



Biodiversity: Basic Commodity or Luxury Item?

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CONTENTS

1. Biodiversity: Basic Commodity or Luxury Item?.....	2
2. Conclusions and Recommendations	5
3. Key References.....	6

1. BIODIVERSITY: BASIC COMMODITY OR LUXURY ITEM?

How is biodiversity defined? The United Nations Convention on Biological Diversity (CBD), agreed at the UN Conference on Environment and Development in Rio De Janeiro, defines biodiversity or ‘biological diversity’ as *‘the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.’* Biodiversity is thus acknowledged at three hierarchical levels: within species, between species, and between ecosystems. Diversity ‘within’ species refers in this definition to genetic diversity.

How many species are there? It is estimated that there are 11 million species currently living on earth, with only 2 million of this number actually documented (Chapman 2009). This implies that most of the species are still unknown to us. For the marine environment, for example, 230,000 species are described, but every day an additional 4 to 5 marine species are added to the records. The global number of documented species is growing at a rate of circa 18,000 species per year. Some organism groups are relatively well inventoried: mammals 5,500 species; birds 10,000 species; fish 30,000 species; plants 310,000 species. Other groups, such as insects, remain largely underrepresented. Estimates of insect diversity range between 2 and 7 million species.

Why is conserving biodiversity important? Biodiversity may play an important role in the *functioning of ecosystems* (i.e. the activities, processes or properties of ecosystems, such as decomposition of organic matter, soil nutrient cycling and water retention), and consequently in the provisioning of *ecosystem services*. The United Nations Millennium Ecosystem Assessment (MEA), a study involving more than 1,300 scientists, has defined ecosystem services as *‘the benefits that people obtain from ecosystems’*. Ecosystem services have been categorized into four broad categories: *provisioning services* such as food, water, timber, and fibre; *regulating services* that affect climate, floods, disease, wastes, and water quality; *cultural services* that provide recreational, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling (MEA 2004).

Is there formal scientific evidence for the positive relationship between biodiversity and ecosystem functioning? It is currently generally accepted that biodiversity plays an important role in the extent and the stability of the services provided by ecosystems (reviewed by Naeem *et al.* 2009). Much of the available scientific evidence for the relationship between biodiversity and ecosystem services or ecosystem functions is based on relatively small-scale experiments where species richness is locally manipulated, and where the effects of this manipulation on primary production and its stability is measured. Two mechanisms have been proposed through which biodiversity may impact ecosystem functioning: 1) the stochastic *‘sampling or selection effect’* and 2) the deterministic *‘complementarity effect’*. The sampling effect hypothesis suggests that positive effects of high biodiversity are caused by the greater chance of one – or a few – dominant species with high biomass being present in the polyculture. The complementarity hypothesis states that niche differences among species, such as interspecific

differences in resource use, will lead to more efficient acquisition of limiting resources and therefore to higher productivity. '*Transgressive overyielding*' occurs when systems with many species have higher biomass production than any system with one species present. It provides very strong evidence in support of the complementarity hypothesis. The exact shape of the relationship between biodiversity and ecosystem functioning remains as yet undefined. Species diversity may exhibit a linear relationship, or an asymptotic relationship, where species at higher levels of diversity are functionally redundant. Also the exact position of the tipping point (if any), where ecosystem functioning abruptly decreases when an additional species is removed from the ecosystem, has not been clearly identified. The recognition of this point is nevertheless of the utmost importance, as it is an indicator for potential catastrophic shifts in ecosystems (Scheffer 2009).

There are many concrete examples of biodiversity providing a variety of ecosystem services. Pollination of plants by insects, for example, delivers both direct and indirect services. The direct value of pollination to humans covers the increase in production of crops and animal feed in agriculture, while the indirect value is associated with the increase in reproduction of wild plants that may play a role in other ecosystem services such as erosion control, ecosystem stability and carbon storage. The direct value of pollination services by honeybees in the USA has been estimated to be between 12.3 and 16.3 billion USD. Native North-American pollinators (excluding honeybees) have been estimated to generate 3.1 billion USD in fruits and vegetables produced in the USA. Without pollination services, economic losses are therefore expected to be huge. More generally, recent reviews have reported that 70% of all major world crops rely on animal pollination for seed set. This corresponds with 35% of the production volume of all world crops (Klein *et al.* 2006). There are very concrete examples of yield (e.g. of coffee and melon) increasing with the increasing presence of natural forest habitats providing nesting and shelter to pollinators.

Crop wild relatives (CWRs) represent a further example of an ecosystem service provided by biodiversity. CWRs are defined as the wild congeners or closely related species of a domesticated crop or plant species, including relatives of species cultivated for medicinal, forestry, animal feed or ornamental reasons. CWRs have been intensively used for crop improvement during the last hundred years and their economic importance cannot be overestimated. The accumulated global monetary benefits from yield increase through genetic improvements in five major crops (soybean, sorghum, cotton, corn and wheat) between 1975 and 1992 was estimated to vary between 8 and 15 billion USD. Between 1986 and 2006, over 60 wild species contributed over 100 beneficial traits, mainly related to pest and disease resistance, to 13 major crops including wheat, rice, tomato and potato (Hajjar & Hodgkin 2007).

Modern agriculture has become isolated from biodiversity benefits through investment in highly productive cultivars, fertilizer input and the use of pesticides. Currently, however, 2,500 cases of species resistance to biocides have been recorded, involving more than 310 pesticide compounds and 540 different insect species. Biodiversity may play an important role in disease control in agriculture. The extensive cultivation of field margins, for example, can provide a natural habitat for predatory insects that decrease pest prevalence in crops on arable land. High crop species richness (so called agro-biodiversity), instead of monocultures, also often improves the stability of agricultural production over time by reducing the incidence of herbivores, pathogens, and weeds. This is especially the case in low to medium input agriculture.

To what extent is biodiversity threatened? A very recent study published in *Science* magazine compiled indicators on the state of biodiversity (population trends, extinction risk, habitat extent, and community composition) and reported overall declines, with no significant recent reductions in the decline rate. This strongly suggests that the rate of biodiversity loss is not slowing down (Butchart *et al.* 2010). At the same time, the compiled indicators of the different anthropogenic pressures on biodiversity increased. There are five important mechanisms that contribute to biodiversity loss: 1) the loss and fragmentation of habitats, 2) the invasion of exotic species, 3) pollution, 4) overexploitation by hunting and fishing, and 5) climate change. The rate at which species become extinct is

currently circa 500 times higher than the 'normal' species extinction rates that can be derived from the fossil record. These rates are expected to increase further by a factor of 10 in the coming years. The International Union for the Conservation of Nature (IUCN) assessed that 17,000 out of the 48,000 evaluated species worldwide are threatened with extinction. For the best known species group, the mammals (5,490 documented species), 79 species (1.4%) became extinct, 637 (12%) are threatened with extinction, and 505 species (9%) are vulnerable. For the most threatened species group, the amphibians (6,285 known species), 1,895 species (30%) are threatened with extinction. It can be expected that decreasing biodiversity will strongly affect the ability of ecosystems to provide ecosystem services.

Conservation and the law. The most important legal framework in the conservation of biodiversity is The United Nations *Convention on Biological Diversity* (CBD), agreed at the UN Conference on Environment and Development in Rio De Janeiro, which came into force on December 29th 1993. It has 3 main objectives: 1) the conservation of biological diversity; 2) the sustainable use of the components of biological diversity and 3) the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. The convention is one of the most widely ratified (193 parties). The *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) is also of considerable importance as an international agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. The text of the Convention was finally agreed at a meeting of representatives of 80 countries in Washington D.C. in 1973. Thirdly, *The Habitats Directive* (Council Directive 1992/43/EEC) was adopted by the European Union in 1992 and is one of the EU's two directives related to wildlife and nature conservation (in addition to the Birds Directive [2009/147/EEC]). It aims to protect circa 220 habitat types and approximately 1,000 species listed in the its Annexes. These are species and habitats that are considered to be of European importance. *The Habitats Directive* forms the core of the so-called Natura 2000 networks, interconnected natural areas throughout Europe.

Despite these different international legal frameworks, biodiversity loss has not been halted. There is growing recognition of the importance of an economic valuation of biodiversity, because this would allow the internalization of the external costs of biodiversity loss related to economic activities. Furthermore, standardized tools to assign economic value to biodiversity and ecosystem services facilitates balancing environmental damage with economic and/or social benefits during project planning. Although it seems virtually impossible to obtain a correct and complete evaluation of biodiversity, a more realistic – albeit challenging – approach currently being developed is to determine reference values for specific biodiversity aspects, or for certain habitat changes (e.g. Chevassus-au-Louis *et al.* 2009). An important achievement in this context is the publication of the TEEB reports¹ (The Economics of Ecosystems and Biodiversity). This international initiative focuses on the global economic benefits of biodiversity and the increasing costs of biodiversity and ecosystem losses. These reports clearly demonstrate that restoring natural capital can lead to very high economic and societal returns. By taking ecosystem services and biodiversity into account, the potential return on investment can be 45% for mangrove forests, 50% for tropical forests and even as high as 79% for grasslands. The TEEB approach will most likely be part of the general strategy devised to halt biodiversity loss that is to be the subject negotiation at the Nagoya summit of the Convention on Biological Diversity, held in October 2010 in Japan.

¹ <http://www.teebweb.org>

2. CONCLUSIONS AND RECOMMENDATIONS

The interdisciplinary analysis provided by this position paper allows us to make a series of recommendations. It will come as no surprise that the recommendations stated here exhibit similarities with those proposed by others, such as the League of European Research Universities (LERU Biodiversity Working Group 2010)², the EU ('Cibeles priorities', 2010)³, the Flemish government⁴ and experts in academic journals (Sutherland *et al.* 2009; Rands *et al.* 2010). For a list of 18 specific biodiversity research challenges, reference can be made to the position paper of the LERU working group.²

1. Scientific evidence exists for a positive causal relationship between biodiversity on the one hand, and ecosystem functioning and provision of ecosystem services on the other. **Increased research efforts** are needed, however, **to elucidate the exact role of biodiversity**. Increased attention to **the role of uncharismatic species** such as invertebrates and (soil) micro-organisms is of the utmost importance. A focus shift from taxonomic diversity to **functional diversity** seems crucial.
2. The exact relationship between biodiversity and ecosystem functioning determines the existence of tipping points, beyond which catastrophic shifts in the capacity of ecosystems to provide services occur. **Research into the existence and quantification of these tipping points** should be a priority.
3. Limiting biodiversity conservation to small-scale nature reserves is not effective. Therefore, **conservation efforts also need to target (semi-)urban areas, production forests and agricultural land**.
4. High input agro-ecosystems exert a huge influence on biodiversity. Furthermore, these agro-ecosystems have been decoupled from the regulating and supporting roles of biodiversity within and around the agro-ecosystem. **Restoring the relationship between agro-ecosystems and these ecosystem services** may be challenging, but it can also lead to significant benefits for both agriculture and biodiversity.
5. Besides 'wild' biodiversity, **agrobiodiversity is also declining**. **Specific attention for the conservation of the diversity of landraces and varieties** is warranted.
6. The exploitation of marine biodiversity is unsustainable, while only a very small percentage of the marine ecosystem is protected. **Extra efforts for the conservation of marine biodiversity** are necessary, and priority should be given to the establishment of **marine reserves**.
7. Ecosystem services are either free or insufficiently valued in economic terms. This leads to unsustainable use of these services, with the costs of biodiversity loss being passed on to society. Appropriate mechanisms for the internalization of these costs are needed. **Biodiversity should be valued as a public good**. Collaboration between economists, ecologists and policy makers needs to be strengthened in order to design mechanisms that allow the effective enforcement of an economic evaluation of biodiversity. The TEEB reports are an important milestone in this process.

² <http://www.leru.org/index.php/public/publications/>

³ http://www.countdown2010.net/2010/wp-content/uploads/Prioridades_Cibeles_eng.pdf

⁴ http://www.jokeschauvliege.be/pers/persberichten/message_from_ghent_for_biodiversity_post_2010/

8. Current **policies** are not sufficient to guarantee the conservation of biodiversity. Several specific recommendations can be made:
- a. A tightening of legal frameworks and law enforcement concerning biodiversity **at international, European and Flemish levels** is necessary.
 - b. Specific policies designed by governments are not always effective. **Communication between science and policy should be improved** to optimize the **effectiveness** of the resources invested in policy and management measures.
 - c. **Financial resources** for conservation and restoration of biodiversity should be increased significantly.
 - d. Policy decisions in various sectors such as transport, fisheries, agriculture and energy can have far reaching consequences for biodiversity. Therefore, an **evaluation of the impact on biodiversity should be standard practice** when proposing new measures in other policy domains. It is inefficient to support biodiversity conservation while government spending in other sectors indirectly and simultaneously results in the destruction of biodiversity.

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