CBD

UNEP

CONVENTION ON BIOLOGICAL DIVERSITY

Distr.
GENERAL

UNEP/CBD/SBSTTA/10/6
13 December 2004

ORIGINAL: ENGLISH

SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE
Tenth meeting
Bangkok, 7-11 February 2005
Item 5.2 of the provisional agenda*

MILLENNIUM ECOSYSTEM ASSESSMENT: REVIEW OF THE DRAFT REPORTS, IN PARTICULAR THE DRAFT SYNTHESIS REPORT PREPARED FOR THE CONVENTION ON BIOLOGICAL DIVERSITY

Note by the Executive Secretary

The Conference of the Parties, in decision VII/6, took note of the progress of the Millennium Ecosystem Assessment and the outline for the synthesis report that would be prepared for the Convention on Biological Diversity, and encouraged national focal points to participate in the review of the Millennium Ecosystem Assessment reports. Further, the Conference of the Parties requested the Subsidiary Body for Scientific, Technical and Technological Advice (SBSTTA) to review the findings of the Millennium Ecosystem Assessment including the synthesis report on biodiversity, to be taken into account by the Millennium Ecosystem Assessment in finalizing its reports, and to prepare recommendations to the eighth meeting of the Conference of the Parties.

Annexed to the present note is the draft Summary for Decision Makers of the synthesis report on biodiversity, as submitted by the Secretariat of the Millennium Ecosystem Assessment. The Summary for Decision Makers summarizes the main findings of the full draft synthesis report (UNEP/CBD/SBSTTA/10/INF/5). The Summary for Decision Makers and the full Synthesis Report were made available for expert and government review on 15 December 2004. The Synthesis Report integrates and synthesizes findings related to biodiversity from the reports of the four working groups of the Millennium Ecosystem Assessment. These reports are listed in document UNEP/CBD/SBSTTA/INF/5 and available at: http://www.millenniumassessment.org/en/index.aspx. The full Synthesis Report includes references to the original source of the material in the full technical assessment reports of the four MA working groups. The final version of the Sumary for Decision Makers will include references to the full synthesis report.

In line with decision VII/6, SBSTTA is expected to review the draft synthesis report prepared for the Convention on Biological Diversity giving particular attention to the Summary for Decision Makers. The draft will be revised based on comments of SBSTTA as well as those received during the expert and government review, and finalized by the Panel of the Millennium Ecosystem Assessment.

* UNEP/CBD/SBSTTA/10/1.

The final versions of the synthesis report and its Summary for Decision Makers will be available to SBSTTA at its eleventh meeting, in order that it may prepare recommendations for the eighth meeting of the Conference of the Parties.

SUGGESTED RECOMMENDATION

The Subsidiary Body on Scientific Technical and Technological Advice may wish to:

(a) Recall decision VII/6, in which the Conference of the Parties, *inter alia*, requested SBSTTA to review the findings of the Millennium Ecosystem Assessment including the synthesis report on biodiversity, to be taken into account by the Millennium Ecosystem Assessment in finalizing its reports;

(b) Welcome the progress made by the Millennium Ecosystem Assessment, and the opportunity to review the draft synthesis report on biodiversity and its Summary for Decision Makers;

(c) Provide its comments on the Summary for Decision Makers;

(d) Invite the Panel of the Millennium Ecosystem Assessment to take into account the comments provided pursuant to paragraph (c) above, as well as those made individually by delegations during the tenth meeting of SBSTTA, when finalizing the synthesis report on biodiversity and its Summary for Decision Makers.

Annex

Millennium Ecosystem Assessment: Synthesis Report for the Convention on Biological Diversity Summary for Decision-makers

Draft for Expert/Government Review (December 15, 2004)

Background

1. The Millennium Ecosystem Assessment (MA) was carried out between 2002 and 2005 to assess the consequences of ecosystem change for human well-being and to analyze options available to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. The MA responds to requests for information received through the Convention on Biological Diversity and other international conventions (UN Convention to Combat Desertification, Ramsar Convention on Wetlands, and the Convention on Migratory Species) and is also designed to meet needs of other stakeholders including business, civil society, and indigenous peoples. It was carried out by approximately 1,300 experts from 95 countries through four working groups and encompassed both a global assessment and sixteen sub-global assessments. An independent review board has overseen an extensive review by governments and experts. Each working group and each sub-global assessment has produced detailed technical assessment reports.

2. This report synthesizes and integrates findings related to biological diversity from the four MA working groups. The material presented in this report, and in the full MA, is an assessment of the current state of knowledge and is based on existing published literature and other existing sources of knowledge and information. The purpose of the assessment is to:
   - provide an authoritative source of information;
   - mobilize knowledge and information to address specific policy questions;
   - clarify where there are areas of broad consensus within the scientific community and where important controversies remain; and,
   - provide insights that emerge from a broad review of knowledge that might not be apparent in individual studies.

3. Consistent with the Ecosystem Approach, the MA assumes that people are integral parts of ecosystems and that a dynamic interaction exists between people and other parts of ecosystems, with the changing human condition serving to drive, both directly and indirectly, change in ecosystems and with changes in ecosystems causing changes in human well-being. (See Figure 1.) At the same time, many other factors independent of the environment change the human condition, and many natural forces influence ecosystems. The MA places human well-being as the central focus for assessment, while recognizing that biodiversity and ecosystems also have intrinsic value (value of something in and for itself, irrespective of its utility for someone else) and that people take decisions concerning ecosystems based on considerations of well-being as well as intrinsic value.

4. Biological diversity is the variability of living organisms. It includes all plants, animals, microorganisms, the ecosystems of which they are part, and the diversity within species, among species, and of ecosystems. No single component of biodiversity (i.e. genes, species, or ecosystems), is consistently a good indicator of the overall biodiversity as these components can vary independently (see Box 1). Biodiversity can be described, simply, as "diversity of life on earth". Biodiversity is essential for ecosystem functioning and underpins the provision of ecosystem systems.

5. The MA focuses on the linkages between ecosystems and human well-being and in particular on "ecosystem services" – the benefits people obtain from ecosystems. These include *provisioning*

services such as food, water, timber, and fiber; *regulating services* such as the regulation of climate, floods, disease, wastes and water quality; *cultural services* such as recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis and nutrient cycling. The MA assesses the indirect and direct drivers of change in ecosystems and their ecosystem services, the current condition of those services, and how changes in the services have affected human well-being. The MA uses a broad definition of human well-being, examining how ecosystem changes influence income and material needs, health, sound social relations, security, and freedoms and choice. The MA developed four global scenarios exploring plausible future changes in drivers, ecosystems, ecosystem services, and human well-being (see Box 2). Finally, the assessment examined the strengths and weaknesses of various response options that have been used to manage ecosystem services and identified promising opportunities for enhancing human well-being while conserving ecosystems.

Main Findings[1]

What is the Problem?

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

7. **Virtually all of earth's ecosystems have now been dramatically transformed through human actions.** More land was converted to cropland since 1945 than in the 18th and 19th centuries combined. Between 1960 and 2000 reservoir storage capacity quadrupled and, as a result, the amount of water stored behind large dams is estimated to be 3 to 6 times the amount held by rivers. Some 35 percent of mangroves have been lost in the last two decades in countries where adequate data are available (encompassing about half of the total mangrove area). Roughly one-quarter of the world's coral reefs were badly degraded or destroyed in the last several decades of the 20th century. Although the most rapid changes in ecosystems are now taking place in developing countries, industrialized countries historically experienced comparable changes. Biomes with the highest rates of conversion in the last half of the 20th century were temperate, tropical and flooded grasslands and tropical dry forests (more than 14 percent lost between 1950 and 1990). Areas of particularly rapid change in terrestrial ecosystems over the past two decades include:
    - the Amazon basin and Southeast Asia (deforestation and expansion of croplands)
    - Asia (land degradation in drylands)
    - Bangladesh, Indus Valley, parts of Middle East and Central Asia, the Great Lakes region of Eastern Africa, and the Great Plains region of the United States (expansion of croplands).

8. **Globally, the net rate of conversion of some ecosystems has begun to slow (in some instances because little habitat remains unconverted), and in some regions ecosystems are returning to more natural states**. Generally, opportunities for further expansion of cultivation are diminishing in many regions of the world as the finite proportion of land suitable for intensive agriculture continues to decline. Increased agricultural productivity is also diminishing pressures for agricultural expansion.

[1] **Note:** In this report, the following words have been used where appropriate to indicate judgmental estimates of certainty (based upon the collective judgment of the authors using the observational evidence, modeling results, and theory that they have examined): *very certain* (98% or greater probability), *high certainty (*85-98% probability), *medium certainty* (65-85% probability), *low certainty* (52-65% probability), and *very uncertain* (50-52% probability). In other instances, a qualitative scale to gauge the level of scientific understanding is used: *well established, established-but-incomplete, competing explanations*, and *speculative*. Each time these terms are used they are in *italics*.

Since 1950, cropland areas in North America, Europe and China have stabilized, and even decreased in Europe and China. Cropland areas in the Former Soviet Union have decreased since 1960. Within temperate and boreal zones, forest cover increased by approximately 3 million hectares per year in the 1990s, although approximately half of this increase consisted of forest plantations.

9. **Across a range of taxonomic groups, the population size or range or both of the majority of species is declining.** Studies of amphibians globally, African mammals, birds in agricultural lands, British butterflies, Caribbean corals, and commonly harvested fish species show declines in populations of the majority of species. Exceptions include species that have been protected in reserves, have had their particular threats eliminated (such as over-exploitation), and that tend to thrive in landscapes that have been modified by human activity.

10. **Over the past few hundred years humans have increased species extinction rates by as much as 1000 times background rates typical over the planet's history**. (See Fig. 2.) There are approximately 100 documented extinctions of birds, mammals and amphibians over the past 100 years, a rate approximately 50 to 500 times higher than background rates. Including possibly extinct species, the rate is more than 1000 times higher than background rates. A range of techniques, including extrapolations from known extinctions and estimations based on modeled impacts of habitat change yield comparable estimates of contemporary species extinction rates.

11. **The distribution of species on earth is becoming more homogenous.** By homogenous, we mean that the differences between the set of species at one location on the planet and the set of species at another location are, on average, diminishing. Two factors are responsible for this trend. First, the extinction of species or the loss of populations results in the loss of the presence of species that had been unique to particular regions. Second, the rate of invasion or introduction of species into new ranges is already high and continues to accelerate in pace with growing trade and faster transportation. Currently documented rates of species introductions to different regions of the world are greater than documented rates of extinction. Thus, while the total number of species on the planet is decreasing due to extinctions, the total number of species on every individual continent is actually increasing. The full ecosystem consequences of homogenization depends on the aggressiveness of the introductions and the services they either bring or impair.

12. **Between ten and fifty percent of well-studied higher taxonomic groups (mammals, birds, amphibians, conifers, and cycads) are currently threatened with extinction, based on World Conservation Union (IUCN) criteria for threats of extinction**. Twelve percent of bird species, 25% of mammals and 23% of conifers are currently threatened with extinction. Thirty-two percent of amphibians are threatened with extinction but information is more limited and this may be an underestimate. Higher levels of threat (53%) have been found in the cycads, a group of evergreen palm-like plants.

13. **Genetic diversity has declined globally, particularly among cultivated species.** Since 1960 there has been a fundamental shift in the pattern of intra-species diversity in farmer's fields and farming systems as a result of the "Green Revolution." Intensification of agricultural systems coupled with specialization by plant breeders and the harmonizing effects of globalization, has led to a substantial reduction in the genetic diversity of domesticated plants and animals in agricultural systems. The on-farm losses of genetic diversity of crops have been partially offset by the maintenance of genetic diversity in seedbanks. In addition to cultivated systems, the extinction of species and loss of unique populations that has taken place has resulted in the loss of unique genetic diversity contained by those species and populations.

14. **All scenarios explored in the Millennium Ecosystem Assessment project continuing rapid conversion of ecosystems in the first half of the 20th century.** Roughly 10 to 20% *(low to medium*

certainty) of current grassland and forest land is projected to be converted to other uses between now and 2050, mainly due to the expansion of agriculture and secondarily, because of the expansion of cities and infrastructure. The habitat losses projected in the MA scenarios will lead to global extinctions as populations approach equilibrium with the remnant habitat. The equilibrium number of plant species is projected to be reduced by roughly 10-15% as a result of habitat loss over the period of 1970 to 2050 in the MA scenarios (*low certainty).* (See Fig. 2.) Similarly, modification of river water flows will drive new losses of fish species.

Why is biodiversity loss a concern?

15. **Finding #2. Biodiversity contributes directly (through biological products) and indirectly (through ecosystem services) to human well-being. Biodiversity contributes to more than just material welfare; it also contributes to security, social relations, health, freedom of choices and personal happiness. Some people have benefited significantly from actions causing changes in biodiversity over the last century, but others have suffered decreased well-being with some being pushed into poverty by these changes.**

16. **Substantial benefits have been gained from many of the actions that have caused the homogenization or loss of biodiversity.** For example, agriculture, fisheries, and forestry, three activities that have placed significant pressures on biodiversity, are often the mainstay of national development strategies, providing revenues that have enabled investments in industrialization and economic growth. Still today, the agricultural labor force comprises approximately 22% of the world's population and half the world's total labor force. In developed countries, natural resources continue to be important for livelihoods and economies in rural regions. Similarly, many species introductions, which contribute to the homogenization of global biodiversity, have been intentional because of the benefits the species provide. In other cases, humans have eradicated some harmful components of biodiversity, such as particular disease organisms, pests or other species.

17. **However, the benefits of these changes have not been equitably distributed among people and many of the costs and risks of changes in biodiversity have historically not been factored into decision-making.** These costs and risks include:

    Decline of specific ecosystem goods and services. Many of the changes that have been made in biodiversity and ecosystems have occurred to enhance the production of specific ecosystem services such as food production. However, only four of the 22 ecosystem services examined in this assessment have been enhanced: crops, livestock, aquaculture, and (in recent decades) carbon sequestration. In contrast, 14 other services have been degraded, including capture fisheries, timber production, water supply, waste treatment and detoxification, water purification, natural hazard protection, regulation of air quality, regulation of regional and local climate, regulation of erosion, and many cultural services (spiritual, aesthetic, recreational and other benefits from ecosystems). Modifications of ecosystems to enhance one service generally have come at a cost to other services that the ecosystem provided. The impacts of these trade-offs among ecosystem services affect people in different ways. For example, an aquaculture farmer may gain material welfare from management practices that increase soil salinization and thereby reduce rice yields and threaten food security for nearby subsistence farmers.

    Loss of biodiversity and ecosystem services that support the well-being of poor and vulnerable people. Even where the net economic benefits of changes leading to the loss of biodiversity have been positive, many people have often been harmed by the changes. In particular, poor people, particularly those in rural areas in developing countries, are more directly dependent on biodiversity and ecosystem services and more vulnerable to their degradation. For example, the ecosystem service with the most significant decline in production – capture fisheries – is also a service that was particularly valuable to poor people, since it provided a cheap source of protein. Richer groups of people are often less affected by the loss of ecosystem services because of their ability to purchase substitutes or to offset local losses of ecosystem services by shifting production and harvest to other regions. For example, as fish stocks have been depleted in the north Atlantic, European and other commercial fishers have shifted to harvest fish from West Africa. Similarly, agricultural intensification may increase production of the main crops while denying poor people, especially the landless, access to food plants – including those regarded as weeds – which make important contributions to household nutrition.

Many costs associated with changes in biodiversity may be slow to become apparent, may be apparent only at some distance from where biodiversity was changed, or may involve thresholds or changes in stability that are difficult to measure. For example, there is established but incomplete evidence that reductions in biodiversity reduce the resilience of ecological systems. The resilience of a system is a measure of the ability of a system to return and to its pre-disturbance state following a disturbance. The costs associated with this loss of resilience may not be apparent for years until a significant disturbance is experienced. Similarly, a change in biodiversity in one location may have impacts in other locations. The conversion of forest to agriculture in one region for example, can affect the timing and magnitude of river flows in downstream areas far removed from the change in biodiversity. Threshold effects – abrupt or non-linear changes in a system in response to a more gradual change in a driving force – have been commonly encountered in ecosystems and are often associated with changes in biodiversity. For example, over fishing is known to cause abrupt changes in species populations in coastal ecosystems. In tropical coral reefs, loss of herbivorous fish, has contributed to the degradation of reefs to algal-dominated forms. Multiple drivers may be involved in these “regime shifts”. For example, in the case of coral reefs, nutrient loading is also found to trigger these changes. Introduced invasive species can act as a trigger for dramatic changes in ecosystem structure, function, and delivery of services. For example, the introduction of the carnivorous ctenophore Mnemiopsis leidyi (a jellyfish-like animal), in the Dead Sea, caused the loss of 26 major fisheries species, and has been implicated (along with other factors) in the subsequent growth of the oxygen-deprived “dead” zone.

Loss of unique genotypes, species, and habitats: Biodiversity loss is important in its own right because biodiversity has intrinsic and cultural values, and also represents unexplored options for future (option value) which may be exploited through bio-prospecting. People from all walks of life value biodiversity for spiritual, resource and recreational values. Species extinction at the global level is of particular significance since it is absolutely irreversible. But population extirpation and loss of habitat is also important at national and local levels. This is because most ecosystem services are delivered at the local and regional level and strongly depend on the kind and relative abundance of species.

18. **Finding #3. The magnitude of these uncounted costs and risks is uncertain, but multiple lines of evidence indicate that the costs and risks may substantial, often exceeding the benefits, and appear to be growing. Nonetheless, it is unlikely that existing levels of biodiversity can be maintained globally on the basis of utilitarian considerations alone.**

19. **While only partial costs and risks associated with the loss and homogenization of biodiversity can be calculated based on the data available today; the available evidence suggests that the magnitude of these costs and risks is significant, and often outweighs the benefits**.

- In a number of existing studies of changes in economic value associated with changes to biodiversity in specific locations (such as the conversion of mangrove forests, degradation of coral reefs, and clear-felling of forests) the costs of ecosystem conversion is found to be significant and sometimes exceeds the benefits of the habitat conversion. Despite this, in a number of these cases, conversion was promoted because the cost associated with the loss of ecosystem services was not internalized, and sometimes also because subsidies distorted the relative costs and benefits. Often, the majority of local inhabitants were disenfranchised by the changes.

- A country's ecosystems and its ecosystem services represent a capital asset, but the benefits that could be attained through better management of this asset are poorly reflected in conventional economic indicators. A country could cut its forests and deplete its fisheries and this would show only as a positive gain to GDP despite the loss of the capital asset. When the decline in these "natural capital assets" are factored into the measures of national wealth, the estimates of national wealth decline significantly for countries with economies that are significantly dependent on natural resources. Some countries that appeared to have positive growth in the 1970s and 1980s, for example, actually experienced a net loss of capital assets, effectively undermining the sustainability of the gains that they may have achieved.
- The costs resulting from ecosystem "surprises" can be very high. The US, for example, spends hundreds of millions of dollars each year on controlling invasive alien species. Increased insurance premiums for floods, fires, and other extreme events have increased dramatically in recent decades. Changes in ecosystems are sometimes an important factor in contributing to the increased frequency and severity of the impacts of these extreme events.

20. **The costs associated with biodiversity loss are expected to increase, and fall disproportionately on the poor** As biodiversity and the provision of some ecosystem services decreases, the value of what remains tends to be an increase in the value, at the margin. For components of biodiversity of most concern to people, the existence value of these components increases as they become scarcer. In consequence, costs of biodiversity loss will increase as the amount of biodiversity decreases. There are also distributional impacts that are not necessarily borne out in economic valuation studies since the poor have a relatively low "willingness to pay." Many aspects of biodiversity decline have a disproportionate impact on poor people. The decline in fish populations for example has major implications for artisanal fishers and the communities that depend on fish as an important source of protein. As dryland resources are degraded, it is the poor and vulnerable who suffer the most.

21. **Tools now exist for a far more complete assessment of the consequences of biodiversity loss for human well-being but most decisions continue to be made in the absence of a detailed analysis of the full costs, risks and benefits**. The concept of total economic value (TEV) is widely used by economists. This framework typically disaggregates the utilitarian value of biodiversity into various components including use and non-use values. Various valuation methods are available to estimate, these different values and to estimate marginal changes in the TEV under different policy or management alternatives. Despite the existence of these tools, only provisioning ecosystem services are routinely valued. Most supporting and regulating services are not valued at all because the demand curves for these services—which are not privately owned or traded—cannot be directly observed or measured. In addition, it is recognized that biodiversity has intrinsic value, which, not being anthropocentric, cannot be valued in conventional economic terms. Common methods used for finding intrinsic values and increasingly for even conventional use and non-use values are based on open public deliberation and not on the aggregation of measured individual preferences.

22. **There is substantial scope for greater protection of biodiversity through actions justified on their economic merits for material or other benefits to human well-being**. Conservation of biodiversity is essential as a source of particular biological resources, to maintain different ecosystem services, to maintain the resilience of ecosystems, and to provide options for the future. These benefits that biodiversity provides to people have not been well reflected in decision-making and resource management and thus the current rate of loss of biodiversity is higher than what it would be had these benefits been taken into account. (See Figure 3.)

23. **However, the total amount of biodiversity that would be conserved based strictly on utilitarian considerations is likely to be less than the amount present today (*medium certainty*)**. Even if utilitarian benefits were fully taken into account, the planet would still be losing biodiversity. Other utilitarian benefits often 'compete' with the benefits of maintaining greater diversity and on balance the level of diversity that would exist would be less than that present today. Many of the steps taken to increase the production of ecosystem services require the simplification of natural systems (e.g., agriculture). And, protecting some other ecosystem services may not necessarily require the conservation of biodiversity. (For example, a forested watershed could provide clean water whether it was covered in a diverse native forest or in a single-species plantation.) Ultimately, the level of biodiversity that survives on Earth will be determined not just by utilitarian considerations but to a significant extent by ethical concerns including considerations of intrinsic values of species.

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

24. **Finding # 4. The pressures driving the loss of biodiversity and changes in ecosystem services are in general remaining constant or increasing in intensity.**

25. **In the aggregate and at a global scale, there are five root causes of changes in ecosystems and their services: population change, change in economic activity, socio-political factors, cultural factors, and technological change.** In particular, growing consumption of ecosystem services (as well as growing consumption of fossil fuels), which results from growing populations and growing per capita consumption, leads to increased pressure on ecosystems and biodiversity. Global economic activity increased nearly 7-fold between 1950 and 2000. Under the MA scenarios, per capita GDP is projected to grow by a factor of 1.9 to 4.4 by 2050. Global population doubled in the past forty years reaching 6 billion in 2000. Population is projected to grow to between 8.1 and 9.6 billion by 2050 across the various MA scenarios. The many processes of globalization have amplified some driving forces of changes in ecosystem services and attenuated other forces. Over the past fifty years, there have been significant changes in sociopolitical drivers, including a declining trend in centralized authoritarian governments and a rise in elected democracies which allows for new forms of management, in particular adaptive management, of environmental resources. Culture conditions individuals' perceptions of the world, and, by influencing what they consider important, has implications for conservation and consumer preferences and suggests courses of action that are appropriate and inappropriate. The development and diffusion of scientific knowledge and technologies can, on one hand allow for increased efficiency in resource use while on the other hand provide the means to increase exploitation of resources.

26. **The most important direct drivers of biodiversity loss and change in ecosystem services are habitat change (land use change and physical modification of rivers or water withdrawal from rivers), climate change, invasive alien species, overexploitation, and pollution**. For most of these drivers, and for most ecosystems where they have been important, the impact of the driver is currently remaining constant or growing (See Fig. 4). Each of these drivers will have important impacts on biodiversity in the 21st century:

Overexploitation, especially overfishing. For marine ecosystems the most important direct driver of change globally has been over-fishing. Demand for fish as food for people and feed for aquaculture production will expand, and the result will be an increasing risk of major, long-lasting collapse of regional marine fisheries. In some marine systems the biomass of both targeted species, especially larger fish, and those caught incidentally (by-catch) has been reduced up to one or more orders of magnitude compared to pre-industrial fishing levels. About three quarters of the world's marine fisheries are either fully exploited or overexploited.

Biotic exchange. The spread of invasive alien species and disease organisms has increased because of increased trade and travel, including tourism. Increased risk of biotic exchange is an inevitable effect of globalization. While, increasingly there are measures to control the pathways of invasive species, for example, through quarantine measures and new rules on the disposal of ballast water in shipping, several pathways are not adequately regulated.

Habitat transformation, particularly from conversion to agriculture: Roughly one-third of the earth's terrestrial surface is already cultivated land. Under the MA scenarios, a further 10 to 20% of grassland and forest land is projected to be converted by 2050 (primarily to agriculture). While the expansion of agriculture and the increased productivity of agriculture is a success story of enhanced production of one key ecosystem service, this success has come at high and growing costs in terms of trade-offs with other ecosystem services, both through the direct impact of land cover change and as a result of water withdrawals for irrigation and release of nutrients into rivers. For example, globally roughly 15 to 35 percent of irrigation withdrawals are estimated to be non-sustainable.

Nutrient Loading: Since 1950, nutrient loading has emerged as one of the most important drivers of ecosystem change in terrestrial, freshwater and coastal ecosystems, and this driver is projected to substantially increase in the future (*high certainty*). Synthetic production of nitrogen fertilizer is been a key driver for the remarkable increase in food production that has occurred during the past 50 years. Humans now produce more reactive nitrogen than is produced by all natural pathways combined. Aerial deposition of reactive nitrogen into natural terrestrial ecosystems, especially temperate grasslands, shrublands and forests leads directly to lower plant diversity while excessive levels of reactive nitrogen in water bodies, including rivers, and other wetlands, and coastal zones frequently leads to algal blooms and eutrophication. Similar problems have resulted from P, the use of which has tripled. Nutrient loading will become an increasingly severe problem, particularly in developing countries and particularly in east and south Asia. Only significant actions to improve the efficiency of nutrient use will mitigate these trends.

Anthropogenic Climate Change: Observed recent changes in climate, especially warmer regional temperatures, have already affected biological systems in many parts of the world. There have been changes in species distributions, population sizes, the timing of reproduction or migration events, and an increase in the frequency of pest and disease outbreaks, especially in forested systems. Many coral reefs have undergone major, although often partially reversible, bleaching episodes, when sea surface temperatures have increased by $1^{o}C$ during a single season. By the end of the century, climate change and its impacts will be one of the most important direct drivers of biodiversity loss and change of ecosystem services. Climate change will:

- increase the rate of species extinction and the loss of genetic diversity;
- directly alter ecosystem services, for example, by causing changes in the productivity and growing zones of cultivated and non-cultivated vegetation;
- change the frequency of extreme events, with associated risks to ecosystem services.
- indirectly affect ecosystem services in many ways, such as by causing sea level to rise which threatens mangroves and other vegetation that now protect shorelines; and,
- increase the difficulty of meeting needs for clean water, energy services and food.

What actions can be taken?

27. **<u>Finding # 5.</u> Actions that have been taken to conserve biodiversity and promote its sustainable use have been successful in limiting biodiversity loss and homogenization to rates less than they would otherwise have been in the absence of such actions. Further progress will require a portfolio of actions that address important drivers of biodiversity loss and ecosystem service degradation.**

28. **Less biodiversity would exist today had not communities, NGOs, governments, and, to a growing extent, business and industry taken actions to conserve biodiversity and to support its sustainable use.** Many traditional cultural practices have served to protect components of

biodiversity important for utilitarian and/or spiritual reasons. In additional, substantial investments have been made to protect threatened biodiversity and to establish more sustainable patterns of use of biodiversity. For example, since 1950, both the number and area of protected areas increased at rates greater than either the rate of population or economic growth. The substantial growth in protected areas has successfully conserved much biodiversity. Similarly, a number of community resource management arrangements that have placed community-level benefits as central objectives for sustainable management have slowed the loss of biodiversity while contributing benefits to the people.

29. **To achieve greater progress toward biodiversity conservation, it will be necessary (but alone insufficient) to strengthen response options that are designed with the conservation of biodiversity and ecosystem services for sustainable human development as the primary goal.**

Responses that have been particularly successful but could be further strengthened include:

- *Protected Areas.* Protected areas are an extremely important part of programs to conserve biodiversity and ecosystems, especially for sensitive environments that require active measures to ensure the survival of certain components of biodiversity. At the global and regional scales, the existence of current protected areas, while essential, is not sufficient for conservation of the full range of biodiversity. Protected areas need to be better located, designed, and managed to deal with problems like lack of representativeness, impacts of human settlement within protected areas, illegal harvesting of plants and animals, unsustainable tourism, impacts of invasive alien species, and vulnerability to global change. Marine and freshwater ecosystems are even less well protected than terrestrial systems. In addition, better policy and institutional options are needed to promote the fair and equitable sharing of costs and benefits of protected areas at local, national, regional and international levels. Protected area networks are most successful if they are designed and managed in the context of an ecosystem approach, with due regard to external threats such as pollution, climate change and invasive species.
- *Species protection and recovery measures for threatened species*. Considerable scope exists to conserve and sustainably use biodiversity through more effective management of individual species. Although "habitat-based" approaches to species conservation are critical, they are by no means a replacement for "species-based" approaches.
- *Genebanks.* The benefits from *ex situ* conservation of genetic diversity are substantial. While the technology continues to improve, the major constraint is ensuring that an adequate range of genetic diversity is contained within the *ex situ* facilities, and that these remain in the public domain where they can serve the needs of poor farmers.
- *Public awareness.* Education and communication programs have both informed and changed preferences for biodiversity conservation and have improved implementation of biodiversity responses. While the importance of communication and education is well recognized, providing the human and financial resources to undertake effective work is a continuing barrier.

Several newer types of responses hold considerable potential but also face significant challenges.

- *Payments and markets for biodiversity and ecosystem services.* In many countries, tax incentives, easements, tradable development permit programs, and contractual arrangements (such as between upstream landowners and those benefiting from watershed services) are becoming more common and have often been shown to be useful for conserving land and ecosystem services. Between 1996 and 2001, for example, Costa Rica provided $30 million to landowners to establish or protect over 280,000 ha of forests and their environmental services. While more market-oriented approaches such as these show considerable promise, many challenges remain such as: a) the difficulty of obtaining the information needed to ensure that the buyers are indeed obtaining the services that they are paying for; and, b) the need to establish underlying institutional frameworks required for markets to work and ensure benefits are distributed in an equitable manner.

- *Capture of benefits by local communities.* Response strategies designed to provide incentives for biodiversity conservation by ensuring that local people benefit from one or more components of biodiversity (e.g. products from single species or from ecotourism) have proved to be very difficult to implement. They have been most successful when they have simultaneously created incentives for the local communities to make management decisions consistent with overall biodiversity conservation. However, while "win win" opportunities for biodiversity conservation and local community benefits do exist, local communities can often achieve greater benefits from actions that lead to the loss of biodiversity.
- *Incorporating considerations of biodiversity conservation into management practices in other sectors, such as agriculture, forestry, and fisheries.* Two types of opportunities exist. First, more diverse systems of production can often be as effective as alternative low-diversity systems or sometimes even more effective. For example, markets for organic farming are growing in many countries. Integrated pest management can increase biodiversity on farm, reduce costs by reducing the need for pesticides and meet the growing demand for organic food products. Second, strategies that promote the intensification of production rather than the expansion of the total area of production allow more area for conservation.
- *Ecosystem restoration.* Ecosystem restoration activities are now common in many countries and include actions to restore almost all types of ecosystems including wetlands, forests, grasslands, estuaries, coral reefs, and mangroves. Restoration will become an increasingly important response as more ecosystems become degraded and demands for their services continue to grow. Ecosystem restoration, however, is generally far costlier than protecting the original ecosystem and it is rare that all of the biodiversity and services of a system can be restored.
- *Integrated use of responses.* The use of a variety of instruments in an integrated manner so that biodiversity gains can be complimentary. When successful, this integration of policy instruments leads to greater net benefits, improved trade-offs and synergies and the reaping of economies of scale.

30. **Many of the responses designed with the conservation of biodiversity or ecosystem service as the primary goal will not be sustainable or sufficient, however, unless other indirect and direct drivers of change are addressed.** For example, the sustainability of protected areas will be severely threatened by human caused climate change. Similarly, the management of ecosystem services cannot be sustainable globally if the growth in consumption of services continues unabated. From the standpoint of decision-makers focused on the goal of the conservation and sustainable use of biodiversity, it is likely to be most cost effective to encourage the establishment of responses to drivers that have the most direct impact on biodiversity rather than on the entire array of indirect and direct drivers of change. Responses addressing other direct and indirect drivers that would be particularly important for biodiversity and ecosystem services are needed that address the following issues:

- *Elimination of subsidies that promote excessive use of specific ecosystem services*. Subsidies paid to the agricultural sectors of OECD countries between 2001 and 2003 averaged over US$324 billion annually, or one third the global value of agricultural products in 2000. These subsidies lead to over-production, reduce the profitability of agriculture in developing countries, and promote overuse of fertilizers and pesticides. Similar problems are created by fishery subsidies which amounted to approximately $6.2 billion in OECD countries in 2002, or about 20 percent of the gross value of production. Removal of perverse subsidies will not be without costs. Reduced subsidies within OECD countries will lessen pressure on some ecosystems in these countries, but could lead to more rapid conversion of land to agriculture in developing countries. And compensation mechanisms will be required for the poor who may be adversely affected by the immediate removal of subsidies.

- *Promotion of sustainable intensification of agriculture*. Agricultural expansion will continue to be one of the major drivers of biodiversity loss well into the 21st century. Development, assessment and diffusion of technologies that could sustainably increase the production of food per unit area would significantly lessen pressure on biodiversity.
- *Slowing climate change*. Based on the current understanding of the climate system, and the response of different ecological and socio-economic systems, if significant global adverse changes to ecosystems are to be avoided, the best guidance that can currently be given suggests that efforts be made to limit the increase in global mean surface temperature to 2oC above pre-industrial levels and limit the rate of change to less than 0.2oC per decade. This will require that the atmospheric concentration of carbon dioxide be limited to about 450 ppm and the emissions of other greenhouse gases stabilized or reduced.
- *Slowing the global growth in nutrient loading (even while increasing nutrient application in relatively poor regions such as Sub-Saharan Africa)*. Technologies already exist for reduction of nutrient pollution at reasonable costs but new policies are needed for these tools to be applied on a sufficient scale to slow and ultimately reverse the increase in nutrient loading.
- *Correction of market failures and internalization of environmental externalities that lead to the degradation of ecosystem services*. Because many ecosystem services are not traded in markets, markets fail to provide appropriate signals that might otherwise contribute to the efficient allocation and sustainable use of the services. In addition, many of the harmful trade-offs and costs associated with the management of one ecosystem service are borne by others and so too do not weigh into decisions regarding the management of that service. In countries with supportive institutions in place, market based tools can be used to correct some market failures and internalize externalities, particularly with respect to provisioning ecosystem services.
- *Integration of biodiversity conservation strategies and responses within broader development planning frameworks*. For example, protected areas, restoration ecology and markets for ecosystem services will have higher chances of success if these responses are reflected in the national development strategies or in poverty reduction strategies in the case of many developing countries. In this manner, the costs and benefits of these conservation strategies and their contribution to human development are explicitly recognized in the Public Expenditure Review and resources for the implementation of the responses can be set aside in the Mid-Term Budgetary Framework.

The 2010 target and the implications for the CBD

31. **Finding #6. Substantial efforts would be needed to achieve, by 2010, a significant reduction in rate of biodiversity loss although the target can be achieved for certain components of biodiversity (or for certain indicators), and in certain regions The design of future goals, targets, and interventions for the conservation and sustainable use of biodiversity can be informed by advances in measuring biodiversity, considerations of key drivers of change, the importance of inertia in biodiversity and in response options, and the potential tradeoffs and synergies with other societal goals.**

32. **An unprecedented effort would be needed to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional, and national levels**. The magnitude of the challenge of slowing the rate of biodiversity loss is demonstrated by the fact that most of the direct drivers of biodiversity loss are projected to either remain constant or to increase in the near future. (See Figure 3.) Moreover, inertia in natural and human institutional systems results in time

lags – of years, decades or even centuries – between the time when actions are taken and when their impact on biodiversity and ecosystems is apparent.

33. **With appropriate responses, at global, regional, and especially national level, it is possible to achieve, by 2010, a reduction in rate of biodiversity loss for certain components of biodiversity (or for certain indicators), and in certain regions, and several of the 2010 sub-targets adopted by the CBD could be met.** The rate of habitat loss – the main driver of biodiversity loss in terrestrial ecosystems – is now slowing in certain regions. This may not necessarily translate into lower rates of species loss however, because: a) the nature of the relationship between numbers of species and area of habitat; b) decades or centuries may pass before species extinctions reach equilibrium with habitat loss; and c) other drivers of loss, such as climate change, nutrient loading and invasive species, are projected to increase. While, rates of habitat loss are decreasing in temperate areas, they are projected to continue to increase in tropical areas. At the same time, if areas of particular importance for biodiversity are maintained within protected areas or by other conservation mechanisms, and if proactive measures are taken to protect endangered species, then the rate of biodiversity loss of the targeted habitats and species could be reduced.

34. **Trade-offs between achieving the 2015 targets of the MDGs and reducing the rate of biodiversity loss are likely.** For a reduction in the rate of biodiversity loss to contribute to poverty alleviation, priority would need to be given to protecting the biological diversity that is under threat and of particular importance to the well-being of poor and vulnerable people. Long term sustainable achievement of the Millennium Development Goals requires that biodiversity loss is controlled as part of MDG7 – ensure environmental sustainability, even though it is not possible at present to define "how much biodiversity" is necessary or desirable. However, there are both potential synergies and trade-offs between the shorter-term targets of achieving the 2015 targets of the Millennium Development Goals and reducing the rate of loss of biodiversity by 2010. For example, one of the MA scenarios that showed relatively good progress toward a number of the MDG targets such as poverty reduction and health gains (*Global Orchestration)* also showed relatively high rates of habitat loss and the second highest rate of biodiversity loss. (See Figure 5).

35. **Given the characteristic response times for human (politico-socio-economic) systems and ecological systems, longer term goals and targets (e.g. for 2050) are needed to guide policy and actions in addition to short term targets**. Differences in the inertia of different drivers of biodiversity change and different attributes of biodiversity itself make it difficult to set targets or goals over a single time frame. For some drivers, such as the overharvest of particular species, lag times are rather short, for others such as nutrient loading and, especially, climate change, lag times are much longer. Similarly, for some features of biodiversity such as population size, lag times of many species may be measured in years or decades while for other features, such as the equilibrium number of species, lag times may be measured in hundreds of years. As a consequence, some drivers and features of biodiversity will require long-term targets, while short term targets may be appropriate for others..

36. **Improved, and more widely applicable, measures of biodiversity would aid decision making, at global, regional and national levels**. Existing biodiversity indicators are helping to communicate trends in biodiversity and highlight its importance to human well-being. Improved measures, of biodiversity, agreed by stakeholders, would assist in setting appropriate targets, addressing tradeoffs between biodiversity conservation and other objectives, and in optimizing responses. Models could be developed and used to make better use of limited observational data. Additional effort is required to reduce critical uncertainties, including those associated with thresholds of biodiversity related to the provision of ecosystem goods and services. Given the multiple values of biodiversity, no single measure is likely to be appropriate for all situations.

37. **A very wide array of possible futures for biodiversity remains within the choices of people and decision-makers today and these different futures have very different implications for human well-being and for future generations**. The world in 2100 could have substantial remaining biodiversity or could be relatively homogenized and contain relatively low levels of diversity. Biodiversity important for utilitarian concerns and ecosystem services could be protected, while biodiversity of intrinsic value lost. Multiple objectives for biodiversity will thus be necessary to produce the pattern and distribution of biodiversity that would be most desirable. Science can help to inform the costs and benefits of these different futures and identify paths to achieve those futures (plus risks and thresholds), but ultimately the choice and decision of biodiversity levels must be determined by society.

Box 1: Biodiversity and its Loss – Avoiding Conceptual Pitfalls

Different interpretations of several important attributes of the concept of biodiversity can lead to confusion in understanding both scientific findings and their policy implications. Specifically:

The value of the *diversity* of genes, species, or ecosystems *per se*, is too often confused with the value of a particular component of that diversity. Species diversity in of itself, for example, is valuable because the presence of a variety of species helps to increase the capability of an ecosystem to be resilient in the face of a changing environment. At the same time, an individual component of that diversity, such as a particular food plant species, may be valuable as a biological resource. The consequences of changes in biodiversity for people can stem both from a change in the diversity per se and a change in a particular component of biodiversity. Each of these aspects of biodiversity deserves its own attention from decision-makers and each often requires its own management goals and policies.

Second, because biodiversity refers to diversity at multiple scales of biological organization (genes, species, and ecosystems) and can be considered at any geographic scale (local, regional, or global), it is generally important to specify the specific level of organization and scale of concern. For example, the introduction of widespread weedy species to a continent such as Africa, will increase the species diversity of Africa (more species present), while decreasing ecosystem diversity globally (since the ecosystems in Africa then become more similar in species composition to ecosystems elsewhere due to the presence of the cosmopolitan species). Because of the multiple levels of organization and multiple geographic scales involved, any single indicator, such as species diversity, is generally a poor indicator for many aspects of biodiversity that may be of concern for policy makers.

These two considerations are also helpful in interpreting the meaning of biodiversity "loss". The Convention on Biodiversity defines biodiversity loss to be "the long-term or permanent qualitative or quantitative reduction in components of biodiversity and their potential to provide goods and services, to be measured at global, regional and national levels" (CBD COP VII/30). Under this definition, biodiversity can be lost either if the diversity *per se* is reduced (such as through the extinction of some species) or if the potential of the components of diversity to provide a particular service is diminished (such as through unsustainable harvest). The homogenization of biodiversity – that is, the spread of widespread invasive alien species around the world – thus also represents a loss of biodiversity at a global scale (since once-distinct groups of species in different parts of the world become more similar) even though the diversity of species in particular regions may actually increase because of the arrival of new species.

Box 2: MA Scenarios

The MA developed four scenarios to explore plausible futures for ecosystems and human well-being. The scenarios explored two global development paths (globalized versus regionalized societies and economies) and two different approaches for ecosystem management (reactive management where problems are addressed only after they become obvious versus proactive management to maintain ecosystem services for the long term).

- *Global Orchestration* - globalization with an emphasis on equity, economic growth, and public goods such as infrastructure and education; a reactive approach to ecosystems;
- *Order from Strength* - regionalization with an emphasis on security and economic growth; a reactive approach to ecosystems;
- *Adapting Mosaic* – regionalization with proactive management of ecosystems and local adaptation; and,
- *TechnoGarden* –globalization with proactive management of ecosystems and an emphasis on green technology

These four scenarios were not designed to explore the entire range of possible futures – other scenarios could be developed with either more optimistic or more pessimistic outcomes.

Figure 1. Framework of interactions between biodiversity, ecosystem services, human well-being, and drivers of change. Changes in drivers that indirectly affect biodiversity, such as population, technology, and lifestyle (upper right corner of figure), can lead to changes in drivers directly affecting biodiversity, such as the catch of fisheries or the application of fertilizers to increase food production (lower right corner). These result in changes to biodiversity (lower left corner) which and to ecosystem services, thereby affecting human well-being. These interactions can take place at more than one scale and can cross scales. For example, a global timber market may lead to regional loss of forest cover, which increases flood magnitude along a local stretch of a river. Similarly, the interactions can take place across different time scales. Actions can be taken either to respond to negative changes or to enhance positive changes at almost all points in this framework (black cross bars).

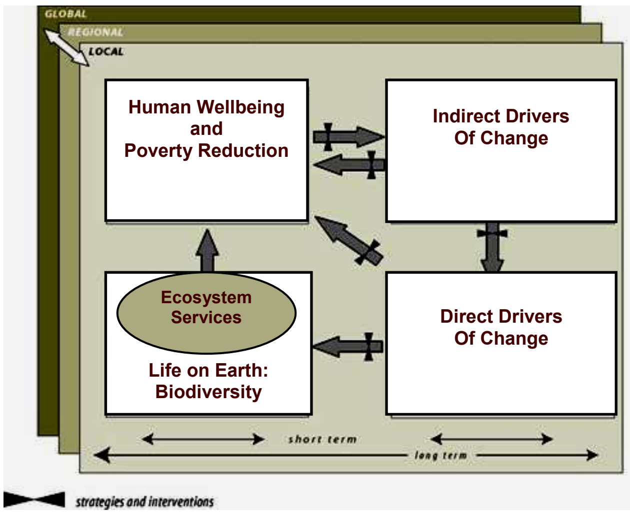


Figure 2. Relative rates of background, contemporary and projected extinctions.

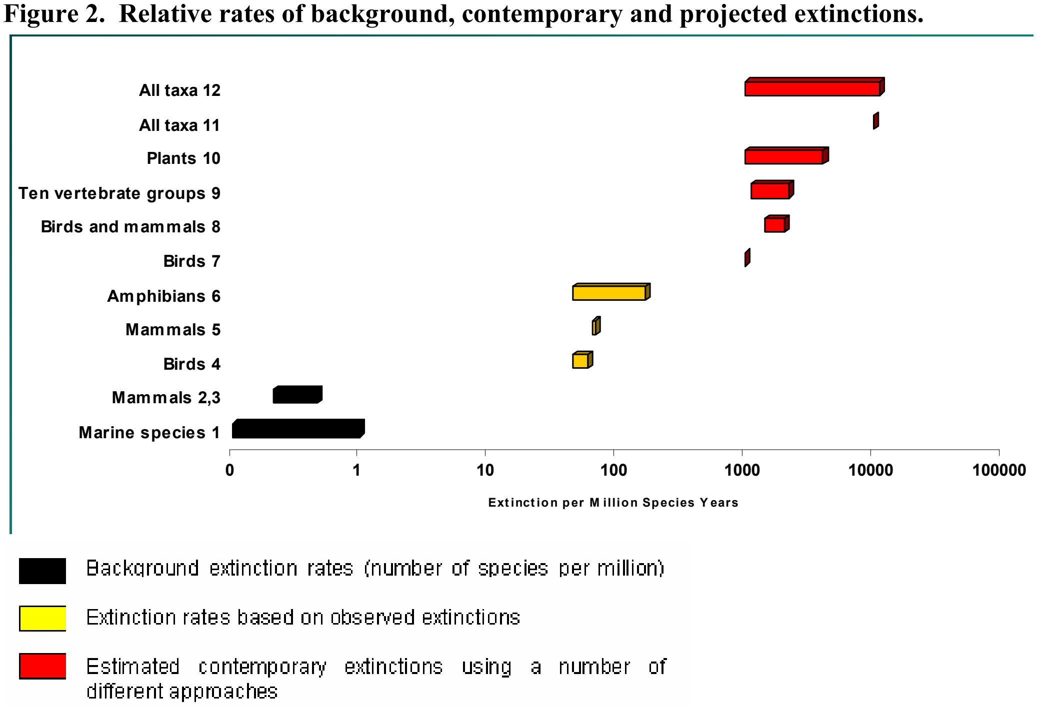


Figure 3. How much biodiversity will remain? The level of biodiversity present on the planet today will decline significantly by the end of the century under the policies and practices in place today. The height of the bar in the figure below represents the level or amount of biodiversity. The solid arrow shows the likely loss of biodiversity between today and 2100 under current policies and practices. Given the technologies available today, some loss of biodiversity is an inevitable result of trade-offs with other important human needs. Land converted to agriculture over the last several decades and likely to be converted over the next several decades, for example, will result in both local and global species extinctions during the century. However, the full costs and risks associated with biodiversity loss are not currently considered in management and resource use decisions and as a result relatively more biodiversity is lost than actually would be justified on utilitarian grounds. If instead, the importance of biodiversity for ecosystem services was factored into decisions, then more biodiversity would persist through the end of the century. And if the full benefits of the added capability that biodiversity will provide in adapting to change, avoiding unwanted threshold changes, and serving as a source of future options were also added, still more biodiversity would be conserved on utilitarian grounds. Even so, strictly utilitarian considerations are not likely to be sufficient to justify the protection of all current biodiversity in the face of other utilitarian needs that are sometimes in conflict with biodiversity conservation. For some elements of biodiversity such as species diversity, however, some people feel that even beyond the utilitarian role of biodiversity, even more conservation is justified because of the intrinsic value of species – that other species have as much 'right' to exist on the planet as humans.

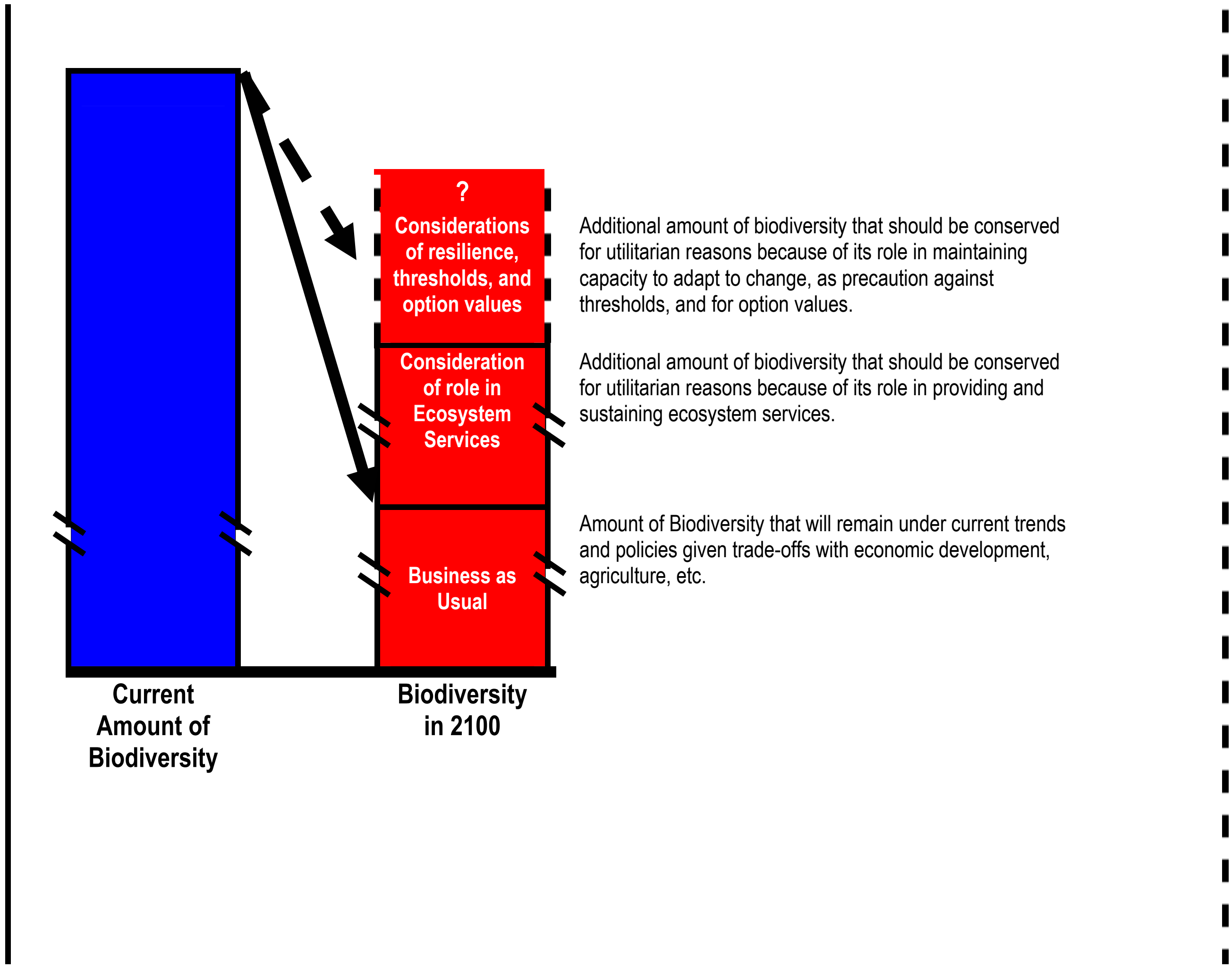


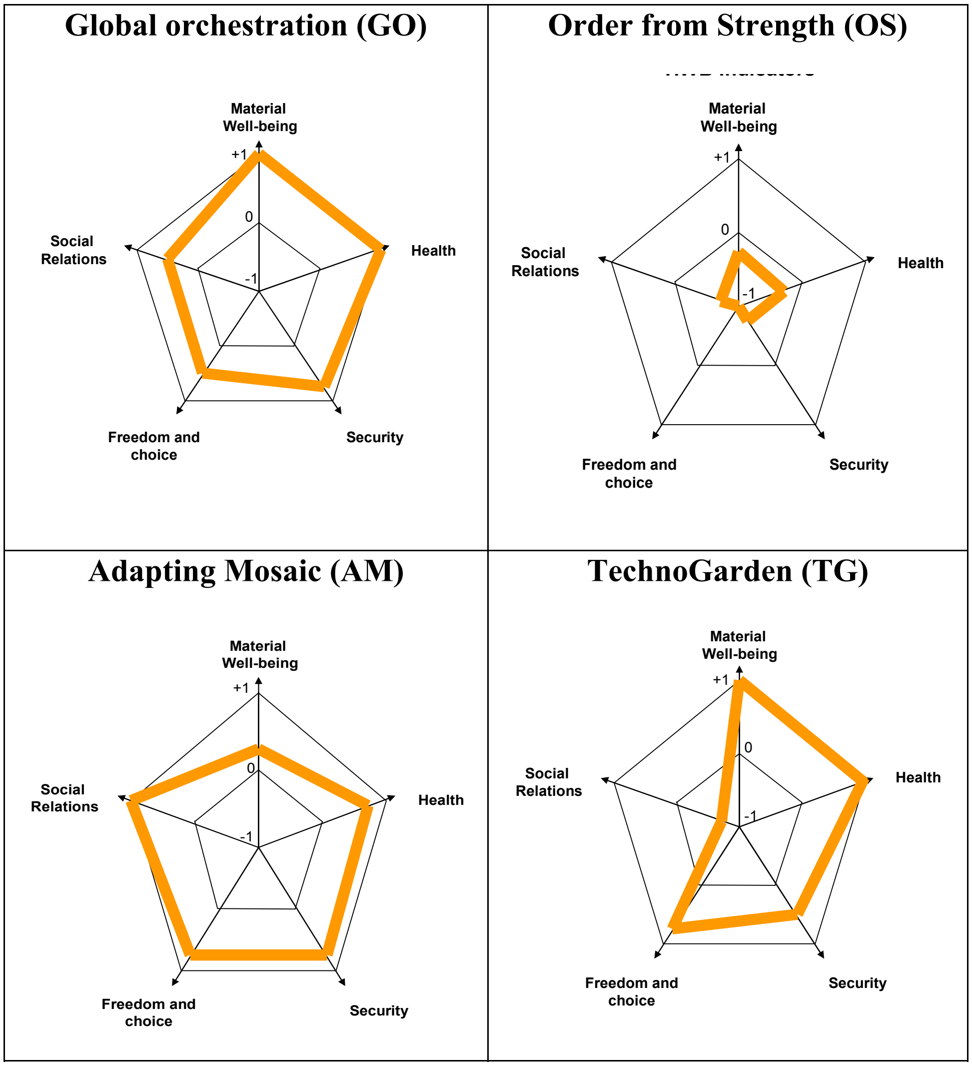
Figure 4. Main direct drivers. The cell colour indicates impact of each driver on biodiversity in each biome, over the past 50 to 100 years. The arrows indicate the trend in the impact of the driver on biodiversity. Horizontal arrows indicate stabilisation of the impact, diagonal and vertical arrows indicate progressively stronger increasing trends in impact.

BIOME		MAIN DRIVERS OF BIODIVERSITY CHANGE: Habitat change	Climate Change	Invasive species	Over-exploitation	Pollution (N, P especially)
Forest	Boreal	↗ (Low)	↑ (Low)	↗ (Low)	→ (Low)	↑ (Moderate)
	Temperate	↘ (High)	↑ (Low)	↑ (Low)	→ (Moderate)	↑ (Moderate)
	Tropical	↑ (Very high)	↑ (Low)	↑ (Low)	↗ (High)	↑ (Low)
Dryland	Temperate grassland	↗ (Very high)	↑ (Low)	→ (Moderate)	→ (Low)	↑ (Very high)
	Mediterranean	↗ (High)	↑ (Low)	↑ (High)	→ (Moderate)	↑ (Low)
	Tropical grassland & savannah	↗ (High)	↑ (Moderate)	↑ (Low)	→ (Very high)	↑ (Moderate)
	Desert	→ (Low)	↑ (Moderate)	→ (Moderate)	→ (Low)	↑ (Low)
Inland Water		↑ (Very high)	↑ (Low)	↑ (High)	→ (Moderate)	↑ (Very high)
Coastal		↗ (Very high)	↑ (Moderate)	↗ (High)	↗ (High)	↑ (Very high)
Marine		↑ (Moderate)	↑ (Low)	→ (Low)	↗ (Very high)	↑ (Low)
Island		→ (High)	↑ (Low)	→ (Very high)	→ (High)	↑ (Low)
Mountain		→ (High)	↑ (Moderate)	→ (Low)	→ (Low)	↑ (Low)
Polar		↗ (Low)	↑ (High)	→ (Low)	↗ (Moderate)	↑ (Moderate)

- Low impact of driver
- Moderate impact of driver
- High impact of driver
- Very high impact of driver

Figure 5. Changes in human well-being and socio-ecological indicators between the present and 2050 for the four MA scenarios. A) Each arrow in the star diagrams represents one component of human well-being. The '0' line represents the status of each of these components today. If the thick line moves more towards the center of the pentagon this component of human well-being deteriorates in relative terms between today and 2050, if it moves more towards outer edges of the pentagon it improves. B) Loss of biodiversity is least in the two scenarios that feature a proactive approach to environmental management (*Technogarden* (TG) and *Adaptive Mosaic* (AM)) while the *Global Orchestration* (GO) scenario does most to promote human well-being and achieves the fastest progress towards the Millennium Development Goals of eradicating hunger and poverty. The MA scenario with the worst impacts on biodiversity (high rates of habitat loss and high rates of species extinction) is also the scenario with the worst impacts on human well-being (*Order from Strength*). However, one scenario with relatively positive implications for human well-being (*Global Orchestration),* had the second worst implications for biodiversity

A) Outcomes for different components of well-being under different MA scenarios



B) Trade-offs between biodiversity and human well-being under different scenarios. (HWB = Human Well-being)