The loss rate for Europe in the period 2000-2050 is expected to decrease, while the global average still increases. This implies that neither the CBD's global 2010 target (significantly reducing the rate of biodiversity loss), nor the European Union's 2010 target (halting the loss of biodiversity) will be achieved.

The Mean Species Abundance (MSA) indicator

In the COPI study, a model framework and biodiversity indicator were used for assessment of terrestrial biodiversity dynamics which are able to reflect the impacts of the most important direct and indirect drivers: the extent of biomes and ecosystems, trends in abundance and distribution of species, protected areas, nitrogen deposition, climate change and fragmentation. The biodiversity indicator chosen for use in the COPI study is the Mean Species Abundance (MSA), as used in the GLOBIO model and the IMAGE framework (B. ten Brink, 2006; Alkemade et al., 2006). This measure of mean species abundance (MSA) is similar to the Biodiversity Intactness Index (Scholes and Biggs, 2005) and is a composite of the CBD 2010-indicator 'the abundance and distribution of a selected set of species'.

The process of biodiversity loss is generally characterised by the decrease in abundance of many original species and the increase in abundance of a few other -opportunistic- species, as a result of human activities. Extinction is just the last step in a long degradation process. Countless local extinctions precede a potentially final global extinction. As a result, many different ecosystem types are becoming more and more alike, the so-called homogenisation process (Pauly *et al.*, 1998; B. ten Brink, 2000; MA, 2005b). Decreasing populations are as much a signal of biodiversity loss as rapidly expanding species populations, which may sometimes even become plagues in terms of invasions and infestations (*figure 7* illustrates this process of changing abundance (indexed) of the original species from left to right). The Convention on Biological Diversity (VII/30) has chosen a limited set of indicators to track this degradation process, including the "change in abundance of selected species".

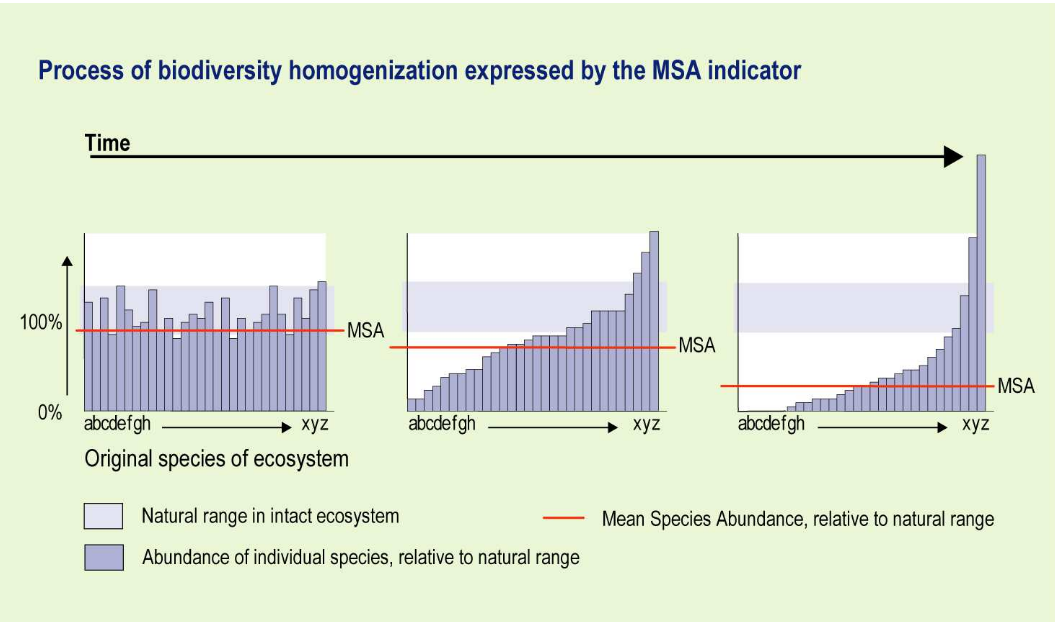


Figure 7 ***Species dynamics during the homogenisation process, and the response in the MSA biodiversity indicator.***

The MSA indicator has the advantage that it measures the key process, is universally applicable, and can be measured and modelled with relative ease. In the GLOBIO model, biodiversity loss is therefore calculated in terms of the *mean species abundance of the original species (MSA) compared to the natural or low-impacted state*. This reference is used here as a means of comparing different model outputs, rather than as an absolute measure of biodiversity. The *mean species abundance (MSA)* at global and regional levels is the sum of the underlying biome values, in which each square kilometre of every biome is equally weighted (ten Brink, 2000; UNEP, 2003, 2004).

Trends in the marine biome

Fishing pressure in the past century has been such that the biomass of larger high-value fish and those caught incidentally has been reduced to 10% or less of the level that existed before industrial fishing started. Loss of biomass and fragmented habitats have led to local extinctions.

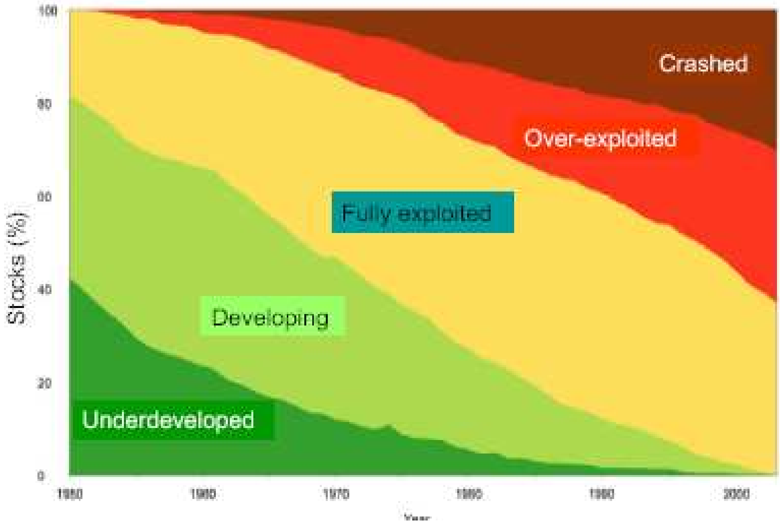


Figure 7 ***The unsustainability of global marine fisheries 1950- 2000***

The scenarios that were analysed indicate that with current trends or increased effort whether for commercial or recreational fisheries all lead to collapses in stocks and ecosystems; they differed only in their rates of decline. The full consequences of this unfolding drama have not sunk in at the highest policy levels yet, as can be inferred from the slow implementation of protective measures in marine systems and the continuation of subsidising policies.

Trends in coastal ecosystems

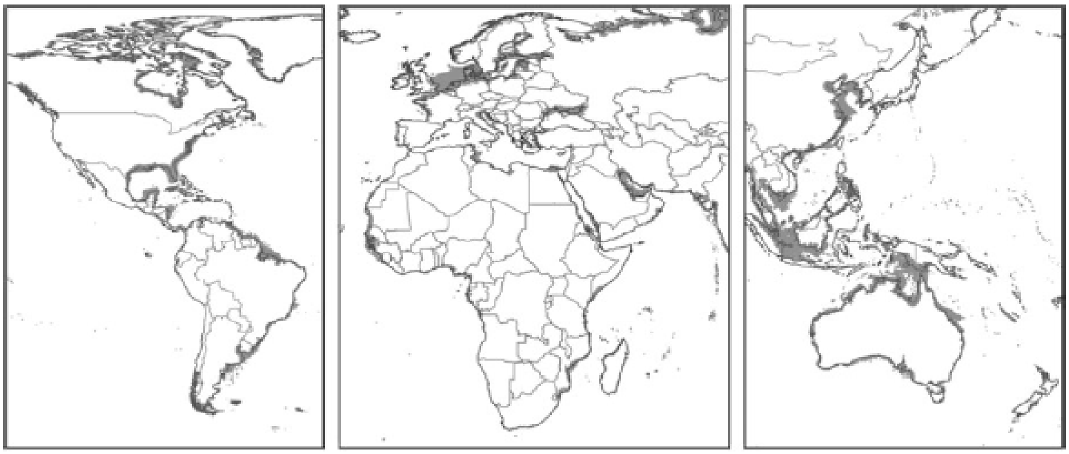


Figure 8 ***Coastal systems around the world***

Worldwide, some 1,200 major estuaries have been identified and mapped, yielding a total area of about 500,000 square kilometers. There has been a substantial loss of estuaries and associated wetlands globally. In the United States, for example, over 50% of original estuarine and wetland areas have been substantially altered. Salt marshes and coastal peat swamps have also undergone massive change and destruction, whether they are within estuarine systems or along the coast. Peat swamps in Southeast Asia have declined from 46–100% in countries monitoring changes.

Mangroves are trees and shrubs found in intertidal zones and estuarine margins that have adapted to living in saline water. About 15.2 million hectares of mangroves currently exist worldwide, with close to half the global area found in just five countries: Indonesia, Australia, Brazil, Nigeria and Mexico. Many mangrove areas have become degraded worldwide, and habitat conversion of mangrove is widespread. Over the last 25 years, 3.6 million hectares of mangroves, about 20 percent of the total extent found in 1980, have disappeared worldwide.

Coral reefs exhibit high species diversity and are valued for their provisioning, regulating, and cultural services. Reef formations occur as barrier reefs, atolls, fringing reefs, or patch reefs, and many islands in the Pacific Ocean, Indian Ocean, and Caribbean Sea have extensive reef systems occurring in a combination of these types. Many coral reefs are transformed from productive, diverse biological communities into degraded ones due to coastal construction that causes loss of habitat as well as changes in coastal processes that maintain reef life. In 1999, it was estimated that approximately 27% of the world's known reefs had been badly degraded or destroyed in the last few decades, although the latest estimates are of 20% of reefs destroyed and more than a further 20% badly degraded or under imminent risk of collapse.

The loss of coastal ecosystems is dramatic in itself, with habitat and species populations disappearing forever locally and some globally. It is also dramatic in light of the total marine ecosystem collapse, as potential restoration is thus eradicated as well. Estuaries and mangroves are important breeding zones for marine species. The conversion to food production sites, in fact is, ironically, counterproductive.

Protected areas

The number and extent of protected areas have been increasing rapidly worldwide in recent decades; they now cover almost 12% of global land area. However, the biomes represented in that coverage are uneven. Marine areas are under-represented in all categories of protected areas. The CBD has set a target of conserving 10% of the earth's surface in formally protected areas. Currently some 13% of terrestrial area, 10% of territorial waters, which is 0.7% of total marine area, is protected. This is an increase from 8.5% in 1990.

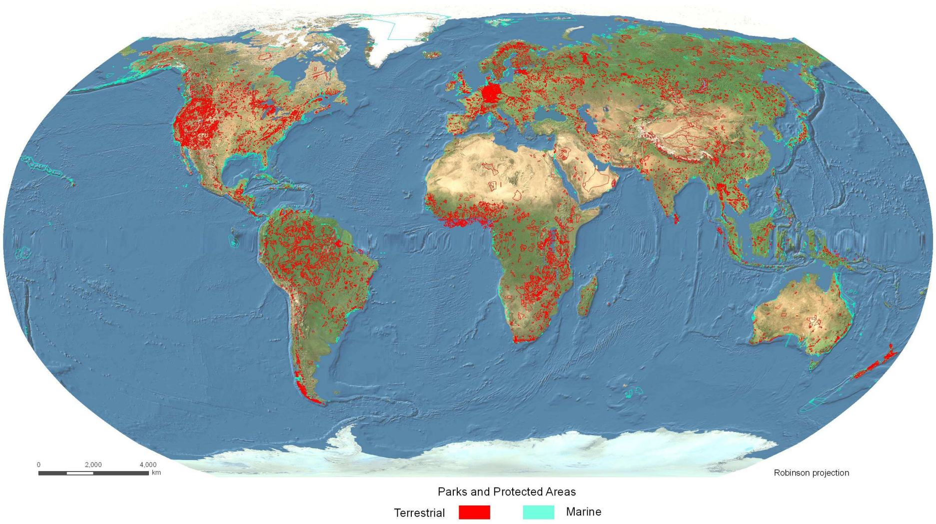


Figure 9 ***Protected areas around the world***

- A focus on protected areas only is not enough as some 20% of threatened species occur outside protected areas and some protected areas are "paper parks" and are not managed and protected sufficiently well to guarantee that biodiversity be maintained.

Biodiversity loss at the species level
In 2006, the IUCN Red List of endangered species contained 40,177 species, 16,119 (more than 40%) of them threatened with extinction. Of the groups for which every species has been assessed globally, 12% of all birds are classified as threatened, 23% of mammals, 33% of amphibians, approximately 42% of turtles and tortoises, 25% of conifers and 52% of cycads.

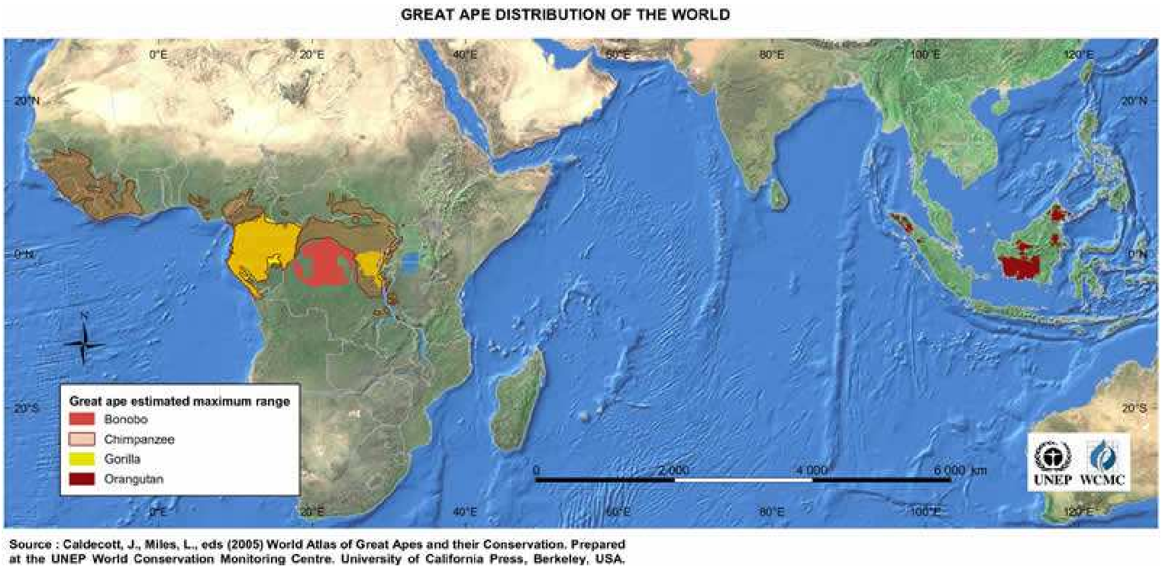


Figure 10 ***Distribution of the great apes***

The great apes are our closest living relatives, yet are among the most endangered species on the planet. All are endangered and all are in decline. *Orang-utans* in Borneo and Sumatra have declined by 75% to 93%, respectively, since 1900. More than 70% of African great ape habitat has already been affected by development, and by 2030, it is predicted that less than 10% of African great ape habitat will be free of disturbance. *Mountain gorillas* number only *a few hundred*, but the sub-species is stable in a handful of well-protected areas in the Albertine Rift area of central Africa. The surrounding *Eastern Lowland Gorilla* is much more numerous but of much greater immediate concern due to hunting and armed conflicts. *Chimps* are more numerous and more adaptable than Gorillas, but overall trends are negative; current continental estimates range from 170,000-300,000, down from an estimated 1 million in 1960. *Bonobos* probably number fewer than 100,000 distributed patchily over a large area of the Congo basin. They are hunted for food in many areas particularly in times of conflict and food shortage.

Invasive alien species
These species continue to lead to a wide range of ecological and socio-economic impacts including changes in species composition and dynamics, habitat characteristics, provisioning of ecosystem services (e.g. provision of food, water retention and regulation of erosion and forest fires). Invasive alien species also have negative impacts on health and cause damage to infrastructure, e.g. by competing with other organisms (Japanese knotweed, Giant hogweed), predating on native organisms (Nile perch), causing extinction or displacement of native species displacement of native species, toxic (toxic algae blooms caused by alien phytoplankton), a reservoir for parasites or a vector for pathogens (rainbow trout as a host for the salmon parasite , signal crayfish which is a carrier and host of the crayfish plague) and disrupting pollination (alien plant competes for pollinators with the native species). IAS are also increasingly seen as a threat to ecosystem services and negatively affecting economic development and human well-being. The economic effects are related to the negative impacts of IAS on various human activities, such as hindering navigation by blocking waterways, and causing damage to forestry and crops.

5. Changes in ecosystem services

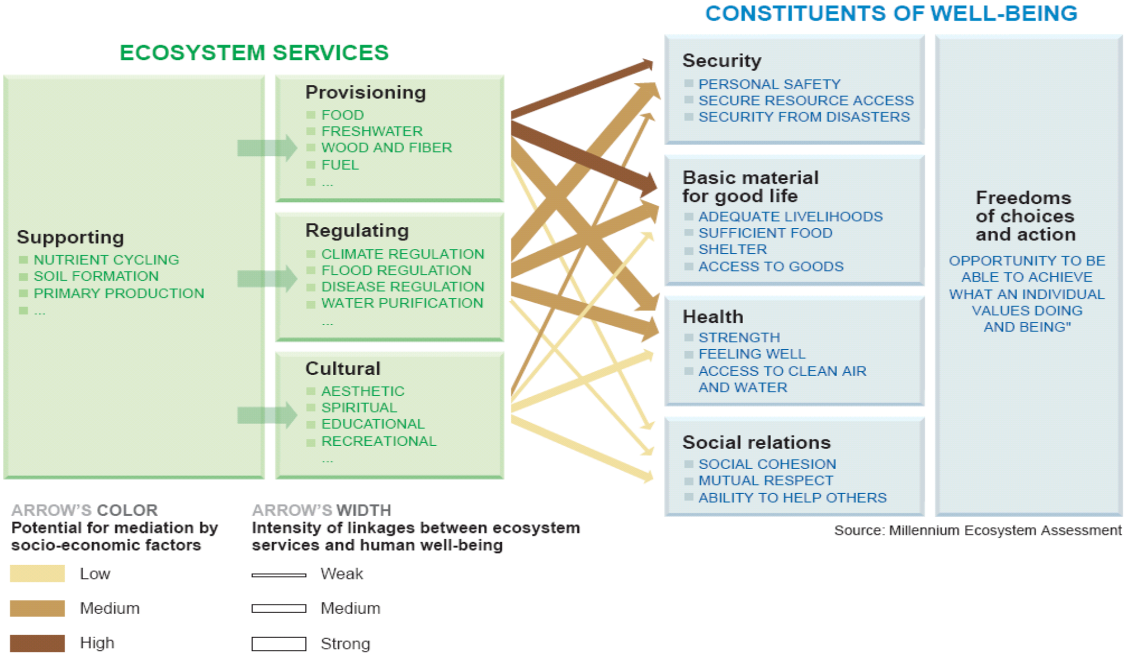


Figure 11 *The Ecosystem services – Well being relationships (Millennium Ecosystem Assessment , 2005a)*

With conversions of natural ecosystems to other forms of land use, such as cropland, pasture land or urban land, or by unsustainable fishing the oceans, or converting coastal mangrove to shrimp farms, the total flow of services in a region is altered. The changes often bring short-term economic benefits but longer-term costs. Maximization of provisioning services such as food, fish and timber has caused the loss of area with intact ecosystems and biodiversity and thus with the capability of these systems to provide regulating services such as climate and flood control, and air and water purification (see *figures 12 and 13*). The publication of the Millennium Ecosystem Assessment (2005a) has been instrumental in introducing the concept of ecosystem services in all levels of environmental and nature policy. It is not yet common knowledge though, to what extent the social benefits of economic production are dependent on the availability and quality of ecosystem services and in turn on ecosystem health and biodiversity.

To produce food, timber and fuel, pristine ecosystems with a wide range of ecosystem services are converted to single purpose land uses with great loss of biodiversity and risk of total degradation. *Figure 13* illustrates the relationships between different ecosystems. In diagram 1, the service levels in a natural ecosystem are depicted to be in some kind of balance, fitting the capability of the particular ecosystem. In the second diagram, the system has been converted to extensive use for *food* production, thereby decreasing the potential and actual service levels of the other provisioning (energy, freshwater), regulating (climate) and supporting services (soil protection). In Diagram3, representing an intensive food production system, the other services have been reduced to very low levels.

A set of simplified functional relationships for groups of ecosystem services have been developed to allow a bridge between the calculated future changes in areas and changes in total biodiversity, and the wide variety of monetization case studies and estimates of economic benefits (*Figure 14*) . Summarising the literature and example discussed above, the following reasoning underlies the shape of the curves. Obviously, these are generalised curves. Specific situation will have specific versions of these generalised curves.

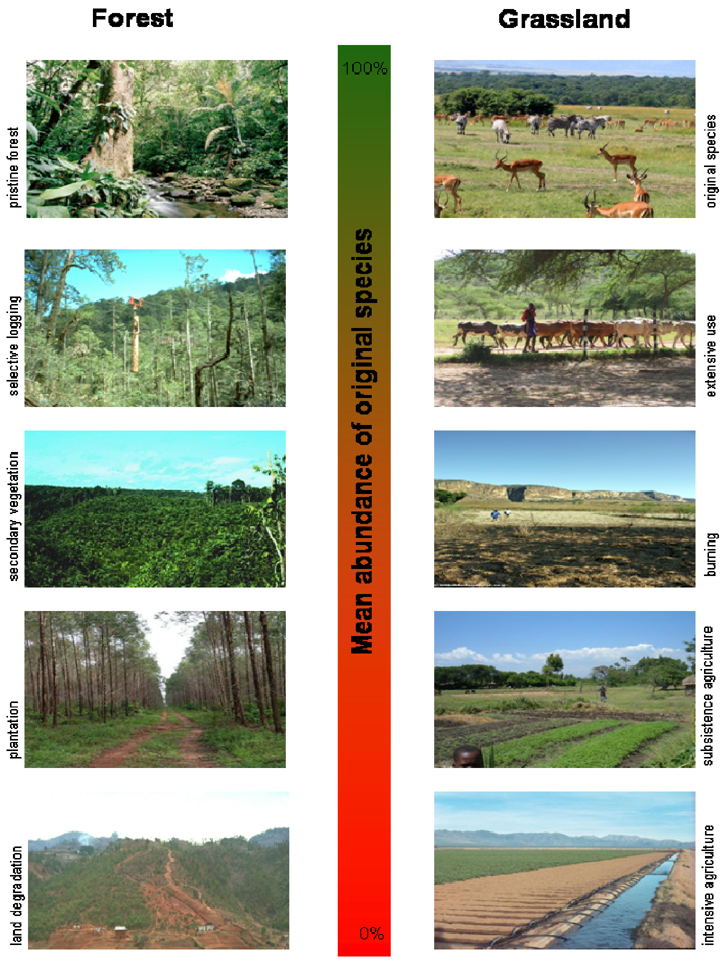


Figure 12 ***The stages of economic development and ecological degradation in forest and grassland biomes.***

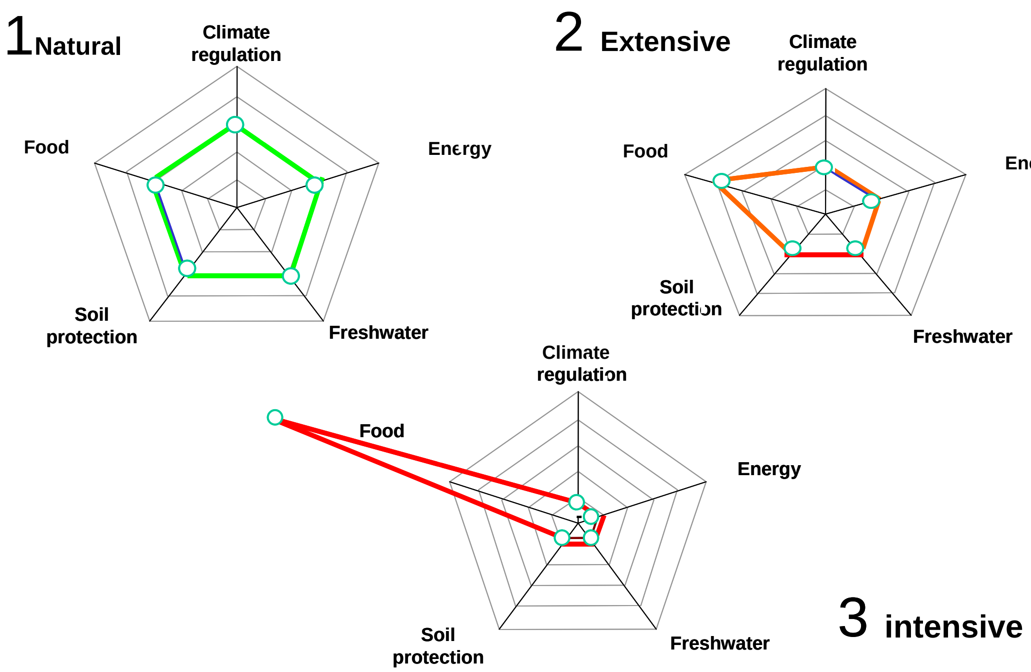


Figure 13 ***The loss of services in conversion of natural systems to food production systems degradation in forest and grassland biomes.***

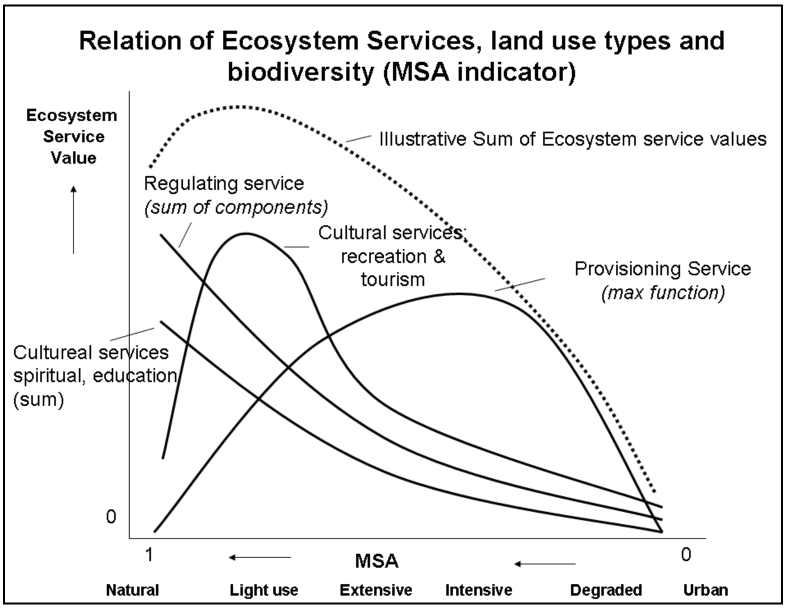


Figure 14 ***The generalized relationships between land use / biodiversity and ecosystem services.***

- **Provisioning services (P)**: There is no provisioning service, by definition, in a pristine ecosystem. With increasing intensity of use and conversion of the structure, species composition and thus functioning of the original natural area (MSA, mean species abundance) decreases (from 1 to 0) and the benefit flow (EV, ecosystem service value) increases. Adding labor, fertiliser, irrigation, pest control etc. will raise the gross benefits, and possibly the net.
- **Regulating services (R):** Regulating services are complex processes at the ecosystem level. As ecosystems are converted, their regulating service capability drops more or less proportionally with the decrease of MSA along the range of land use types.
- **Cultural – recreation services (Cr):** A crucial feature in the valuation of the recreational services of ecosystems is accessibility. The service value therefore increases from low value at pristine systems to high values in accessible light use systems and a subsequent drops to low values for degraded systems.
- **Cultural – Information services (Ci):** Most of the other cultural ecosystem services and their values are a function of the information content which is generally decreases with the degree of conversion.

The relationships between the levels and quality of ecosystem services on the one hand and the biodiversity and other indicators of ecosystem functioning are known in a general sense. The fields of agricultural science, forest ecology, and outdoor recreation management all have extensive knowledge of necessary conditions, possible risks and optimal use strategies. Less well known is the specific relationship between a desired level of service and the minimum required biodiversity, and the sensitivities to change in biodiversity under the various local conditions. Also still largely unknown are the complexities of multiple use of ecosystems. What is clear, though, is that it is essential to take account of the *net change in services*, as some benefits may increase while others get lost. Increasing one particular local service with private benefits generally leads to losses of the regional or global services with public benefits. It is also essential to assess the *net benefits of changes*, as many human interventions require additional energy.

Social and economic consequences of changes in ecosystem services

It is estimated that 1 billion people worldwide are dependent on fish as their sole or main source of animal protein, while fish provided more than 2.6 billion people with at least 20 percent of their average per capita animal protein intake. Similarly, water scarcity is a globally significant and accelerating condition for 1–2 billion people worldwide, leading to problems with food production, human health, and economic development.

6 The Cost of Policy Inaction – in Monetary terms

Introduction

The evaluation challenge is well exemplified by the oft-cited Costanza et al (1997) study. This study focused on providing an estimate for the total economic value of Nature's services. Their result - $ 33 trillion as a value for ecosystem services, as against $ 18 trillion for global GDP - was criticized on the one hand for extrapolating marginal valuations to entire global ecosystems (as economic values estimated for small marginal changes are not valid anymore when dealing with big changes), and on the other, for being "a significant under-estimate of infinity" (Toman, 1999). The COPI study aims, just like Costanza et al., to highlight the importance of the value of ecosystem services and biodiversity to society and the importance of the loss and urgency of action to halt the loss, but it does so by looking at the marginal losses, and the value of the loss of flow of services. There are, of course, still a wide range of assumptions to arrive at this value. The COPI analysis aimed not just at calculating some illustrative numbers, but aimed to create and test a method and develop insights for the methodology to be use in the phase 2 evaluation of the Economics of Ecosystems and Biodiversity (TEEB) work[1].

Box 6.1 COPI values: Welfare, GDP and interpreting the numbers

It is important for understanding the COPI assessment, to appreciate that the COPI costs are actually a mixture of cost types – some are actual costs, some are income foregone (e.g. lost food production), some are stated welfare costs (e.g. building on willingness to pay (WTP) estimation approaches). Some directly translate into money terms that would filter directly into GDP (gross domestic product); some would have an effect indirectly, and others would not be picked up by GDP statistics (which themselves are only economic statistics and not fully representative of welfare or wellbeing[1]). The combined COPI costs should be seen as welfare costs, and for the sake of ease of comparison are given as % of GDP.

The core elements of the COPI analysis:

COPI Core Step 1: Data for land-use change over the period 2000 to 2050.

The underlying values within the GLOBIO work were used; these combine two elements - change in land-use (see *table 2*) and a loss of quality of the land due to climate change, pollution, fragmentation – which is represented by the mean species abundance (MSA) index used in the model. Both elements form a basis for the monetary evaluation.

Table 2 Total Area by Land-use; Global total aggregated across all biomes

Actual	2000	2050	Difference
Area	**Million km2**	**million km2**	**2000 to 2050**
Natural areas	**65.5**	**58.0**	**-11%**
Bare natural	**3.3**	**3.0**	**-9%**
Forest managed	**4.2**	**7.0**	**70%**
Extensive agriculture	**5.0**	**3.0**	**-39%**
Intensive agriculture	**11.0**	**15.8**	**44%**
Woody biofuels	**0.1**	**0.5**	**626%**
Cultivated grazing	**19.1**	**20.8**	**9%**
Artificial surfaces	**0.2**	**0.2**	**0%**
World Total *	**108.4**	**108.4**	**0%**

[1] See also Sukhdev et al (2008) The Economics of Ecosystems and Biodiversity. An Interim report.

Core Step 2: Develop and populate a matrix of ecosystem service values across land-uses for each biome (and for each region)

Key issues are: data coverage, meaning of the data, selection of suitable cases to develop representative picture of ecosystem service values for land use and biome, and populate the matrix. As regards data coverage, there are different levels of information for different regions, different biomes, different ecosystem service types and also for different value types. To populate the matrix entailed four key steps:

- Do a literature of ecosystem service values,
- Develop representative values from the data available,
- Own analysis to develop ecosystem service values – carried out for forestry biomes by the COPI Team,
- Gap Filling, to address gaps in ecosystem service values by land uses, biomes, geography and into the future.

Core Step 3: Gap Filling for ecosystem services values within a biome – across landuse types:

The data from the literature did not give enough detail on different values for different land used within a given biome and a range of approaches were used by the COPI team to fill these gaps. The first significant gap filling was carried out to develop values for different land use types within a given biome. In general, the evaluation litterature provided a value for ecosystem service for a given landuse type within a biome (usually for natural areas that were being studied). If only these were to be applied, then there would be too many gaps to derive a total value for the change in landuse.

Core Step 4: Gap Filling for ecosystem services across biomes:

The available data from the literature also leads to some gaps in ESS values for some biomes. In some cases it is clear that there are services and that these are broadly similar between biomes. Where a broad relationship was establishable, the values from one biome were transferred to another.

Core Step 5: Applying "Conventional" Benefits transfer:

A "conventional" benefits transfer approach was applied to address the gaps in ESS coverage for geographic regions, and across time. For transfering values across regions, GDP (in purchasing price parity (PPP) terms)/capita ratios between countries was used for where the ecosystem service salues were judged to best reflect relative incomes – and where the good was seen as a global good with market prices (eg timber) the common global values were used (ie a transfer ratio of 1).

Core Step 6: Extrapolation of "today's" ecosystem service values into the future. Extrapolation into the future from current numbers is an important and necessary step in the analysis and one that is by its nature risky and imprecise. Leaving numbers at today's levels (in real terms) would lead to major weaknesses in the outputs –world population growth, income level growth, change in societal preferences, and increased competitions for limited and decling natural resources will each affect value. Hence assumptions are needed to attempt to take these into account..

Core Step 7: COPI Analysis: Combine the land use changes with the values for ecosystem services (ESS) under each land use for each region to derive values for the change in ecosystem services.

In the year 2050, the land coverage of natural areas and of (natural) forests will have decreased relative to the reference year 2000, as there is conversion to intensive agriculture and to plantations for biofuels. There will therefore be a shift from the ESS from natural areas and forests to ESS from intensive agriculture and plantations, and hence a trade-off between the different provision of services. To arrive at a value for the changes, the loss of area covered by natural areas is multiplied by the range of relevant ecosystem services for which values are available, the same is then done for forests, and to the post conversion land uses and a picture is developed of losses and gains. This gives the loss in 2050 from what land use there would been for that year. There will, of course be gaps, and hence it is important to be clear as to what is not covered and the influence of the gaps. This is done for both the partial estimation and the fuller estimation scenarios.

Core Step 8: Ecosystem services (ESS) are also lost where there are reductions in the quality of the land.
As an ecosystem is degraded generally this leads to a loss of ecosystem services. To capture these losses, the land-use and coverage in the final year of the analysis (2050) is taken (million hectares) and multiplied by the value of the services in that year (as per earlier analysis and method steps) and then multiplied by the loss of MSA index between 2000 and 2050 for the land use. The average hectare of grassland would have produced greater services in 2000 than in 2050 where the modelling suggests that pollution, climate change and fragmentation, have led to quality losses. This calculation therefore builds on a broad assumption that the MSA broadly reflects the provision of services, at least at an aggregate level. The use of broad relations (generally and specifically for ESS) are obviously important assumptions, and hence the MSA aspect of the evaluation is presented separately from the land-use. Note, of course, that the level of individual services does not follow the MSA pattern generally and hence were given different treatment in the gap filling. As with other assumptions, not treating quality losses would lead to an arguably unacceptable gap in the COPI assessment of what the impact of biodiversity loss is, at the same time including it raises questions as whether the approach is the best one.

Results: analysis of land-use change

For the fuller estimate the welfare losses from the loss of ecosystem services amount to 545 billion EUR in 2010 or just under 1% of world GDP by 2010. This amounts to around 50 billion Euros extra loss per year, every year. By 2010, the loss is “grown to” 545 billion EUR that year, for the land based ecosystems alone. This continues to increase until by 2050, the opportunity cost from not having preserved our natural capital stock, is a loss in the value of flow of services of $14 trillion (thousand billion) a year (see *table 3*). The opportunity costs will continue to rise beyond that as long as biodiversity and ecosystem losses are not halted. This then is the cost in the case that the 2010 target is not met.

Table 3 Annual Loss in 2050: The value of ecosystem services that would have benefitted mankind had biodiversity not been lost & remained at 2000 & 2010 levels.

	Value of Ecosystem service losses - Annual Billion (10^9) EUR lost							
	Fuller Estimation		**Partial Estimation**		**Fuller Estimation**		**Partial Estimation**	
	Relative to 2000	**Relative to 2010**	**Relative to 2000**	**Relative to 2010**	**Relative to 2000**	**Relative to 2010**	**Relative to 2000**	**Relative to 2010**
Area	**Billion EUR**	**Billion EUR**	**Billion EUR**	**Billion EUR**	**% GDP in 2050**	**% GDP in 2050**	**% GDP in 2050**	**% GDP in 2050**
Natural areas	-15568	-12703	-2119	-1679	-7.96%	-6.50%	-1.08%	-0.86%
Bare natural	-10	-6	-2	-1	-0.01%	0.00%	0.00%	0.00%
Forest managed	1852	1691	258	213	0.95%	0.87%	0.13%	0.12%
Extensive Agriculture	-1109	-819	-206	-141	-0.57%	-0.42%	-0.11%	-0.08%
Intensive Agriculture	1303	736	307	143	0.67%	0.38%	0.16%	0.09%
Woody biofuels	381	348	55	50	0.19%	0.18%	0.03%	0.03%
Cultivated grazing	-786	-1181	-184	-215	-0.40%	-0.60%	-0.09%	-0.13%
Artificial surfaces	0	0	0	0	0.00%	0.00%	0.00%	0.00%
World Total (Land-based ecosystems*)	-13938	-11933	-1891	-1518	-7.1%	-6.1%	-1.0%	-0.8%

The cumulative losses will be equivalent to around 7% of global consumption by 2050. This is a conservative estimate for three main reasons: 1) it is only partial, as not all ecosystem services are valued - significant ecosystem losses from coral reefs, fisheries, wetlands, and invasive aliens are not included 2) the estimates for the rate of land use change and biodiversity loss are fairly conservative[2], with the rate of loss estimated to slow 3) values do not account for non-linearities and threshold effects.

There are important losses that we can expect to occur in the next 50 years, and these relate primarily to the conversion of natural areas and also of extensive agriculture to intensive agriculture, managed forestry, more grazing and also woody biofuels (note that biofuels based on agricultural crops is within the agriculture bands). Overall, the analysis suggests that without halting biodiversity loss, the world in 2050 shall benefit much less from the flow of ecosystem services than in 2000. The loss in the value of the flow of services by 2050 would be equivalent to between 1% to 7.1% of GDP each year were 2000 to be taken as the biodiversity level of reference, and between 0.8% and 6% if 2010 were to be taken as the reference point (which due to continued incurred losses since 2000, of course, has a lower worldwide biodiversity value left than 2000). The loss in value of ecosystem services in 2010 of not having halted biodiversity loss at 2000 levels is estimated to be equivalent to[3] between just under 1% of GDP. These values related to the losses of services from land based ecosystem services alone, i.e. not taking into account marine fisheries, coastal, wetlands, coral reefs or the impact of invasive alien species (IAS). The total global loss across ecosystem types shall in fact be much greater.

Losses across regions
The variation across regions relates to the change in the land-use patterns within each region, quality losses for land in the region, different values for ESS across the regions and, when compared to national GDPs, the variation in national GDPs. While the welfare losses presented as an average of global GDP is 7%, the welfare losses due to ecosystem and biodiversity losses in the regions range from very small (MEA) to 17% in Africa, 23 to 24% in Brazil, other Latin America & Caribbean and Russia, and highest in Australia/New Zealand. A significant share of the losses is due to loss of the value of carbon storage, and hence a global loss rather than one felt directly by the local populations. Water regulation, air pollution regulation, cultural values and tourism losses, however, do affect national populations. The loss of these services make up more than half of the losses in Australia and New Zealand, but carbon storage losses make up a large share of losses in the other regions.

When seen from an absolute loss (Billion EURs) point of view, the regions most affected are:

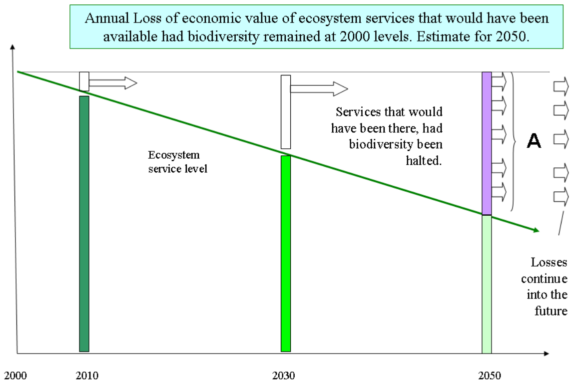
- North America: 3.4 trillion (10^12)EUR loss in 2050 from lost natural areas and overall 2.9 trillion EUR (10^12) loss in the High estimation scenario for 2000 to 2050.
- Africa: 3.15 trillion EUR (10^12)loss in 2050 from lost natural areas, and overall near 2.4 trillion (10^12) loss in the High estimation scenario for 2000 to 2050.
- and then other Latin America & Caribbean, Russia, other Asia, and Europe, and then Brazil and China, where losses are of the order of 1 trillion EUR in each (more in the earlier first countries in the list (e.g. Russia with near 1.5 trillion) and less in the last (China with 0.8 trillion EUR). (See table 6.9 for details.)

In other words, most regions of the world face serious losses of ecosystem services from biodiversity loss.

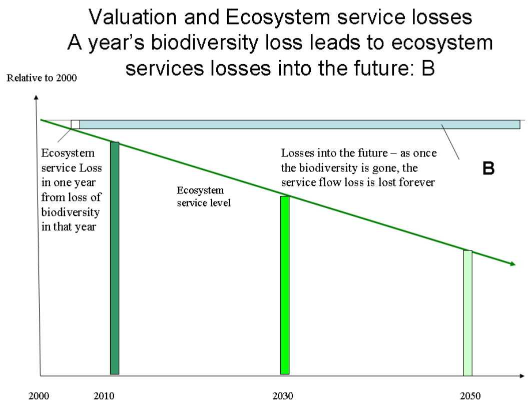
[2] The projection follows from the calculated losses due to a "middle of the road" economic and demographic OECD baseline scenario.
[3] The actual numbers are welfare numbers and not all these will translate into actual GDP loss. In other words, actual GDP as measured and reported might not be 1% lower.

Box 6.2: Different ways of presenting the scale of the COPI of biodiversity loss – example for the forestry biomes.

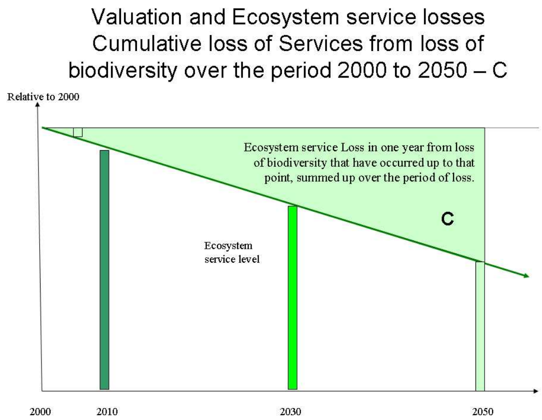
There are several ways of representing the losses for ecosystem services over a time period, with each different approach responding to different audience's perspectives. The COPI approach focused primarily on the estimation of the loss of benefit arising from the cumulative losses of biodiversity over the period to 2050, by looking at the value of the loss of ecosystem services in a given year, here 2050. This is an indication of the scale of the benefits from biodiversity that our children or grandchildren would not appreciate due to the loss of biodiversity due to the current generation's inaction. The schematic for this value is presented below - A.



There are, however, other ways of presenting the value. In the financial sector there is a preference for looking at the market capitalisation of the loss in value due to the future loss of services due to loss of ecosystems and biodiversity. This can be presented as a "net present value" (NPV) of the future stream of loss of value from one year's loss of natural capital. As, however, the loss of biodiversity and hence ecosystem services continues into the future, the losses add up, and this can be presented by the aggregated loss. The schematics for theses values are presented below – B and C. For the latter two, to derive associated NPVs requires the application of a "discount rate". Here two illustrative values are used – a 4% real and a 1% real discount rate. The former is broadly a market discount rate as used in most CBA, and the latter is a social discount rate that tries to integrate ethical issues of future generations.



What is the value over the next 50 years of a year's biodiversity loss today? Total for the forest biomes. Using a 4% real discount rate the net present value of the loss of ecosystem services is around 161 billion (10^9) EUR for the partial estimate and 1.35 trillion (10^12) EUR for the fuller estimate. With a 1% discount rate the values are significantly higher as the future value is less discounted. The partial estimate's NPV is 377 billion EUR and the fuller estimate at 3.1 trillion (10^12) EUR. What is the cumulative value over the next 50 years of biodiversity loss to 2050? The NPV of the cumulative losses (the "total bill" for the losses) are:



d.r. 4% Partial estimate 4.1 trillion EUR Fuller estimate 33.3 trillion EUR
d.r. 1% Partial estimate 11.8 trillion EUR Fuller estimate 95.1 trillion EUR

There are several messages from this. First whichever way the cost of not halting biodiversity loss is presented, the numbers are compelling and underline the need for urgent action. Secondly, the choice of discount rate plays an important role in the perception of value in the present. Even a relatively "low" (in conventional terms) rate seriously discounts the perception of future value. This raises ethical questions regarding what is an appropriate choice of discount rate for societal evaluations. The COPI study has sought to use the loss in a 2050 to communicate the level and importance of the loss and avoid the discount trap.

Losses across biomes

The greatest losses are from the tropical forest biomes. The next greatest total losses are from other forest biomes. Total losses from Savanna and Grassland are estimated to be less. Note that the total values reflect the combination of different levels of the value of loss of ecosystem services per hectare (which are also higher for tropical forests than others), and total areas lost/converted. For a range of biomes there have been no estimations – particularly in the partial estimation scenario, though also in the higher estimation scenario. This underlines that the numbers should be seen as underestimates, even the fuller scenario has a range of gaps, both at the biome level, and at which ecosystem services are represented in the calculations .

As more information was available on ecosystem service values for the forest biomes and that information was complemented by extensive additional work to develop values for each of the global regions without recourse, as extensively, to benefits transfer techniques, further details are given on the forestry biomes. The losses of services from the change in landuse and biodiversity for the 6 forest biomes together are equivalent to 1.3 trillion (10^12) EUR (partial estimation) and 10.8 trillion (10^12) EUR (fuller estimation) loss of value in 2050 from the cumulative loss of biodiversity over the period 2000 to 2050. These numbers have been calculated using values for 8 ecosystem services. When compared to the projected GDP for 2050, these values equate to 0.7% of GDP for the partial estimate, and 5.5% of GDP for the fuller estimate.

Losses and gains per ecosystem service type

Table 4 shows the relative importance of losses (and gains) in ecosystem services and their contribution to the total. Climate regulation, soil quality maintenance and air quality maintenance are the main items, with climate regulation being sensitive to the carbon price assumptions. Food, fiber and fuel are generally positive, with losses stemming from natural areas and extensive agriculture as these are (generally) converted to intensive agriculture. Other ecosystem services are not presented in the table here, either as not significant in the final numbers (eg bio-prospecting), which often reflects the limits of data availability. As noted earlier, these numbers should be seen as working numbers to illustrate the importance of the issue and help clarify where additional research is needed to advance the understanding of the risk of loss of ecosystem services.

Table 4 Total Annual loss of value of various ecosystem Services in 2050 (relative to 2000)

2050 relative to 2000: Fuller Estimation	Total	Food, fiber, fuel	Air quality maintenance	Soil quality maintenance	Climate regulation (i.e. carbon storage)	Water regulation, & water purification and waste management	Cultural diversity, identity, heritage & Recreation & ecotourism
World Total (Land-based ecosystems*)	-13938	192	-2019	-1856	-9093	-782	-303
Natural areas	-15568	-383	-2025	-1778	-10274	-748	-291
Bare natural	-10	0	-1	-1	-6	0	-2
Forest managed	1852	184	208	166	1188	70	31
Extensive Agriculture	-1109	-256	-56	-50	-712	-23	-8
Intensive Agriculture	1303	746	38	41	448	21	6
Woody biofuels	381	29	33	30	270	15	2
Cultivated grazing	-786	-128	-217	-264	-6	-116	-41
Artificial surfaces	0	0	0	0	0	0	0

* (Exl Ice / Hot Desert)

The importance of change in quality of the ecosystems and ecosystem services

It is also useful to look at the relative contribution of land-use area change and ecological quality changes to the total monetary losses. The economic losses from loss of ecosystem services associated with loss of natural areas are broadly similar for land-use changes and quality changes. However quality losses are generally negative across land-uses[4]. Gains are mainly due to increases in provisioning services (timber and food and (bio)fuels). At a *net level*, the loss for land-use change is smaller than that due to the quality change, given the increases in provision from the managed forest, intensive agriculture, and woody biofuels. Some would argue that the increased benefits from post converted land uses should be ignored in a strict COPI, but we concluded that it is better to present the details to facilitate a more transparent reading of the results.

Key observations as to data inputs, methods, assumptions and interpretation

It is important to underline that the estimates of the COPI for biodiversity loss presented are "rough" estimates. There is a wide range of gaps in available data. There are more data available for certain regions, biomes and ecosystem services than for others. This therefore creates a cautionary note in too detailed an interpretation of the results – the limitations need to be borne in mind. Furthermore, the stepwise analysis (scenario drivers-> pressures-changes) does not allow a feedback of the economic impact results back into the OECD economic model, and hence losses to the economy related to ecosystem service losses from biodiversity losses do not link back to the OECD economic projections. Ultimately a feedback mechanism would be required. Figure ? shows the different paths of (a) GDP growth and (b) population growth and (c) ecosystems and biodiversity losses (with associated ecosystem service losses).

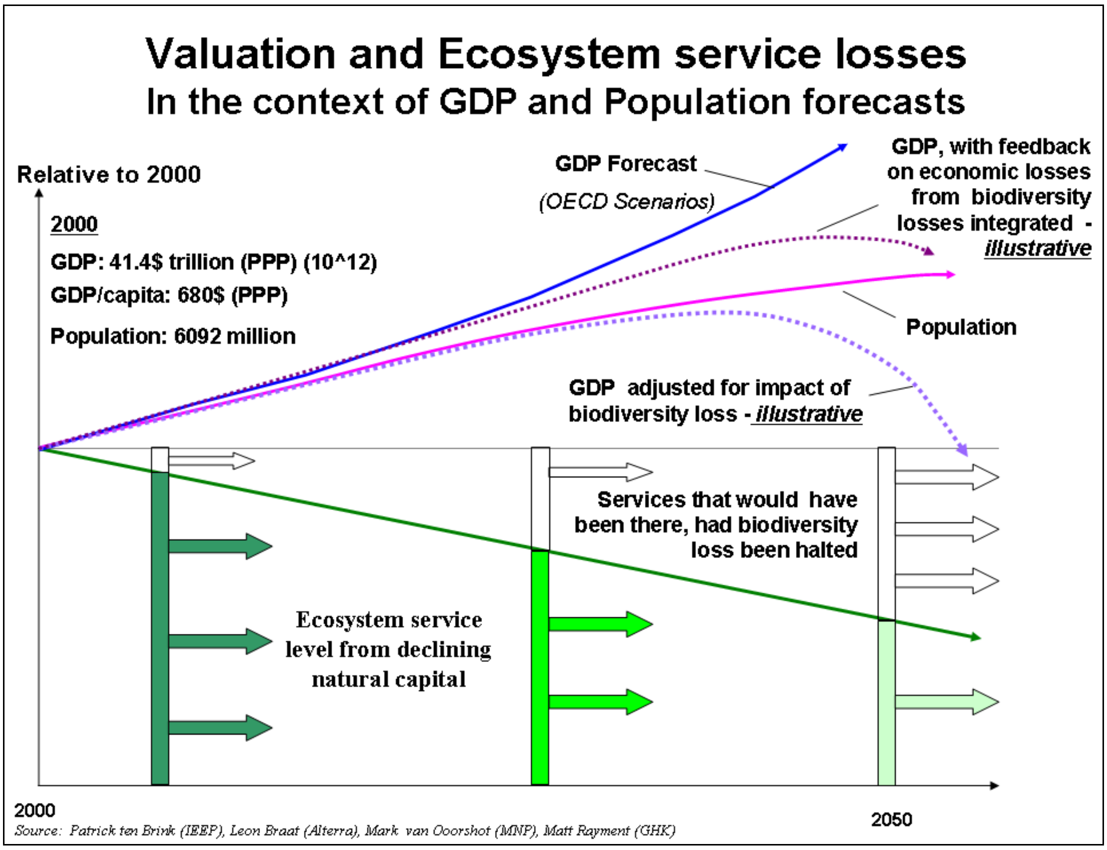


Figure 15 Economic projections, ecosystem service losses and economic consequences.

[4] There is one small exception - of a slight quality rise in intensive agricultural land. This is most probably due to the influence of higher quality (MSA rating) of extensive land that is converted to intensive land and hence entering at a higher average MSA, compensating for other quality losses to the intensive areas.

Clearly as the natural capital is drawn down, and the level of services falls, society and the economy also benefit less. Under current GDP statistics some of the losses will be translated into GDP values directly (eg loss of output of fisheries will be seen, when substitution possibilities run out), other will impacts indirectly (as more expenditure on water purification is needed to compensate for loss of natural purification, taking money away from other foci) and a range will have no GDP impact (eg loss of cultural values, option values, existence or bequest values). A fuller analysis would allow a feedback to take into account changes in inputs to the economy from loss of ecosystem service outputs, and change on manmade inputs to compensate for the loss (Eg growth in water purification, desalination). This will change the overall numbers, but probably not the high level messages. In addition were the carbon prices to be added, then the value of maintaining forests to preserve the carbon store service would likely lead to a different future land use scenario. Hence, if policy makers launch and enforce measures then there is potential for a different future.

Other values of ecosystem and biodiversity loss to complement the COPI land based analysis

Some examples to highlight the importance of the issues are presented below.

- **Coral reefs*:*** A recent review by the French Government found a wide range of values from different studies for different aspects of the economic value of coral reefs. For example, different studies have estimated the value of coastal protection at $55 to $260,000/ha/yr; biodiversity and existence values at $12 to $46,000/ha/yr; recreation and tourism at $45 to $10,320/ha/yr; fishing at $120 to $360/ha/yr; and total economic value at $1,000 to $893,000/ha/yr. The latter estimate relates to Montego Bay, Jamaica, a popular holiday resort and famous for its recreational activities, such as diving and sailing.
- **Wetlands:** For Europe, an estimate for the total annual flow of ecosystem services for wetlands (Brander et al, 2007) gave a value of 6 billion (10^9) EUR/year. Averages values per hectare ranged from hundreds of Euros per hectare (in countries with extensive wetlands - Sweden, Finland, Ireland) to several thousands of Euros per hectare (generally the case). These relate to a range of ecosystem services. The Zambezi Basin wetlands provide over *$70 million* in livestock grazing, almost *$80 million* in fish production, and *$50 million* in flood plain agriculture. Carbon sequestration is also a significant value.
- Another global estimate carried out concerns **Invasive Alien Species (IAS**). Pimentel l (2001) developed an order of magnitude estimate to highlight the likely importance of action on IAS – he and his colleagues estimate that IAS represents around $1.4 trillion per year of impacts (equivalent to around 5% of GDP). Within the COPI study, an update of the costs of IAS has been carried out, building on a literature review.
- For **recreation and the economic impact of tourist activities**, values can be very large. For example, the economic impact of forest recreation in national forests in the USA, was valued $6.8 billion in 1993 and 139,000 jobs in 1996. The wider contribution to GDP was estimated at $110 billion/year. Total economic value of fishing in national forests: $1.3-2.1 billion in 1996.
- **Pollination:** As regards pollination, Ricketts et al. found the value of bee pollination for coffee production to be worth US$361/ha/year, although the benefits were only felt by producers located within 1km of natural forests (Ricketts, 2004).
- **A further Invasive alien species impact concerns the** zebra mussel - this has led to damage to US and European industrial plants. Cumulative costs for the period 1988-2000 have been estimated at between $750 million to $1 billion
- For the ecosystem service "**biochemicals, natural medicines and pharmaceuticals**", found in tropical forests, the values for bioprospecting have been estimated at ranging from

$1/ha to $265/ha when employing a random search, including locations with the highest biodiversity.

- For **provisioning services**, marine capture fisheries, offer an impressive example. Marine capture fisheries are an important source of economic benefits, with an estimated first-sale[5] value of *$ 84,900 million*, and important for income generation, with an estimated 38 million people employed directly by fishing, and many more in the processing stages. The scale of this (and of course the scale of dependency on fish for protein) underlines the importance of not compromising this fundamental ecosystem service.
- **Finally, carbon storage** – this depends on carbon in the soil, in the trees or grass, the isolation levels and the value depends on these and the price of carbon, which in turn relates to a wide range of factor (political targets, trading mechanisms, supply and cost of measures for CO2 reductions).

Synthesis across values

The COPI landcover based analysis derives a broad set of estimates, with losses of ESS from biodiversity and ecosystem loss represented at between 1 and 7.5% of global GDP loss every year by 2050. This is a conservative estimate for three main reasons:

- it is only partial, as not all ecosystem services are valued - significant ecosystem losses from coral reefs, fisheries, wetlands, and invasive aliens are not included
- the estimates for the rate of land use change and biodiversity loss are fairly conservative in the OECD-scenario and GLOBIO model, with the rate of loss estimated to slow down
- values do not account for non-linearities and threshold effects .

As regards the partial coverage, the range of values for other areas have demonstrated that that values for fisheries, coastal areas, coral reefs and wetlands/inland waters and invasive alien species are all significant.

The exact monetary scale is not known and arguably not knowable. The best that can be achieved are orders of magnitude estimates that help clarify and communicate the urgency of action to avoid the problems. One should also be careful about % of GDP estimates, as ultimately there is significantly more to livelihood and wellbeing than GDP, and also average figures hide important detail. A % GDP loss figure, needs to be seen in the context of the level of impacts on the individual, of population groups etc. In some cases the destruction of a local forest will hardly show up in % GDP terms, but it will be clearly felt by local communities depending on the provisioning and other services from that forest.

The scale of the ecosystem service losses underlines the important of improving understanding of the losses better and seeing where this information can put halting biodiversity further up the agenda, and also where the valuation information can be integrated into tools and decision making to improve the evidence base of decisions making and hence improve our governance of natural capital, our natural heritage, and help ensure that ecosystem and biodiversity loss is halted.

7 Conclusions and recommendations

Changes in Biodiversity

The facts with respect to past losses of biodiversity confirm that there is an urgency for action. Global averages, dramatic as they are, hide even more dramatic changes. Locally and regionally the levels in many places are much higher, with much greater impact on the livelihoods of societies The effect of trends such as these is that approximately 60% of the

[5] Value to fishermen, does not include the value added along the retail chain.

earth's ecosystem services that have been examined have been degraded in the last 50 years, with human impacts the root cause. Further declines in global biodiversity as well as local extinctions of species are expected in the next few decades because of continuing population growth, economic expansion, conversion of natural ecosystems to human environments and global climate change.

On a more positive note, the number and extent of protected areas have been increasing rapidly worldwide in recent decades; they now cover almost 12% of global land area. However, the biomes are unevenly represented in that coverage. Marine areas are under-represented in all categories of protected areas. Realisation of actual protection is at risk with the increasing pressure on land and resources due to the increasing human populations. A focus on protected areas only is not enough as some 20% of threatened species occur outside protected areas and some protected areas are "paper parks" and are not managed and protected sufficiently well to guarantee that biodiversity be maintained. The GBO2 (Global Biodiversity Outlook 2)[6] analyses in 2006 already showed that full implementation of the protected areas targets will only decrease the biodiversity losses on land by 2-3 %-points (compared to projected losses of 8-11% points). Whilst degradation is usually less within protected areas than in surrounding unprotected zones and many of the world's flagship protected areas are threatened by external pressures and lack of adequate protection.

Changes in ecosystem services

Ecosystem services form the conceptual bridge between loss of biodiversity and loss of welfare and well being. With conversions of natural ecosystems to other forms of land use, such as cropland, pasture land or urban land, or by unsustainable fishing of the oceans, or converting coastal mangrove to shrimp farms, the total flow of services from ecosystems to humans in a region is altered. While ecosystem conversion often generates substantial economic benefits and improvements in human well-being, it also deteriorates the capacity of ecosystems to provide other services, in particular regulating services, that are essential for other groups of people or for society at large. The changes often bring short-term private economic benefits for a few people but long-term social costs for many.

It is essential for achieving sustainable use of natural resources to understand the different relations between ecosystem services and biodiversity, and the trade-offs involved in a conversion from one type of land use to another as this leads to a different portfolio of services. It is also essential to take account of the *net change* in services, as some benefits may increase while others get lost in the conversion. Increasing one particular local service with private benefits generally leads to losses of regional or global services with public benefits. For a full and relevant assessment, it is also quite important to address the *net benefits of changes*, taking account of the energy cost of human interventions in exploiting ecosystem services.

Change is economic value

The study has shown that the problem of the economic and social consequences of biodiversity loss is potentially severe and economically significant, but that significant gaps remain in our knowledge, both ecologically and economically, about the impacts of future biodiversity loss. Further work is needed, which can usefully build on the insights gleaned in this first scoping valuation exercise. The COPI study aims, just like Costanza et al., to assess the importance of the value of ecosystem services and biodiversity to society and the importance of the loss and urgency of action to halt the loss, but it does so by looking at the losses from changes in the stocks of natural capital, and the change in value of the loss of flow of services that ensue. There are, of course, a wide range of assumptions needed to arrive at this value– and there is a specific COPI challenge in the route taken.

[6] http://www.cbd.int/gbo2/

The COPI analysis is aimed not just at calculating some illustrative numbers, but also at creating and testing a method and developing insights for the methodology to be used in future evaluations. The numbers here should therefore be seen as indicative and the insights from the COPI evaluation challenge should be seen as one useful input to the wider evaluation challenge of The Economics of Ecosystems and Biodiversity (TEEB) being launched at COP9. Shortcomings in the COPI approach, and there will inevitably be some, could therefore be seen as challenges to be solved within the wider TEEB.

The results in methodological perspective

On benefit transfer
Transferring results from one area to another (benefit transfer) to develop regional or global totals, presents a range of valuation challenges. Some will reject global numbers on the grounds that they are fraught with too many assumptions to be accurate and hence credible. Others will see them as helpful illustrative numbers to communicate the importance of an issue and source of inspiration for further evaluation to improve the understanding, or source of argument to contribute to policy making to help address biodiversity loss. The COPI team approach has been to present both the cases and the illustrative global totals and explore what can and cannot be defended methodologically and what could usefully be done in follow up research.

Monetary loss and GDP
It has to be noted that the monetary losses are current and future welfare losses, not a loss of GDP, as a large part of the benefits from ecosystem services is currently not included in GDP, and GDP includes monetary estimates of human activity of which the welfare contribution is at least dubious. Losses of our natural capital stock are felt not only in the year of the loss, but continue over time, and are added to by losses in subsequent years of more biodiversity. These cumulative welfare losses of land based ecosystem services could be equivalent in scale to 7% of (projected) GDP by 2050. The 7% figure should be seen as a conservative estimate, as:

- it is partial, excluding numerous known loss categories, e.g. all marine biodiversity, deserts, the Arctic and Antarctic; some ecosystem services are excluded as well (disease regulation, pollination, ornamental services, etc), while others are barely represented (e.g. erosion control), or underrepresented (e.g. tourism); losses from invasive alien species are also excluded;
- estimates for the rate of land use change and biodiversity loss are globally quite conservative;
- the negative feedback effects of biodiversity and ecosystems loss on the development of GDP are not accounted for in the model;
- values do not account for non-linearities and threshold effects in ecosystem functioning.

Losses across regions
While the welfare losses presented as an average of global GDP is 7%, the welfare losses due to ecosystem and biodiversity losses in the regions range from very small in the Middle East to 17% in Africa, 23 to 24% in Brazil, “Other Latin America & Caribbean” and Russia, and around 40% in Australia/New Zealand. A significant share of the losses is due to loss of the value of carbon storage, and hence a global loss rather than one felt directly by the local populations. Water regulation, air pollution regulation, cultural values and tourism losses, however, do affect national populations directly. The loss of these services makes up more than half of the losses in Australia & New Zealand, but carbon storage losses make up a large share of losses in the other regions.

Losses across biomes
The greatest losses are from the tropical forest biomes. The next greatest total losses are from other forest biomes. Total losses from Savanna and Grassland are estimated to be less. Note

that the total values reflect the combination of different levels of the value of loss of ecosystem services per hectare (which are also higher for tropical forests than others), and total areas lost/converted. The losses of services from the change in landuse and biodiversity for the 6 forest biomes together are equivalent to 1.3 trillion (10^12) EUR (partial estimation) and 10.8 trillion (10^12) EUR (fuller estimation) loss of value in 2050 from the cumulative loss of biodiversity over the period 2000 to 2050. These numbers have been calculated using values for 8 ecosystem services. When compared to the projected GDP for 2050, these values equate to 0.7% of GDP for the partial estimate, and 5.5% of GDP for the fuller estimate. For a range of biomes there have been no estimations – particularly in the partial estimation scenario, though also in the higher estimation scenario. This underlines that the numbers should be seen as underestimates, even the fuller scenario has a range of gaps, both at the biome level, and at which ecosystem services are represented in the calculations

Losses and gains per ecosystem service type

Climate regulation, soil quality maintenance and air quality maintenance are the main areas where there are ecosystem service losses, with climate regulation being sensitive to the carbon price assumptions. Food, fiber and fuel are generally positive (gains seen here), with losses stemming from natural areas and extensive agriculture as these are (generally) converted to intensive agriculture. Some other ecosystem services do not come up as significant in the final answer (eg bio-prospecting), which often reflects the limits of data availability.

Importance of change in quality of the ecosystems and ecosystem services

The economic losses from loss of ecosystem services associated with loss of natural areas are found to be broadly similar for land-use changes and quality changes. However quality losses are generally negative across land-uses. A major difference is that there are positive gains to some land-uses in the land-use change set of numbers. This is due to the fact that all land-uses, including conversions of natural land cover, have ecosystem services and it would not be appropriate to completely exclude them. Gains are mainly due to increases in provisioning services (timber and food and (bio) fuels).The assessment of the impacts of changes in ecosystem quality on the amount of services provided ultimately relies to a large extent on the scientific evidence collected and the assumptions made in the valuation case studies used in the matrix. Creative solutions, based on elaborating assumptions on the shape of the relationships between biodiversity and the various types of services, have been developed to extrapolate and fill data gaps.

Policy recommendations

The COPI results follow from a no-new-policy scenario. They underline that such a scenario would lead to substantial losses of services due to the deterioration of our natural capital, and that there is thus a high level of urgency for action to help address these losses. This would inevitably require attention at many administrative levels in parallel. As noted in Chapter 3, there are policies that directly focus on ecosystems and biodiversity, such as the Habitats and Birds directives in the EU. There are also policies that focus on broader environmental issues but have the potential also to be used to support conservation and sustainable use of ecosystems and biodiversity, such as the EU EIA and SEA Directives. On the other hand, there are a number of policies that continue to have direct or indirect negative effects on ecosystems and biodiversity, e.g. aspects of the EU common fisheries and agricultural policies. Additionally, there are several regions on the globe where policies on conservation and sustainable use of biodiversity are still lacking, thus even the potential to address unsustainable use of natural resources is still rather limited.

The economic consequences of the loss of biodiversity and ecosystem services, as assessed in the COPI study, will need to be compared to the consequences of actions to conserve them and use them sustainably, based on appropriate scenarios, in order to develop full policy recommendations. Presently, due to methodological difficulties and patchy data on ecosystem services, most policy decisions with impacts on biodiversity conservation are not based on a full assessment of costs and benefits.

The existence, use and improvement of valuation information can be valuable for policy making and policy tools in a number of areas. Valuation can help in a range of fields:

- In providing information on the benefits of ecosystems and biodiversity, valuation can help encourage the use of associated policy instruments, such as payments for environmental services (PES) and benefit sharing.
- In providing information on the costs of losses of ecosystems and biodiversity, valuation can help develop instruments that make people that benefit from the services pay for the associated costs. Information can help, for example, strengthen liability rules, elaborate compensation requirements and looking again at which subsidies are needed and which are harmful and no longer fit-for-purpose. There is also potential in areas which at first sight might not be obvious candidates for attention – for example, in the EU at the Eurovignette directive, which currently does not permit pricing for environmental externalities, but arguably should.
- Furthermore, information on the contributions of ecosystems systems to societal welfare and economic activity, valuation can help with decision making - for example at the local level the information can help with planning (e.g. for permit applications). At the regional level benefits and costs can help with regional development plans and associated strategic analysis and help with investment allocations and prioritisation. At the national level, greater information on the interrelationships between ecosystems and the economy and society can help improve national accounts and national policies that reflect a fuller understanding of how natural capital benefits the country.

In summary, there is a urgent need to look at the range of biodiversity relevant policies, including related policy- and decision making processes and evaluation tools, to see where perverse incentives exist to damage ecosystem and biodiversity and where valuation information can be used to create more environmentally sustainable policies.

Research recommendations

Areas for further study are:

- to widen the range of models and scenarios so as to assess the value of ecosystem and biodiversity across all the main biomes and services.
- fill in data gaps on ecosystem service values –notably for regulatory functions, and other areas where values are non market.
- values of different Land use types within different biomes.
- better understanding of the production functions of the different services and clarify which elements are due to the contribution of natural ecosystems rather than “man-made” inputs such as fertiliser, pesticides, machinery and labour.
- better understanding the relationship between area loss and ecosystem service provision changes.
- further understanding of ecosystem resilience (not just to changes in area, but also to other pressures) and critical thresholds and how these could usefully be addressed in evaluation and in policy making.
- the issue of substitutability of services and its limits and ethical issues.
- further work on clarifying how other tools, such as risk assessment tools can complement the valuation tool.

Finally, pragmatism will remain important even if the various recommendations are all heeded – there will always remain limitations as to what valuation can do, and what is theoretically “pure”. In some cases practical assumptions are needed to develop the “big picture”. For the wider objectives of looking at what incentives and policy tools can help address the ecosystem and biodiversity loss challenge and how to get political support to develop and apply these, there is a need to see what level of accuracy is actually needed for the job at hand – in practice there will be a need for a mix of small local numbers that are accurate, and bigger numbers to raise the profile, that need to be robust and transparent, but where an order of magnitude answer is "fit-for-purpose" for communicating the importance of the issues and raising the political profile and urgency for action..

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