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Biodiversity

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Synonyms

Biological diversity; Ecological diversity; Ecosystem diversity; Variety of living things

Definition

Biodiversity is an abbreviation for biological diversity and it represents the variety of life. There is a growing recognition that biodiversity represents a resource with enormous value for present and future generations. The Convention on Biological Diversity defines biodiversity as "the variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems" (CDB 1992).

It is possible to distinguish three different hierarchical levels of biodiversity: genetic, species, and ecosystem diversity.

The first one is the genetic variation within a species, and it is the basis of a population's adaptive capacity to environmental stresses.

Species biodiversity refers, instead, to the variety of species within a region, and its easiest measure is the number of species present in the area per unit (the greater is the richness of the species, the greater is the species diversity). To evaluate species biodiversity, however, it is also essential to consider species uniformity, given that not all species coexist in an environment of equal numbers: some are rare, some are popular, and others are abundant. Regions with a higher number of species, with more uniformly distributed individuals, are those with greater species biodiversity.

Ecosystem diversity is the largest scale of biodiversity and describes the number of niches, trophic levels, and different ecological processes that maintain energy flow, food webs, and the recycling of nutrients.

The Dimensions of Biodiversity

The Convention on Biological Diversity defines biodiversity as "the variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems" (CDB 1992).

The well-being (see) and productivity of all ecosystems, on which humans depend, are influenced by the environment around them in which there are different plant and animal species. The sum of all living organisms (microorganisms,

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plants, and animals), the genes that they have, and the complex ecosystems that they constitute in the biosphere represent the biodiversity that can be defined as the wealth of life on Earth.

The Earth's biota is made up of an estimated ten million species (Pimm et al. 1995), whereas UNEP estimates that the possible global total of species amounts at approximately 14 million of which about 1.75 million species have been described and named to date, the others are unknown and undescribed. The most described species are animals (1,320,000 described and 10,600,000 estimated) and plants (270,000 described and 300,000 estimated), covering a total of 90% of the described species, while the currently less identified species are bacteria, for which there is also the greatest gap between described species and estimated species (4,000 described species compared to the estimated 1,000,000) (CBD 2001). There is, therefore, a large portion of unknown biodiversity associated with a loss of biodiversity caused by the extinction of many species. The present extinction rate of species is about 1000 to 10,000 times higher than the natural one (Pimentel et al. 1997). The International Union for the Conservation of Nature (IUCN) has carried out a species extinction risk assessment, identifying different threat categories with an increasing risk of extinction in the short or medium term (least concern, near threatened, threatened, and extinct) (Pimm et al. 2014). By March 2014, IUCN had evaluated 71,576 species (mainly terrestrial and freshwater ones) and their related risk of extinction, observing that 860 were extinct, while 21,826 are threatened with extinction and, among these, 4,286 are endangered. The most threatened species were the terrestrial ones, with values ranging from 13% (birds) to 41% (amphibians and gymnosperms), while for freshwater species, the threat levels ranged from 23% (mammals and fish) to 39% (reptiles).

In addition to the decline in the number of species on the planet, changes that represent loss of biodiversity can also be considered:

- Conversion of biomes (of the 14 terrestrial biomes, two thirds of two and more than half of four have been converted to agriculture since 1990).
- The distribution of species on land is increasingly homogeneous.
- Genetic diversity has decreased globally, especially among cultivated species (MEA 2005).

The main factors for biodiversity loss are the destruction, degradation, and fragmentation of habitats, caused both by natural disasters (volcanic eruptions, tsunamis, floods, etc.) and by profound changes caused by human activities (climate change (see), pollution (see), overexploitation of natural resources, introduction of exotic species, deforestation, and habitat loss).

The Value of Biodiversity

Biodiversity is increasingly recognizable as the core of healthy ecosystems as biodiversity loss reduces multi-trophic interactions. The conceptual guiding principle behind the interconnection between biodiversity, good environmental condition, and human well-being is:

biodiversity → ecosystem functioning (EF) → ecosystem services (ES) → human well-being.

This consequential flow is based on the assumption that the increase in biodiversity has a positive effect, at least to some degree, on the functioning of the ecosystem, which increases ES and can finally enhance human well-being (Pinto et al. 2014).

The diversity of genes, species, and ecological processes makes a vital contribution to the functioning of ecosystems supporting their structure and processes (e.g., water, nitrogen, and carbon cycles are made possible by different species working to maintain ecological processes, and pollinators provide substantial benefits to the diversity of ecosystems, etc.).

Promoting the healthy functioning of ecosystems also directly improves ecosystem services (ES), which are defined as "the conditions and processes through which natural ecosystems, and the species that compose them, sustain and complete human life" (Daily et al. 1997); in short, "the set of ecosystem functions useful to man" (Kremen 2005). There are various benefits that individuals and society can obtain from ecosystems and they are organized in:

- Provisioning services, which are products obtained from ecosystems, for example, foods, freshwater, fiber, genetic resources, fuelwood, biochemical, etc.
- Regulating services, which are benefits obtained from ecosystem processes comprising climate and water regulation, pollination, water purification, etc.
- Cultural services, which are nonmaterial advantages obtained from ecosystems, comprising cultural heritage, recreation and ecotourism, sense of place, aesthetics, etc.

Biodiversity always plays a more or less significant role in all these services so that changes and/or losses of biodiversity affect the functionality in the production of ecosystem services that support various aspects of human well-being.

Ecosystem services are influenced by functional diversity in an ecosystem rather than by species diversity. Indeed, as formulated by McCann (2000), the stability of an ecosystem is related to its functional diversity that is able to provide diverse responses to environmental changes. For example, if there is a competition for the same resource by two different species, it will result in the stabilization of ecosystem functions through the decline of one of the two species and the upper hand of the one that is able to do well under changed conditions, contributing to the maintenance of the ecosystem as a whole. Thus, the functional diversity in an ecosystem impacts ecological resilience (see), that is, the ability of ecosystems to resist stress and shock, to absorb disturbance, and to recover from disruptive change.

Many of the ecosystem services are linked with the ecosystem resilience; a decrease in resilience is expected to have, as a consequence, a decrease in ecosystem services, and, in this context, biodiversity can have a significant influence to ecosystem resilience (Myers 1996). Biodiversity, in fact, offers sustainability and resilience, especially in the poorest and most vulnerable countries where biodiversity has a safeguarding function of providing multiple sources of ecosystem services, for example, alternative options for food and/or other resources (MEA 2005). The loss of biodiversity also influences the sustainability and resilience of agricultural systems; in fact, the deletion of the entire functional groups of species in order to promote intensive agriculture has increasingly compromised the development of ecosystem services. Adopting agricultural systems capable of providing standard production (plant and animal) as well as ecological services that allow for the protection, conservation, and increase of biodiversity would make farmers less at risk for a loss of production and would make agricultural systems more resilient to environmental changes.

The first recognition of the value and commitment needed for the conservation of biological diversity was the Convention on Biological Diversity (CDB 1992), inspired by the world's growing commitment to sustainable development (see). For the first time in history, the Convention focused on the sustainable use of the components of biodiversity and on the benefits arising from the use of genetic resources.

Ten years after its establishment, political leaders at the 2002 World Summit on Sustainable Development agreed to "achieve by 2010 a significant reduction in the current rate of biodiversity loss at global, regional and national levels as a contribution to poverty alleviation and to the benefit of all life on earth" (COP Decision 2002).

Globally, the 2010 biodiversity targets have not been met. The third edition of the Global Biodiversity Outlook (GBO-3) is one of the most significant documents produced during the year 2010, known as the International Year of Biodiversity. In the GBO-3, the probable, further, and rapid loss of biodiversity is reported with a consequent dramatic reduction of many essential services for human society. In response to this failure, at the tenth Conference of the Parties in Nagoya, in Japan, the CDB adopted a new strategic plan for biodiversity 2011–2020 including a vision for 2050 (CDB 2010). The plan provided for 20 ambitious targets, articulated in 56 indicators, collectively known as Aichi Biodiversity Targets, which have been the reference framework for the definition of global, national, and regional targets during this decade, in order to promote and take urgent and effective measures to stop biodiversity loss and ensure resilient ecosystems by 2020.

Summary

Often the term biodiversity is used as synonymous of species richness (the number of species present), although it also includes a wide range of biotic scales, from genetic variations within species to interactions between species and to the diversity of ecosystems. This is due to the fact that the changes generated by the variation in the richness and composition of species are the object where the research is most concentrated (Hooper et al. 2005). Variations in the components of the Earth's biodiversity have a strong impact on the properties and functions of ecosystems and on the goods and services they provide for the livelihood and well-being of humanity.

Cross-References

▶ Climate Change
▶ Pollution
▶ Resilience
▶ Sustainable Development
▶ Well-being

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