Executive Summary

Biodiversity is a vital resource for all humankind

The Earth is home to a rich and diverse array of living organisms, whose genetic diversity and relationships with each other and with their physical environment constitute our planet's biodiversity. *This biodiversity is the natural biological capital of the Earth, and presents important opportunities for all nations.* It provides goods and services essential to support human livelihoods and aspirations, and enables societies to adapt to changing needs and circumstances. The protection of these assets, and their continued exploration through science and technology, offer the only means by which the nations of the world can hope to develop sustainably. The ethical, aesthetic, spiritual, cultural and religious values of human societies are an integral part of this complex equation.

The limited knowledge base

The distribution and magnitude of the biodiversity that exists today is a product of over 3.5 billion years of evolution, involving speciation, migration, extinction, and, more recently, human influences. *Recent estimates of the total number of species range from 7 to 20 million, but we believe a good working estimate is between 13 and 14 million of which only about 1.75 million species have been scientifically described, just under a fifth of them plants or vertebrates.* Less well studied groups of organisms include bacteria, arthropods, fungi and nematodes, while species that live in marine environments and beneath the ground are especially poorly known.

Even for the 1.75 million species that have been described, there is no comprehensive listing and we have a highly incomplete and patchy understanding of their reproductive biology, their demography, the chemicals they contain, their ecological requirements and the roles they play in ecosystems. Genetic diversity within species is known well for only a very small number of species – primarily those that have direct importance for human health, scientific research and economic exploitation.

The threat to nature's adaptability

Diversity of species and genes affects the ability of ecological communities to resist or recover from disturbances and environmental change, including long-term climatic change. Genetic variation within species is the ultimate basis for evolution, the adaptation of wild populations to local environmental conditions, and the development of animal breeds and cultivated crop varieties which have yielded significant direct

benefits to humanity. Losing the diversity of genes within species, species within ecosystems, and ecosystems within a region makes it ever more likely that further environmental disturbance will result in serious reductions in the goods and services that the Earth's ecosystems can provide.

Biodiversity is being destroyed by human activities at unprecedented rates

The adverse effects of human impacts on biodiversity are increasing dramatically and threatening the very foundation of sustainable development. The rate at which humans are altering the environment, the extent of those alterations, and their consequences for the distribution and abundance of species, ecological systems, and genetic variability are unprecedented in human history, and pose substantial threats to sustainable economic development and the quality of life. Loss of biological resources and their diversity threatens our food supplies, sources of wood, medicines and energy, opportunities for recreation and tourism, and interferes with essential ecological functions such as the regulation of water runoff, the control of soil erosion, the assimilation of wastes and purification of water, and the cycling of carbon and nutrients.

The downward spiral

During the last few millennia species have been made extinct as a result of human activities. Prehistoric colonization of islands in the Pacific and Indian oceans some 1000 to 2000 years ago by humans and their commensals, rats, dogs and pigs, may have led to the extinction of as many as a quarter of the world's bird species. Since 1600, 484 animal and 654 plant species are recorded as having gone extinct although this is almost certainly an underestimate, especially as regards tropical regions. *Based on an assumed average life span of 5 to 10 million years for organisms with adequate fossil records, the extinction rate for these groups has been estimated to be fifty to a hundred times the average expected natural rate.* In addition, there has been widespread loss of populations and genetic resources.

Because of the world-wide loss or conversion of habitats that has already taken place, tens of thousands of species are already committed to extinction. It is not possible to take preventive action to save all of them. Projections of impending extinctions due to habitat loss can be made using the empirical relationship between the number of species and the area of a habitat, derived from island biogeography. When applied to tropical forests, published estimates of the number of species that will eventually become extinct or committed to extinction due to projected forest loss over the next 25 years or so range from 2% to 25% in the various groups examined (mainly plants and birds): this would be equivalent to 1000 to 10 000 times the expected background rate. If recent rates of loss of closed tropical forest (about 1% globally per year) were to continue for the next 30 years, the equilibrium number of species in the

forest, as calculated by species–area techniques, would be reduced by approximately 5 to 10%. These potential extinctions would not be immediate: it could take decades or even centuries to reach the new equilibrium number of species. Comparable estimates have not been made for the impact of habitat loss in other biomes.

For some groups of vertebrates and plants, between 5 and 20% of the identified species are already listed as being threatened with extinction in the foreseeable future. These estimates depend strongly on predictions of future rates of forest loss which may increase or decrease, and on the effects of fragmentation. They will also be modified by the effects of conservation action such as the protection of areas of high diversity.

Even if species do not become extinct, many of them will lose distinct populations or suffer severe loss of genetic variability through habitat loss or fragmentation. Natural and agricultural systems are being degraded through soil erosion, introduction of exotic species, fragmentation and pollution; the effects of these most recent human-induced changes will not emerge for some time yet – suggesting that a substantial increase in the level of future extinctions of species or populations as a result of human activity is already inevitable.

The underlying causes

The primary causes underlying the loss of biodiversity are demographic, economic, institutional, and technological factors, including:

- increasing demands for biological resources due to increasing population and economic development;
- failure of people to consider the long-term consequences of their actions, often due to a basic lack of knowledge;
- failure of people to appreciate the consequences of using inappropriate technology;
- failure of economic markets to recognize the true value of biodiversity;
- failure of economic markets to apply the global values of biodiversity at local level;
- institutional failure to regulate the use of biological resources resulting from the growth in urbanization, changes in property rights, and shifting cultural attitudes;
- failure of government policies to address the over-use of biological resources; and
- increasing human migration, travel, and international trade.

These underlying causes manifest themselves in the loss, fragmentation, and degradation of habitats; the conversion of natural habitats to other uses; over-exploitation of wild resources; the introduction of non-native species; the pollution of soil, water, and atmosphere; and, more recently, signs of long-term climate change.

Without immediate action future options will be restricted

Unless actions are taken now to protect biodiversity, we will lose forever the opportunity of reaping its full potential benefit to humankind. Priority actions need to focus on improving the knowledge base, correcting past failures in policy and ensuring that conservation and sustainable use of the planet's resources and the equitable sharing of benefits are made an integral part of all socioeconomic development.

Managing biodiversity

The conservation and sustainable use of biodiversity needs to become an integral component of economic development by correcting policy and market failures. This will require much greater levels of co-operation and co-ordination than has previously been seen in traditional sectoral approaches to the management of natural resources. A balanced mix of incentives and disincentives, working alongside conservation laws, market adjustments, and traditional regulatory techniques, is needed in managing biodiversity at the national level. Institutional and legal frameworks are needed to ensure that conservation and sustainable use of natural resources are integrated successfully into the wide range of social, cultural and economic contexts in which actions must be taken.

The adoption of more ecologically based management systems, which take into account the effects on biodiversity of extracting goods and using ecological services promises a way of balancing human socioeconomic and long-term ecological considerations.

Conserving biodiversity

A wide variety of measures can be used to conserve biodiversity, including both in situ *and* ex situ *methods.* Effective *in situ* approaches include legal protection of endangered species, the preparation and implementation of species management or recovery plans, and the establishment of protected areas to conserve individual species and habitats. Protected areas generally must be augmented by additional measures, such as the preservation or establishment of safe corridors through areas of intensive human use, and must also return some economic benefit to local human populations if access and other restrictions are to be respected. Currently, the percentage of different biomes covered by protected areas ranges from less than 1% for temperate grasslands and lake ecosystems to nearly 10% for subtropical and temperate rain forests and islands.

Ex situ *conservation centres such as arboreta, aquaria, botanic gardens, seed banks, clonal collections, microbial culture collections, field gene banks, forest nurseries, propagation units, tissue and cell cultures, zoological gardens, and museums, can help to conserve stocks of both wild and domesticated animals, plants, fungi and microorganisms, but are less able to maintain their populations.* Serious gaps exist even in the *ex situ* coverage of those species that are known to be of direct economic importance, particularly in the tropics. Indeed the only species that have been sampled in any depth are some of the major crop plants, certain pathogens of humans and crops, and 'model organisms' used in scientific research.

Restoration and rehabilitation of habitats, which depend on the availability of material and its multiplication ex situ, *will come to play increasingly important roles in re-establishing degraded and damaged ecosystems.*

Sustainable use of biodiversity

Sustainable use of biodiversity is a key component of sustainable social and economic development. Management systems must take this into account explicitly, recognizing that social and economic measures may be just as important as technical considerations. Flexibility of management is needed so as to be able to respond to changing

social, biological and physical environments, while still maintaining essential ecosystem functions. Appropriate incentives and the enforcement of management decisions and policies must be ensured. Finding the appropriate balance depends on the particular cultural, legal, economic, ownership, tenure and biological circumstances in each individual country.

Equitable sharing of benefits

An equitable sharing of income and assets is an important component of a strategy for conservation of biodiversity. In particular, an equitable distribution of the benefits of biodiversity conservation is a prerequisite for creating the incentives needed to maintain the Earth's biological wealth. Local benefit sharing has the effect of lowering the opportunity cost of forgoing conversion to commercial or other uses such as arable agriculture, pasture or industry.

The role of research, monitoring and inventory

Enhanced research, inventory and monitoring are important to promote responsible policy-making and management. Research into the uses and applications of biodiversity and its components is important as is further research into the ways in which biodiversity contributes to the provision of ecological services, so that those services can be sustained indefinitely. Monitoring and inventories are needed so that newly discovered life-forms can be properly documented and so that the status of individual species and particularly ecosystems can be gauged over time.

Building national capacity and expertise

Committed and skilled people are the key to successful maintenance and sustainable use of biodiversity. Training must be provided for those involved in managing protected areas, conducting biodiversity inventories, and developing and safeguarding *ex situ* collections of all kinds. An essential element in the training of the next generation of professionals will be the new focus on the broader aspects of resource management and the critical role of maintaining adequate levels of biodiversity in conjunction with the management of forestry, fisheries and agriculture. National training programmes and international exchange programmes must concentrate on producing more skilled scientists, particularly in the developing countries, and on improving the information-handling capacity of those countries through improved access to, and management of, information now available world-wide on computerized databases. Educating the public and making people aware of the issues involved in biodiversity are essential elements in improving the decision-making process.

Summary for Policy-Makers

Introduction

The Earth is home to a rich and diverse array of living organisms, whose species, the genetic diversity they comprise, and the ecosystems they constitute add up to what we call biodiversity (Box 1). Biodiversity is the natural biological capital of Earth. It provides the goods and services essential to human livelihoods and aspirations, and enables societies to adapt to changing needs and circumstances. For example, forested ecosystems provide fuels, medicines, construction materials and animal habitat; wetlands and riparian ecosystems protect water quality and aquatic life; oceans provide food and energy, and regulate climate, and agricultural systems produce food. Ecosystems also afford opportunities for recreation and tourism. More generally, ecosystems provide for the processing, storing and cycling of carbon and nutrients, thus influencing the Earth's climate and atmospheric composition.

Today, the scale of human impacts on the global biosphere is increasing dramatically due to activities that arise from the rapid growth in human population and increasing rates of consumption. Ecosystems are being altered and destroyed, while species in some groups of plants and animals are going extinct at rates some fifty to a hundred times higher than they otherwise would, and others are having their populations depleted. The genetic resources essential for industries such as agriculture, forestry and fisheries continue to be lost. This tragic loss and degradation of biodiversity holds serious economic, ethical and cultural consequences for humanity and the evolution of life on Earth. Indeed, the very foundation of sustainable development is being threatened.

Societies should consider carefully how they interact with biodiversity (Fig. 1). If responsible measures are taken now, losses or alterations can be slowed or in some instances halted by integrating biodiversity concerns into national decision-making processes using a combination of social and economic policies and incentives; by utilizing scientific and technical knowledge more effectively; by addressing the underlying causes of biodiversity loss; and by building human and institutional capacity world-wide.

One indication of the growing international concern about biodiversity was the emphasis given to the issue at the 1992 United Nations Conference on Environment and Development held in Rio de Janeiro and the ensuing Convention on Biological Diversity. The Convention recognizes that actions are needed to conserve biodiversity, ensure the sustainable use of its components, and ensure the fair and equitable distribution of the benefits derived from its use.

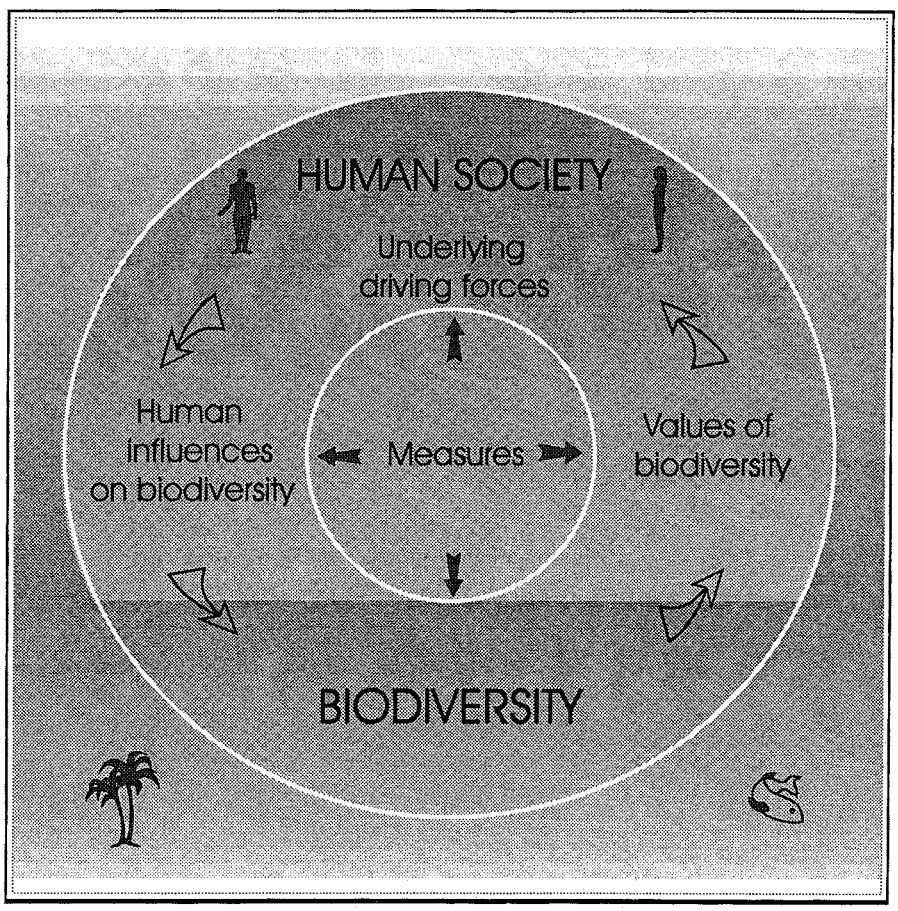

Fig. 1 The interaction between human society and biodiversity.

Box 1 What is biodiversity?

Biodiversity is defined by the Convention on Biological Diversity as *'the variability among living organisms from all sources, including 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'*. More simply, biodiversity is the variety of the world's organisms, including their genetic makeup and the communities they form. Biodiversity is dynamic: the genetic composition of species changes over time in response to natural and human-induced selection pressures; the occurrence and relative abundance of species in ecological communities changes as a result of ecological and physical factors (Box 2).

Ecological diversity: Ecological systems do not exist as discrete units, but represent different parts of a natural continuum. Although terms such as forest, grassland, wetland and coral reef are commonly used to denote ecological systems, their delineation and spatial scale often depend on the intended purpose of the classification (Fig. 3).

Some commonly used terms are:

Biome – a continental-scale region characterized by its distinctive vegetation and climate

Ecosystem – the individuals, populations and species that occur in a defined area, including their interactions with each other and with their physical environment.

Ecological community – a group of species inhabiting a particular area.

Habitat – the biological and physical environment of a particular species.

Organismal diversity: The total number of species on Earth is estimated at between 13 and 14 million, of which only 1.75 million have been described. The enormous diversity between these species, ranging from common annual herbs to bacteria of deep ocean trenches, their arrangement into classifications reflecting their phyletic relationships, and the complex patterns of variation and distribution that they show, provide the very substance of biodiversity. Groups of interbreeding individuals within a species form distinct populations. Groups such as plants, birds, mammals, fishes, reptiles and amphibians – the species with which we are most familiar – account for only *3%* of the estimated total, while the majority of species belong to groups such as insects, arachnids, fungi, nematodes and microorganisms (Fig. 2).

Genetic Diversity: Genetic differences between the individuals of a species provide the basis for the diversity that is found between species. Molecular studies have revealed a wealth of genetic variability in most species: in fact, individuals of virtually all species are genetically unique. Genetic diversity can be described at multiple levels from single genes to visible multi-locus traits. It is expressed as genetic variability both within and between populations. The amount and distribution of genetic diversity vary extensively among species in ways which are incompletely understood. It is well established, however, that genetic diversity within species is necessary to allow them to adapt to changing environmental conditions.

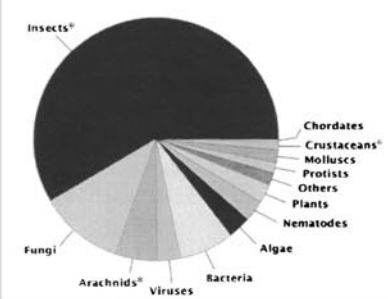

Fig. 2

1. * are arthropod groups
2. Chordates include mammals, birds, reptiles, fish and amphibia

Box 2 The composition and levels of biodiversity

Ecological diversity

biomes
bioregions
landscapes
ecosystems
habitats
populations

Genetic diversity
populations
individuals
chromosomes
genes
nucleotides

Organismal diversity
kingdoms
phyla
families
genera
species
subspecies
populations
individuals

Cultural diversity: human interactions at all levels

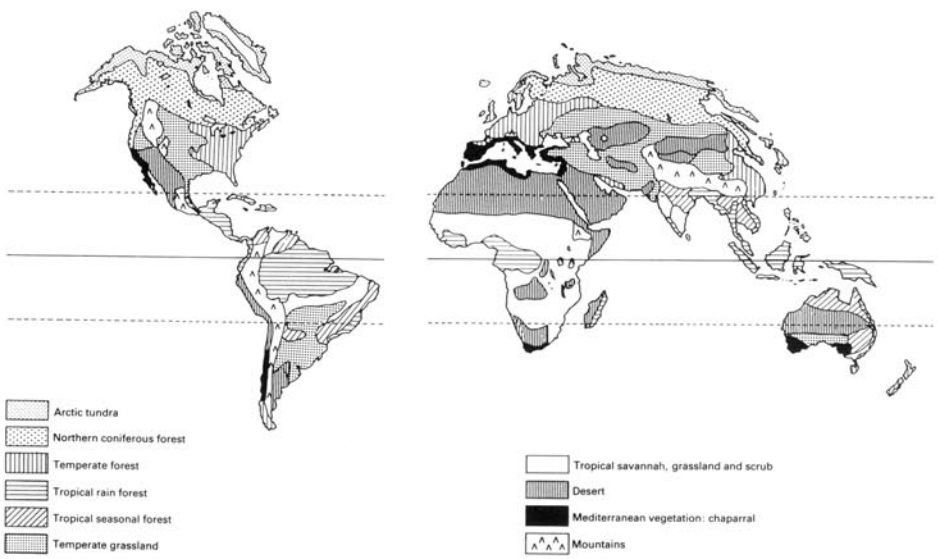

Fig. 3(*a*) Distribution of the world's terrestrial biomes (from Cox, C.B. and Moore, P.D. 1993. *Biogeography: An ecological and evolutionary approach*. Blackwell Scientific, London).

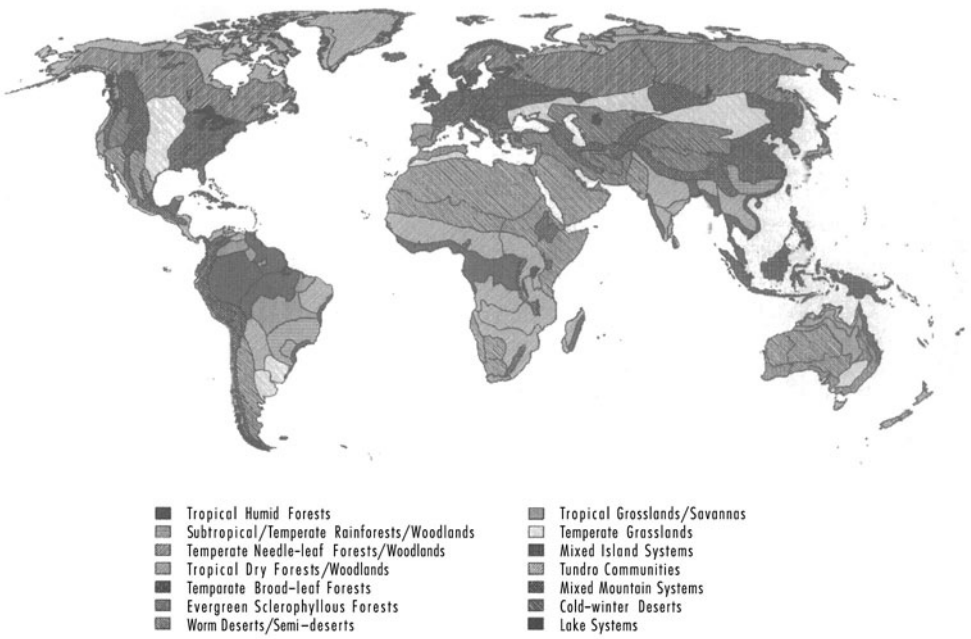

Fig. 3(*b*) The world's biogeographic realms and provinces (after Udvardy, M.D.F. 1975. *A classification of the biogeographical provinces of the world*. IUCN, Morges, Switzerland).

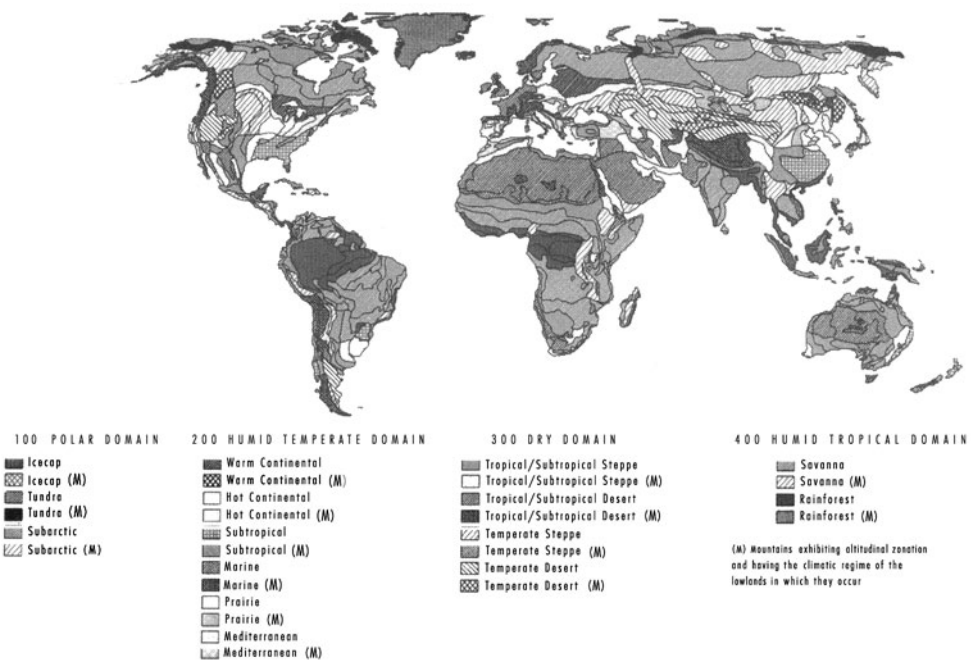

Fig. 3(*c*) The world's ecoregions (after Bailey, R.G. and Hogg, H.C. 1986. A world ecoregions map for resource partitioning. *Environmental Conservation* **13**: 195–202).