CHAPTER 1

BIODIVERSITY AND EXTINCTIONS, PRESENT AND PAST

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1. INTRODUCTION

The concept of 'biological diversity' was used for the first time in 1980 in reference to the number of species that live together in a community. The contracted form 'biodiversity' made its first appearance during the 'National Forum on BioDiversity' held in Washington D.C. in 1986. The proceedings of this forum were subsequently published in 1988 in a book called 'BioDiversity' (WILSON & PETER 1988). The publication of this book, which quickly became a worldwide best seller, was an important milestone in the use of the concept. Since then, there has been a remarkable and nearly exponential growth of the number of scientific publications dealing with biodiversity, including several important reference works on the subject (WILSON 1992, GROOMBRIDGE 1992, HEYWOOD & WATSON 1995, LEVIN 2001). Scientific research has in turn led to increased political involvement, better media coverage and, to some extent, improved public awareness. Why this sudden interest? It had been known for a long time that diversity was a fundamental characteristic of life. But the new and important discoveries during the past two decades led to major changes in our ideas on the biological diversity of our planet. A few of these new developments are presented in this chapter.

2. DEFINITION

The most common definition of biological diversity, or biodiversity, currently in use is formulated in Article 2 of the 'Convention on Biological Diversity' signed during the UN Conference on Environment and Development in Rio de Janeiro (1992). It reads as the following: "Biological diversity means 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" (GLOWKA *et al*. 1994). At least 25 other formulations of the concept of biodiversity have been recorded (VAN GOETHEM 1999b). In the definition given above, the diversity of life is considered at three different levels: the genetic, species and ecosystem levels. In reality, these three levels form a continuum wherein diversity is also expressed at the levels of populations, communities, niches, landscapes, continents, zoogeographical regions, etc. Biodiversity represents more than the sum of all ecosystems, species or genetic material together. It also refers to the variability between and among them. Diversity can therefore be considered as an attribute of life itself.

Because species contain an assortment of genes and are often part of complex ecosystems, species diversity is the easiest level of organisation to understand and the most straightforward parameter to characterise biodiversity. Concretely, this means: how many species are there in a given area, in an ocean or a river, etc.

3. How many species?

Natural scientists in the 18th century, and already before that, understood the necessity of giving a name to animals and plants that surrounded them if they wanted to communicate effectively on their biology. It was Carolus Linnaeus, a Swedish botanist and physician, who laid the basis for the description of biodiversity. The first edition of his *Species Plantarum* (1753), the fifth edition of his *Genera Plantarum* (1754) and the tenth edition of his *Systema Naturae* (1758) still stand as the starting points for the modern methods of biological classification. In these books, he introduced the binomial nomenclature system and outlined his scheme for classifying organisms according to their similarities. In binomial nomenclature, each animal or plant species is identified by a scientific name composed of two elements, the generic name and the specific name. This type of nomenclature has been accepted internationally and is laid down in international codes that state how organisms should be named. Linnaeus' naming system received in this way a universal character. Besides species and genera, there are a series of higher classification categories such as families, orders, classes, etc. It is the task of systematics, in addition to the description of species, to work out a classification system where all organisms can find their place. After Linnaeus, and especially following the acceptance of the theory of evolution, it became more evident that the classification system should be natural, i.e. it should reflect natural relationships between organisms, which in turn are the results of natural evolution.

Since Linnaeus, many systematicians have worked towards the description and classification of the diversity of life, an immense task. On basis of the 'Zoological Record', the world's biggest and oldest database in animal sciences, it can be inferred that the number of new animal species described per year during the past 20 years has been relatively constant, with an average of 11,600 species per year from 1979 to 1988 and a current rate of descriptions of about 13,000 species per year. Most of those species are arthropods, and principally insects. A slow down in the description of new species is not yet in sight (Hawksworth & Kalin-Arroyo 1995, Van Goethem 1999a). The estimation of the total number of organisms already described is nevertheless not an easy task. The precise figure is yet uncertain. One of the reasons is that there is no recognised central register of names for described species, and therefore some species have been described more than one time. This could happen when two scientists were unaware of each other's work or when different forms of the same species were given different names. For example, the European ten-spot ladybird (*Adalia decempunctata* L.), commonly found in Belgium, has at least 40 different synonyms, many of these having been used for the colour morphs (Stork 1997)! Many of those synonymies are not yet clarified. On the other hand, it also appears that, mostly in older publications, several different species have been described under one species name. Solving those particular cases requires additional and sometimes completely new research. Notwithstanding these problems of nomenclature, it is possible to estimate the number of already described organisms to about 1.8 million species. As far as the global number of species is concerned, it was estimated until recently to reach about 3 to 5 million species. In this regard, the difference between the number of known species and the actual number of species, although quite important, did not seem to generate an insurmountable amount of work.

4. New findings

In the 1980s, the scientific world came through new insights as a consequence of research on organisms living in the canopies of tropical rainforests. Canopies were notoriously difficult to reach and indirect sampling techniques were developed (and are still used) to collect study material. Some researchers gathered data by fogging trees with pyrethrum, a natural non-residual insecticide. Animals, mostly insects, falling from the canopy were collected in specially designed collecting sheets. Other researchers used air balloons (or canopy rafts) to land on the tree crowns and to collect material by hand. Yet another technique consisted in erecting huge cranes to reach canopies from the ground. The first results from this completely new research area were published in 1982 by Erwin, an entomologist from the Smithsonian Institution. He studied Coleoptera from one tree species (*Luehea seemannii*) in the tropical rainforest of Panama and found that the vast majority of captured species were new for science. Moreover, he showed that many of the new species were found only on that tree species. On the basis of his findings, he roughly extrapolated the number of species on Earth to be about 30 millions. Similar studies were carried out later by other researchers, in other regions of the world and for other animal groups. Although estimations were somewhat different from study to study, the ratio of unknown to known species always appeared to be considerably greater that what had previously been expected.

These canopy studies dealt mostly with insects, but recent studies on other groups confirm these findings. For example, there should be about 1.5 million species of fungi and moulds worldwide, instead of the 70,000 species already described (Hawksworth 1991). The number of cave species (now 1,444 species recorded) is estimated between 50,000 and 100,000 (Culver & Holsinger 1992). The number of living bacteria and Protoctista lies also well above the recorded number. In oceans, in the deep seas as well as in interstitial waters, a unique biodiversity awaits to be discovered. The difference between known and expected numbers is probably not as impressive as for insects, but, given adequate research possibilities, there should be a considerable increase in the amount of described species.

These new findings, and the resulting estimations, are still much discussed in the scientific literature. Predictions vary from a low 5 million to more than 100 million species on Earth. However, revisions of the estimations made by Erwin and other authors do not support hyperestimates of 30 to 100 million species. They rather indicate a species richness for arthropods of about 5 to 10 million species (Basset *et al.* 1996, Ødegaard 2000).

The question of whether there are now 10, 30 or 50 million species of organisms living on Earth, even though important, is not so relevant. It leads nonetheless to a few fundamental considerations:

a) The number of living species on Earth is considerably greater than the known number. The number of known species probably amounts to only a few percents of the worldwide quantity.
b) At the current rate of description, classification and inventory, it will take many centuries before knowing biodiversity in its simplest form, i.e. named and described species. In addition, substantial work still needs to be achieved on the comprehension of phylogenetical relationships, of autoecological and synecological aspects or of genetic, physiological and biochemical diversity.

c) It is remarkable that at the beginning of the 21st century, such an important parameter as the total biodiversity remains unknown. In the light of present changes on Earth, often referred to as 'global change', and of the measures that need to be taken in this regard, the understanding of biodiversity is certainly indispensable.

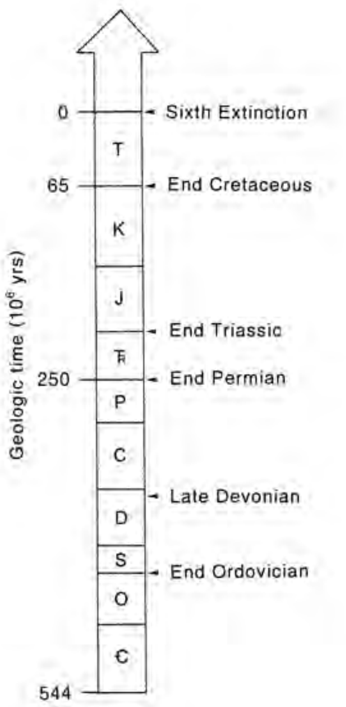
5. Fossil biodiversity

The first clear evidence of fossil organisms dates back to about 3,500 million years. These first fossils are believed to be the remains of prokaryotes. Animal life is recorded as early as the end of the Precambrian (Vendian), but biodiversity starts to increase significantly from the lower Cambrian (544 Ma). A wide range of animals appears at the time, many with skeletons. During the Cambrian and Ordovician, biodiversity rises quickly, to reach a plateau that lasts from the Silurian to the Permian. The Permian-Triassic mass extinction leads to a severe decline in biodiversity, but it recovers in the Mesozoic and Cenozoic to increase subsequently to the levels of today.

This increase was estimated using stratigraphic data of about 4,000 families and more than 30,000 genera of marine invertebrate species (Sepkoski 1984, 1997). The diagrammes resulting from this analysis, which were used in numerous subsequent publications, have led to the general acceptance that modern biodiversity levels are the highest that Earth has ever known. In a recent paper however, Alroy *et al*. (2001) report on the creation of a new database that catalogues each marine fossil record individually. The analysis of the data suggests that the apparent increase in biodiversity in the Mesozoic and Cenozoic is closely correlated to the sampling intensity of different geological periods. Most interestingly, their standardised estimations lead to approximately equal figures for biodiversity in the two time periods studied (of about 150 million years each, one in the middle of the Paleozoic, and one from the mid-Mesozoic to the mid-Cenozoic), suggesting that the supposed increase in biodiversity during the Mesozoic and Cenozoic may merely result from biases in the Sepkoski database (Newman 2001) or from an artefact of variation in the amount of rock available for study (Peters & Foote 2001).

6. Extinctions in geological time

Modern biodiversity is the result of more than 3.5 billion years of evolution. For a long time, the increase in diversity was trivial, but, as said above, the beginning of the Phanerozoic sees a spectacular rise that does not seem an artefact of the fossil record. People often refer to this period as the 'Cambrian explosion'. The number of species does not continue to rise infinitely however, as after species appear and persist for a more or less long period of time, they also cease to exist, giving way to other species better adapted to prevailing circumstances. This process of disappearance or extinction is a fundamental part of the evolutionary process. Besides these permanent 'background extinctions', biological diversity has been interspersed repeatedly and profoundly by periods of mass extinctions during the course of the Earth's history. On the basis of synoptic compilations of stratigraphic ranges of genera, Sepkoski (1986) identified no fewer than 29 extinction events in the Phanerozoic. Mass extinctions are known for the disappearance of great numbers of species or of whole higher taxonomic groups during geologically very short periods of time. Due to their large-scale character, they have been of major importance for the development of life on Earth and have, through their considerable influence on the existing ecosystems, determined the course of evolution. Mass extinctions have been known for a long time in palaeontology, but have received increased attention since the 1980s. The 'Big Five' correspond to mass extinctions that had a very profound effect on life at the End Ordovician (435 Ma), Late Devonian (365 Ma), End Permian (250 Ma), End Triassic (203 Ma) and End Cretaceous (65 Ma). Because only a relatively limited number of fossil species that lived in those periods was found, extinction rates were estimated from the number of families or genera that died out during these mass extinctions. For the 'Big Five', the extinction rates ranged from 16% to 50% for families and from 47% to 82% for genera. Species losses are usually extrapolated using the number of species that occur in present families and genera, with the consequence that it cannot be known for certain whether current numbers are representative of the far geological past. Rough estimations for the 'Big Five' range from 70% to 95% species extinct calculated on basis of families and from 76% to 95% on basis of genera (JABLONSKI 1994, HALLAM & WIGNALL 1997). Strikingly, an estimation of more than 95% species extinct was reached twice for the End Permian, the greatest extinction that the Earth has ever encountered. The precise causes and time spans of each of the mass extinctions are the subject of much debate, but it should be remembered that the mass extinctions happened on the geological time scale and each took more than hundred thousand to million years. In comparison to present extinctions, these are tremendously long periods. As far as causes are concerned, the late Permian mass extinction appears to have been associated with global physical and climate changes, tectonically-induced marine transgressions and increased volcanic activity, whereas the extinction at the end of the Cretaceous might be linked to climate change following an extra-terrestrial impact but this remains quite controversial (HALLAM & WIGNALL 1997).



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Time distribution of the 'big five' mass extinctions in the fossil record, and of the sixth undergoing extinction.

7. Recent extinctions

Natural patterns in global biodiversity are at present affected by the human species. The central issue is: are things getting better or worse, and how quickly? It seems very likely that recent modern extinction rates are higher than would be expected without the influence of man (Groombridge & Jenkins 2000). Present extinction events are difficult to record with precision, but the challenge has been undertaken by the World Conservation Monitoring Centre (WCMC) and The World Conservation Union (IUCN). A species is considered extinct when it has not been observed for at least fifty years. This criterion is not exclusive, as it is not easy to determine with certainty when the last specimen from a given species disappeared. Occasionally, specimens of species regarded as extinct were found again well after fifty years, sometimes following repeated searches in given areas. It is principally among well-recorded groups of animals and plants that known extinctions are relatively representative of actual extinctions. It is much more difficult to come through examples of extinctions of insects or fungi. The list of extinct organisms contains currently about 690 species of animals (IUCN 2002) and 380 species of plants (IUCN 1997), amounting to about 0.05% and 0.15% of the total number of already described animal and plant species respectively. This is likely to be an underestimation of the real number of extinctions. The list for animals is mainly composed of vertebrates, of which nearly 200 birds and mammals. Moreover, the list contains many island species. Small regions such as islands are particularly under strong pressure from extinctions, but they are also easier to sample due to their smaller size and well-defined physical limits. Finally, the underestimation of the number of extinct organisms lies also in regions with complex ecosystems such as tropical rainforests and coral reefs.

In addition to extinct species, many species are in decline or in danger, facing extinction if negative trends in their populations are not reversed. A classification of the risk faced by species, the 'Red List' system, has been developed by IUCN and its Species Survival Commission and is now generally accepted as a standard worldwide. There are seven categories of threat, depending on the amount of risk associated to the disappearance of the species in a nearby future: extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, and least concern. A species is listed as threatened if it falls in the critically endangered, endangered or vulnerable categories (IUCN 2002). The number of animals in the 'Red Lists' of species threatened at the international level amounts to about 5,460 species, while for plants the number reaches 33,400 species (IUCN 1997, 2002). In other words, this means that about 11% of the birds, 18% of the mammals, 5% of the fishes and 12.5% of the vascular plants are threatened in one way or another (Barbault & Sastrapradja 1995). For the great majority of the 1.8 million of described organisms however, it is not possible to judge their status by using available data.

The recent extinction rates are much inferior to those of the mass extinctions. In comparison to the 95% rate of species extinctions of the End Permian, or even to the 70% to 76% of the End Cretaceous, the few hundred already extinct species of modern times seem quite unimportant. One could conclude here that life on Earth is currently in good shape and that biodiversity fears no risk. However, considering that there is only a low number of known species compared to the great number of potentially occurring species, it is likely that the biodiversity crisis is much greater than estimated above. It cannot be excluded that many species, not yet known to mankind, are disappearing or have already disappeared: the 'anonymous extinction'.

Many recent scientific publications send worrying signals showing that there may possibly be an undergoing extinction phase as great as or even greater than the mass extinctions of geological times. The loss of species biodiversity seems to be linked most strongly (but not exclusively) to the disappearance of natural habitats. Because of the latitudinal gradient in biodiversity, the biggest losses occur in the tropical belt, mostly in tropical rainforests but also in aquatic ecosystems such as coral reefs. Tropical rainforests loose about 1.6% of their surface area each year and only 55% of their original cover remains to this date. With the disappearance of the rainforest, many species are also doomed to disappear. The scale of the current extinction rate in the rainforest can be estimated roughly using the theory of island biogeography of MacArthur & Wilson (1967). The theory establishes a relation between the area and the number of species that can be found in a given region. This theory yields the following equation: $S = CA^Z$, where A is the area, S the number of species, C a constant mainly linked to the group considered and Z a parameter depending from the group, the region, etc. On the basis of this model, a ten-fold increase in the surface area leads to a doubling of the number of species, and conversely, a ten-time reduction of the surface area halves the number of species. When tropical rainforests are considered as islands, this leads to an estimation of about 0.2% to 0.3% of species of primary forests disappearing each year (Wilson 1988). Using the estimation that tropical rainforests host about 10 million species (principally insects), this leads to a yearly loss of 20,000 to 30,000 species. If the current deforestation continues at the present rate, it is not excluded that about a fourth or more of all species on Earth will have disappeared within fifty years (Norton 1986). According to Chapin *et al*. (2000), humans have already caused the disappearance of 5% to 20% of species in many groups. Wilson (1988) suggests that "the loss in number of species due to current destruction of rainforests (setting aside for the moment extinction due to the disturbance of other habitats) would be about 1,000 to 10,000 times that before human intervention". A somewhat lower estimate, 100 to 1,000 times greater than pre-human extinction rates, is proposed by Pimm *et al*. (1995) and Lawton & May (1995). These are disturbing numbers, even though it can be argued that the basis on which the estimations are built is not entirely correct. The actual total number of species in tropical rainforests is unknown; it is only known that it reaches several millions. Furthermore, the description of the rainforest as an island is only a very crude approximation. But this approximation is not entirely unfounded as the structure of the tropical rainforest is in itself extremely diversified and can be seen as many small islands of particular habitats, each of which having its own characteristics and biological diversity.

It is not surprising that the reality of biodiversity and of ecosystems, with their amazingly intertwined structure, is much more complex than available data suggest. How inaccurate available data and how diverging estimated extinction rates may be, they all tend in the same direction: an important extinction phase seems to be happening, the so-called 'sixth extinction'. This idea was first put forward by E.O. Wilson in 1986 and later received wider attention through the publication of the book 'The Sixth Extinction' by Leakey & Lewin (1996). Comparisons between the current extinction and the 'Big Five' mass extinctions however need to be undertaken with a few remarks in mind, as records from extinctions in geological time are difficult to compare with modern data. Palaeontological extinction rates were principally identified on the basis of marine invertebrates, but available data today mostly concern endangered terrestrial organisms. As the present status of marine animals is not well known, it is difficult to relate palaeontological marine extinction rates to global modern biodiversity.

While fossil extinction rates were mainly estimated on the basis of families or genera, present day extinction rates are exclusively based on the loss of species. Data on the disappearance of recent families and genera are not yet available. Moreover, the time factor remains difficult to interpret. Present day extinctions occur in historical time, namely in dozens or hundreds of years, which is an extremely short period seen from a geological time perspective (hundred thousand or millions of years). Finally, plant biodiversity seems now to be endangered for the first time. In the geological past, plants appear to have suffered from successive great extinctions only on a limited scale. This implies that few palaeontological data are available on the extinction of plants, and its direct effect on ecosystems. As primary producers, plants sustain most other life forms and are essential building blocks of ecosystems. It seems quite evident that the disappearance of plant species will have an important effect on the functioning of ecosystems.

8. The importance of biodiversity

Palaeontological studies show that after mass extinctions and a strong decrease in biodiversity through the loss of species, recovery can only arise from the evolution of new species. This appearance of new species (= speciation) is rather a slow process, taking from hundred thousand to million years. The impact of a rapid loss of biodiversity on the functioning of ecosystems and on their ability to provide ecological services has been a central issue in ecology for some years already. Both observations and theoretical research have led to conflicting views, with proponents of the hypothesis that processes in ecosystems are rather insensible to changes in biodiversity being opposed to proponents of the theory that even small changes in diversity have dramatic and unpredictable effects on the functioning of ecosystems. It is only recently that relevant experimental research was developed in the laboratory and in the field. Pioneer experiments by Naeem and colleagues (1994) and Tilman & Downing (1994) are presented below. In the 'Ecotron' experiment of Naeem *et al.*, terrestrial communities were recreated under laboratory conditions, with biodiversity as the only changing parameter. Different organisms were put together in 16 isolated cells, i.e. primary producers, reducers, primary and secondary consumers. Diversity in the cells varied from a low 9 species to a high 31 species. After a period of 206 days, it appeared that the most diverse communities also had the highest productivity and stability. The Ecotron-communities were merely an elementary reflection of the real world, but fieldwork experiments by Tilman & Downing lead to similar results. They studied the diversity of 207 grassland plots, where species diversity was changed as a function of nitrogen inputs. After five years, plots with the highest diversity were also those that resisted best to an exceptional event in the form of a major drought. The loss of biomass and diversity were the lowest in those plots. Ecosystems with high biodiversity were therefore the most stable. Biodiversity increased drought resistance and ecosystem stability because more diverse plots were more likely to contain drought-resistant species that grew and compensated for the loss of drought-sensitive species. Major variations appeared however in populations of different species. This experiment illustrates that biodiversity is a very important parameter for ecosystems. It also shows that for each species taken separately biodiversity brings no guarantee of survival, but rather that the instability and fluctuations of individual species are major parameters for the global stability of the ecosystem. There is a trade-off between species characteristics (i.e. species complementarity) that brings greater benefits to the ecosystems. In addition to stability, understood in ecological terms as resistance against changes in the environment, species also prove to be very important for the recovery of ecosystems after more or less important natural disturbances. This introduces the notion of 'ecosystem resilience', where resilience refers to the capacity of the ecosystem to absorb shocks while maintaining function. When change occurs, resilience provides the components for renewal and reorganisation (FOLKE *et al*. 2002). In other words, even though some species may seem superfluous when diversity is high, they prove crucial for the resistance and recovery of the system when diversity falls under a given threshold (LOCKWOOD & PIMM 1994, LAWTON 1994). Several experiments have also shown that primary production seems to be higher with greater biodiversity. Two alternative mechanisms can account for the results, leading to key interpretation problems of experimental data: the species complementarity and the sampling effect, the first being an ecological phenomenon and the second a statistical consequence of the experimental design. LOREAU & HECTOR (2001) devised a method to differentiate between the two and were able to show that species complementarity is a most important mechanism behind the increase in productivity.

If species are so important, the following question comes naturally to mind: can we afford to loose species? Available scientific data are still insufficient to answer the question or to give a concrete judgment for the future. It is known that an important extinction phase is in progress and that many modern species are already extinct or threatened to disappear. Besides the intrinsic value of species as a result of million years of evolution, as part of intricate phylogenetic trees and as carriers of specific genetic information, species are also important for the long-term stability and productivity of ecosystems, of which they are vital functional entities. Two models present diverging explanations of the impact of the loss of biodiversity on ecosystem stability (CHERFAS 1994). In the first model, ecosystems will become slowly and gradually unstable trough the gradual loss of species, before disappearing in the end. In the second model, all species do not have the same value. Some species are less important than others and their loss is not fundamental for ecosystem stability. On the contrary, other species have a key function in the functioning of the ecosystems and their loss would lead to a rapid and catastrophic breakage of the system. However, it has now become evident that, whatever the underlying process, the disappearance of species can lead to instability, vulnerability and eventually to the break down of ecosystems.

Why is it imperative to keep ecosystems in 'good shape'? Human development depends on the generation of ecosystem goods such as food, timber, building material, genetic resources and medicines. The list of ecosystem services is even longer and includes water purification, flood control, carbon sequestration, soil formation, nutrient assimilation, pollination, seed dispersal, disease regulation, as well as aesthetic and cultural benefits. Higher ecosystem vulnerability increases their risk to suffer from stresses and shocks. As ecosystems are degraded, society becomes more vulnerable because options for change are reduced. Human dependence on natural resources is such that it is of the self-interest of society to sustain the capacity of ecosystems to supply their goods and services.

9. Measures

The challenge is to preserve biological diversity and maintain ecosystem functioning as well as to secure prosperous social and economic development (Folke *et al*. 2002). In other words, it is necessary to ensure the balance between the three pillars of sustainable development: economy, society and environment. The outlook is not extremely cheerful. Demographers predict a doubling of the world's population during the 21st century. This population increase will lead to further economic growth and unsustainable patterns of production and consumption. If economic growth is, like today, paired with the accelerated loss of natural habitats, then the major part of the Earth's biodiversity is likely to be threatened. The acquisition of a better and more profound insight into the importance of biodiversity and of ecosystem functioning requires much additional research on a relatively short-term basis. At the same time, politicians and policy-makers need to take rapid initiatives to counter the loss of biodiversity, not only through measures for species conservation but for the maintenance of natural ecosystems and habitats as well. Such actions need to be complemented with measures for the management of biodiversity in human-dominated environments.

The first solutions for the sustainable use of natural resources and sustainable development were proposed during the 1992 UN Conference on Environment and Development (also called the Rio Earth Summit). It led to the adoption of Agenda 21, a comprehensive plan of actions to be taken globally, nationally and locally in every area in which humans impact on the environment. The Rio Earth Summit also saw the historic signature of two international legally binding agreements, the Convention on Climate Change and the Convention on Biological Diversity. The conference and the numerous international meetings that followed, in which our country takes actively part (Van Goethem 1999a), give an optimistic sign that solutions are under way. These solutions will not be easy however and can only be realised through intense and persistent international concertation. Ten years after Rio, world leaders have come together again in Johannesburg for the World Summit on Sustainable Development to evaluate what has been accomplished since 1992. Despite the abundance of treaties, instruments and policy measures established on paper, results in the field are not very encouraging. The UN Secretary General designated biodiversity as one of the five priority thematic areas for the Johannesburg summit, together with water, health, energy and agriculture (WEHAB 2002). The profile of biodiversity has never been higher on the political agenda. Let us hope that the agreed framework for action will lead to real changes in the future.

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