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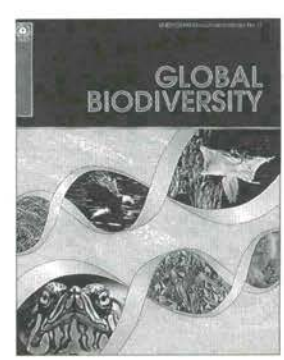

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Foreword

We are wholly reliant upon the environment in which we live, an environment so rich and complex that we cannot fully comprehend it. Despite the great scientific advances of recent years, we can but stand in awe of a world that holds together in such perfect harmony. The human race has a vital role to play in the future of the Earth. We have a responsibility to respect and protect our living resources. In fact, our own survival depends on it.

Yet in our quest for growth, we seem to have lost sight of this fact. We have, this century, been destroying the Earth's biological diversity at an alarming rate. Species extinction is at a level never known before. Ecosystems such as forests, wetlands and grasslands are being altered and destroyed for our own ends, upsetting the delicate balance of nature.

There is much to be gained from conserving biodiversity. We depend upon plant and animal species for food, medicines and raw materials. The genetic resources contained within them form the basis of our continued existence. And there is no doubt that the beauty and variety of living species greatly improve our quality of life.

We cannot continue to exploit our biological resources indefinitely. Conserving biological diversity is a slow process, but some action has already been taken. National and international measures are in place to protect both plants and animals, at least partially. And the UN Conference on Environment and Development was an important way of bringing environmental issues to the forefront of world thinking. It was at this conference that the Convention on Global Biodiversity was signed, a convention designed to iron out the differences between developed and developing countries on the subject of biodiversity and its management, and to ensure that global biodiversity is protected.

This action has come not a minute too early. The existence of clear objectives, under UN supervision, will make it easier to protect our living resources. Working together, we can ensure both our own future and the future of our planet.

Jan W. Huismans
Assistant Executive Director
Earthwatch Coordination
and Environmental Assessment

Overview

The world's biodiversity is made up of the millions of microbial, plant and animal species that inhabit the planet. Within each species is a variety of populations that have naturally evolved particular characteristics over millenia. Some species have become specially adapted to a particular environment, and can flourish in some of the most hostile regions of the Earth in which other species, including humans, would quickly perish. The genetic variation within species is almost immeasurable, and is greatest in micro-organisms, which have had far longer on Earth to diverge. In fact, the very existence of many species is dependent upon micro-organisms, which also play a large part in maintaining ecosystems, the biosphere and global ecology.

The human race depends upon microbial, plant and animal species for food, and uses them as the raw materials for a wide range of products, from medicines to building materials. The world's forests and vegetative cover maintain the fertility of the land and the quality of water resources, and influence the climate. Many other species help to sustain the environmental conditions that enable all species, including humanity, to live on Earth.

Clearly, no species can survive in isolation: all species depend on one another—directly or indirectly—for their survival. Interdependent communities of species and their physical environment form ecosystems, which may exist in an area as small as a single field or, like tropical rain forests, may cover thousands of square kilometres.

... no species can survive in isolation: all species depend on one another ...

Thousands of years ago, humanity learned how to manage the natural environment by clearing land, growing crops and rearing domesticated animals. Crop yields and the productivity of animals kept for food have been improved through cross-breeding, both with other domesticated strains and with wild relatives which often contain valuable genetic material, including resistance to certain diseases and pests.

Within the past few hundred years, human activity has had a profound and, in some cases, irreversible effect on the environment and on individual species. As the human population has increased, more and more land has been cleared for agriculture, settlement and industry, and species have been collected from the wild at an unsustainable rate. Trees in tropical rain forests, for instance, are harvested for timber and to make charcoal; forest lands are cleared for settlement, agriculture, ranching, mining and oil production; rivers within forests are dammed; and forest lands are flooded as part of massive hydroelectric schemes.

Dennis Stanfill/UNEP-Select

Even the most inhospitable environments can be home to different species, all forming part of the jigsaw that is global biodiversity.

Thousands of species worldwide are under threat from overuse, loss of habitat and environmental pollution. Because species in ecosystems are interdependent, the loss of one species can lead to the disappearance of many others. Domestic animals and crop species are also under threat. Local breeds and crops are dying out as they are replaced by the small number of crops and animals developed for modern intensive farming.

The value of maintaining biodiversity is gradually being realized, and steps are being taken to conserve species and ecosystems. Global biodiversity monitoring is providing information on the number and distribution of species, enabling governments to protect areas with a high level of biodiversity, and areas containing rare and threatened species. Action has also been taken to prohibit trade in endangered species.

UNEP has been involved in drawing up the Global Biodiversity Strategy, which outlines steps that can be taken to protect and maintain biodiversity. This strategy complements the Convention on Biological Diversity, signed by more than 150 nations at the UN Conference on Environment and Development in Rio de Janeiro in June 1992. This first international convention on biodiversity regulates the use of genetic resources, and sets out the responsibilities of governments to use their natural resources sustainably and to protect threatened ecosystems. The convention will come into force when ratified by 30 nations; only then will its conditions be obligatory, and only to those nations that ratify it. Beyond this, it may take a long time to convert the requirements of the convention into national legislation. UNEP is helping to implement the convention by providing assistance to signatories carrying out national biodiversity surveys, and by advising governments on how to incorporate the maintenance of biological diversity into government policies.

Thousands of species ... are under threat from overuse, loss of habitat and environmental pollution.

The scientific background

Biological diversity—or 'biodiversity'—describes the diversity of life on Earth. Broadly speaking, the term encompasses all species of plants, animals and micro-organisms, their genetic material and the ecosystems of which they are part—many of which have developed over millennia of evolutionary history. Global biodiversity is usually divided into three fundamental categories—genetic diversity, species diversity and ecosystem diversity.

Genetic diversity

The genetic material of micro-organisms, plants and animals contains information that determines the characteristics of all species and individuals that make up the diversity of the living world. The number of possible combinations of genes and of the molecules making up genes is immense—much larger than the number of individuals making up a species.

Genetic diversity refers to the differences in genetic make-up between distinct species and to genetic variations within a single species. Individuals belonging to a species share, by definition, certain characteristics, but genetic variation determines the particular characteristics of individuals within the species. In simple terms, genetic material dictates whether we have blue or brown eyes, blond or black hair, and are tall or short. It also determines whether an individual animal or plant has the ability to survive in a particular habitat or under particular environmental conditions. Some plants, for example, are able to grow in saline water as a result of genetic variation.

Genetic variation occurs, to varying degrees, in most species of plants and animals. There is high genetic variation in Indian rhinos, for example, but little among cheetahs. Furthermore, the genetic make-up of an individual species is not static—it changes as a result of both internal and external factors.

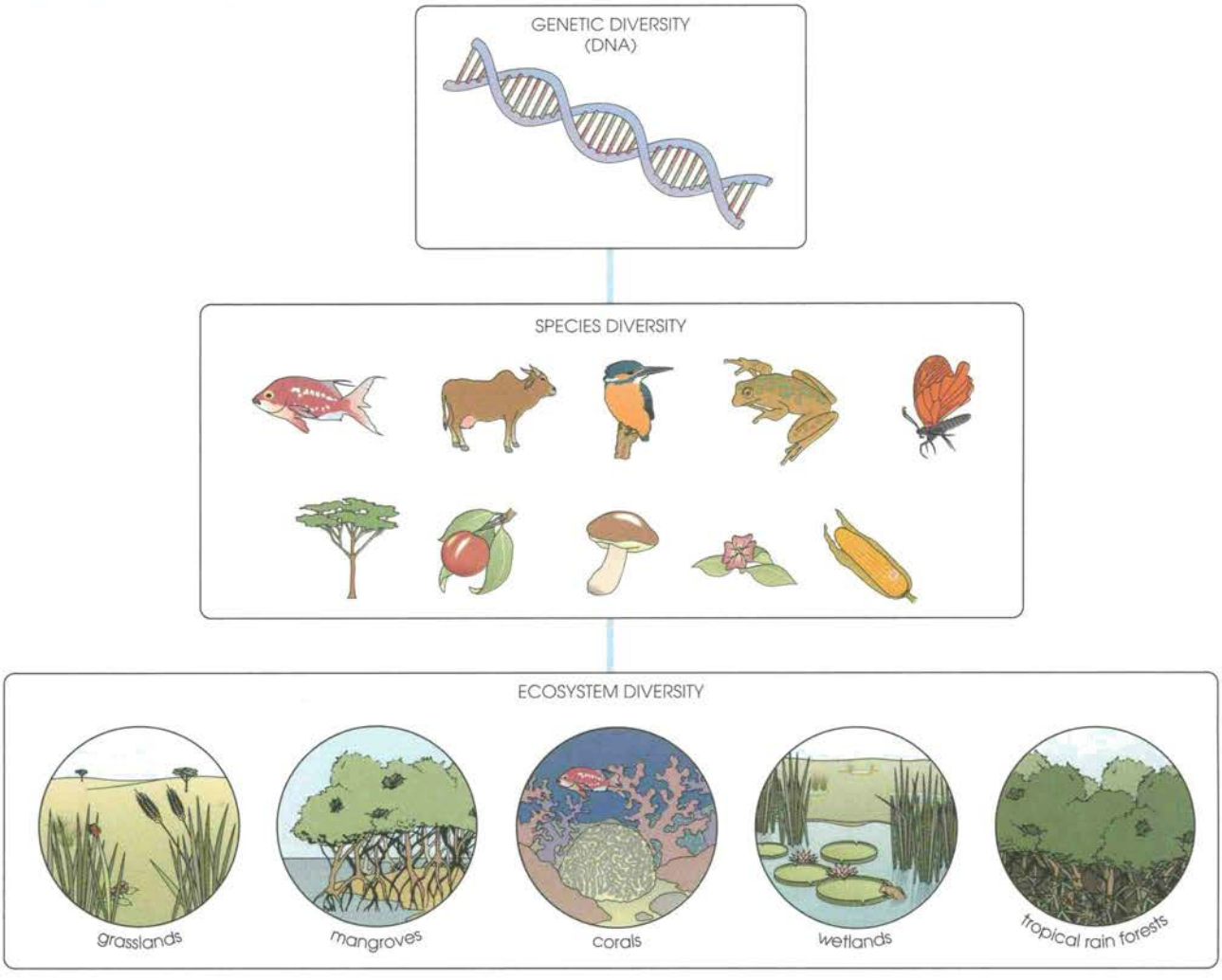
This variety of genetic material within species has enabled distinct species to evolve through natural selection. Broadly speaking, species that inhabit large areas and interbreed throughout the whole area have a high rate of gene flow and show few or no localized characteristics; however, species living in small or isolated areas have low rates of gene flow and, as they adapt over time to their particular environment, they develop into distinct, localized populations.

Behavioural traits can also influence the geographical distribution of genetic characteristics within a given species. For example, the North American eel inhabits streams along 4000 km of coastline, but migrates to the Sargasso Sea to reproduce as one massive population. As a result, individual eels inhabiting streams many miles apart do not demonstrate any geographic differentiation. However, other species, such as salmon, breed in different streams, but spend most of their life at sea; these species develop marked genetic variations between populations.

Species diversity

Species diversity is measured in relation to a given area—from a small field to the entire planet. It can be assessed in terms of the number of species or the range of different types of species an area contains.

So far, 1.7 million species have been described worldwide and estimates of the total number of species on Earth range from 5 to 100 million—12.5 million being a conservative working estimate. Although most of the Earth's species are insects and micro-organisms, this is not reflected in the



types of species that have been described to date. There has been a definite bias towards describing large organisms, those that are considered attractive or appealing (such as flowering plants and butterflies), those most closely resembling humans (vertebrates, especially mammals), and those that have a direct impact on human activities (such as pests). Organisms that can be studied without complex procedures or expensive equipment have also taken precedence, as have those which are relatively easy to locate.

This, however, underestimates the importance of micro-organisms—including algae, bacteria, fungi, protozoa and viruses—which are vital to life on Earth. So far, less than 3–5 percent of micro-organisms have been desribed. Yet the very existence of larger organisms depends upon the continued availability of the micro-organisms they require. Coral reefs, for example, could not exist without algae. At the ecosystem level, the greatest biomass in soil is micro-organisms, especially fungi. These maintain soil structure and composition through, for instance, the biodegradation and incorporation of dead plant and animal remains. Clearly. the loss of micro-organisms can lead to major changes in ecosystems.

Biologists are currently studying both species-rich groups (such as insects) and species-rich areas (such as moist tropical forests) in order to provide a more reliable picture of species richness patterns and a basis for estimating the number of species on Earth.

A different approach to measuring biodiversity incorporates the relative abundance of different species within a given region. A region containing many

Figure 1 Biological diversity is made up of all species of plants and animals, their genetic material, and the ecosystems of which they are part.

Carl Roessler/Bruce Coleman Limited

Tropical rain forests are one of the world's richest ecosystems, containing at least half of all plant and animal species.

different plant and animal species has a greater diversity of species than a region in which a few types of species predominate. An island with two species of birds and one species of lizard, for instance, has greater diversity than an island with three species of birds and no lizards.

Ecosystem diversity

The enormous range of terrestrial and aquatic environments on Earth has been classified into a number of ecosystems. Major habitat types include tropical rain forests, grasslands, wetlands, coral reefs and mangroves (see pages 18–23). Measuring changes in the extent of ecosystems is difficult, because there is no globally agreed classification of ecosystems, and boundaries are often variable and elusive. Species contained within a given ecosystem also vary over time.

Studies of ecosystem diversity are carried out on different scales: from one ecosystem to an entire region containing many different ecosystems. Regions containing a great variety of ecosystems are rich in biodiversity, but individual ecosystems containing endemic species also make a significant contribution to global biodiversity.

Some of the world's richest habitats are tropical moist forests. Although they cover only 7 percent of the world's surface, these areas contain at least 50 percent, and possibly up to 90 percent, of all plant and animal species. Isolated islands are often rich in endemic species.

Loss of biodiversity

Humans have affected the environment for many centuries through hunting, land clearance and other activities. The damage to biodiversity caused by human activities is rapidly increasing as species are over-exploited, and ecosystems destroyed for agriculture and urban development.

For instance, during 1700–1980 the global area of cropland increased more than four-fold, and the area of forests and woodlands fell by 20 percent. Yet overall figures such as these can sometimes mask other changes which also damage biodiversity. In Europe, for example, the area of grassland remained relatively static during the same period, but there was a massive conversion from low nutrient-input, species-rich grassland to high-input, intensively cultivated, species-poor pasture. Equally, although forest area in Europe is increasing, the increase is of low-diversity plantations at the expense of high-diversity native woodland.

Species and ecosystems can be harvested and managed sustainably, but human activities are destroying them at a greater rate than at any time in human history.

Genetic diversity

Genetic diversity is one of the keys to successful agriculture. For generations, the characteristics of various species of plants and domesticated animals have been used by humans, through selective breeding, to develop new strains of crops and animals that flourish in particular climates and agricultural systems, and that are resistant to local pests and diseases.

In modern farming, genetic engineering (the transfer of genes between species) is used to develop high-yield, easy-to-harvest crops. Already, an estimated US$1 billion has been added to the annual agricultural output of the United States in this way.

The genes from micro-organisms are as important as those from larger species; they can be used, for example, not only to increase agricultural production, but also to provide a wide range of pharmaceutical and industrial products (such as organic acids, vitamins, antibiotics and food preservatives).

Wild species provide much important and unique genetic material, and the wild relatives of crop plants and domestic animals will be an essential component of ensuring food security for the next century.

Most genetic resources are used in a country other than where they occur naturally, and the use of new genetic resources is increasing. Exchanges of genetic material between developing countries are particularly important in view of the economic importance of crops such as rubber, oil palm, cocoa, cassava and sugarcane. Such crops are often productive outside their native habitats, but may be susceptible to attacks from various pests and diseases in their new habitats. These problems can often be overcome by infusions of new genetic material from varieties occurring in their native regions.

Cultivated plants

Of the world's estimated 250 000 species of flowering plants, only about 3000 are used as food. Of these, about 200 species have been cultivated and about 15–20 are crops of major economic importance. The cultivation of plants for food probably began between 5000 and 10 000 years ago in the Near East, China, southern Mexico and the Andes. Crop diversity increased as crosses occurred—deliberately or accidentally—between domesticated crops and wild relatives, and as species introduced to new regions adapted to different ecological conditions.

The range of genetic diversity within crop plants and their wild relatives is a storehouse of genetic resources, which is of immense value in both traditional farming and commercial crop breeding. In traditional Mexican farming, for example, a flow of genes between cultivated and wild crops is encouraged by allowing wild relatives of maize to grow near cultivated plants, so that natural cross-fertilization occurs. The most suitable cross-breeds are then used to improve the characteristics of cultivated maize. In commercial crop breeding programmes, genetic resources

from wild species are used mainly to introduce resistance to pests and diseases into cultivated species.

The genetic diversity within traditional crop species that has developed over many thousands of years is now under threat, because modern, intensive forms of agriculture—which produce much of the world's food supply—are based on genetically uniform crops. In Greece, for instance, the introduction of high-yield varieties of wheat has led to the loss of 95 percent of native wheat varieties over the past 40 years.

Genetic uniformity in crops is the cause of many crop failures, as uniform crops are more susceptible to many diseases. In Indonesia, during the period 1974–77, more than 3 million tonnes of rice were destroyed by the grassy stunt virus, and in 1984, bacterial disease in Florida led to the destruction of 18 million citrus trees in 135 nurseries.

Genetic diversity within edible plant species is being eroded by the destruction of the habitats of wild plant species. For instance, more than half the world's wild species of cassava are found only in South and Central America. Their numbers are declining because their habitats are being converted to pasture land and the cassava plants, which are poisonous to grazing animals, are being eradicated. Many wild potato and tomato species are threatened or have already become extinct.

Extent of genetic uniformity in crops

crop	*country*	*number of varieties*
rice varieties	Sri Lanka	From 2000 varieties in 1959 to 5 major varieties in widespread cultivation today. Seventy-five percent of descended from one maternal plant
rice	India	From 30 000 varieties to 75 percent of production from less than 10 varieties
rice	Indonesia	74 percent of varieties descended from one maternal plant
potato	United States	75 percent of crop in 4 varieties
cotton	United States	50 percent of crop in 3 varieties
soya beans	United States	50 percent of crop in 6 varieties
wheat	United States	50 percent of crop in 9 varieties

Table 1 Crops such as rice, potatoes, cotton, soya beans and wheat are becoming less genetically diverse in many countries. Genetic uniformity in such crops can lead to decreased resilience to diseases and other stresses.

Domesticated animals

The domestication of wild animals began in western Asia and the Near East about 12 000 years ago. Cattle, dogs, goats, pigs and sheep were the first domestic animals and, before about 1600 BC, camels, cats, donkeys, horses, llamas, reindeer, water buffalo and yak had been domesticated in various parts of the world.

With time, many domestic breeds of animals developed—naturally, as species adapted to local conditions, and through selective breeding. Livestock farming in the developed world is now based on only a small number of specialized commercial breeds. Thus, many domesticated breeds worldwide are declining in importance and some have become rare or extinct.

A range of breeds within a species provides a wide choice of characteristics for breeders wishing to improve existing stock and develop new breeds. It is much quicker to develop livestock by importing genes from other breeds—genetic engineering—than by selecting animals with the required characteristics from within the same breed.

However, local breeds contribute essential genetic material in the crossbreeding process, and this has not always been recognized. Theoretically, any breed of livestock could be kept in any country if enough resources—such as specialized foodstuffs, veterinary care and shelter—are made available. However, attempts to improve livestock production by introducing new breeds are likely to be sustainable and economically viable only if they involve some crossbreeding with local domestic breeds that are adapted to local conditions. The results of crossbreeding compare favourably with those of genetic engineering. Genetic engineering depends on how an imported gene reacts to the set of genes within its new host, and an imported gene may not always have the same effect on its new host as on its original host; crossbreeding involves a transfer of not only one gene, but of many of its closely linked gene associates, and the results are therefore more predictable.

Many aid programmes have failed because they were based on intensive farming of imported breeds. For instance, large numbers of North American and European dairy cattle were sent to South America during the 1980s under various aid programmes. The mortality rate of the cattle was extremely high and the system unsustainable. In this case, crossbreeding with local cattle could improve survival rates without greatly reducing milk yield.

In North and South America, many breeds have been developed from the original Spanish range cattle. These were first kept for their hides, but the development of refrigerated transport made large-scale beef production possible. The range cattle were successfully crossed with British beef breeds to develop them for this new market. More recently, many countries have imported breeds to add useful genetic characteristics to local stocks. For instance, arid lands in the United States became suitable ranching areas after native cattle were crossed with zebu bulls to produce a breed suited to drought conditions.

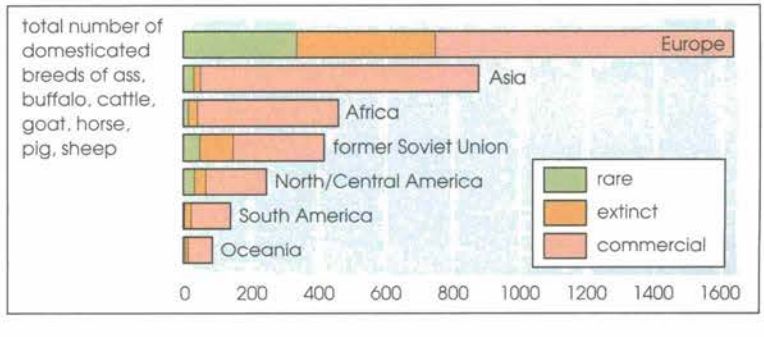


Figure 2 Many commercial breeds have been developed, particularly in Europe and Asia, but populations of less commercially successful breeds are becoming rare (at risk of extinction) or extinct.

Species diversity

Plants

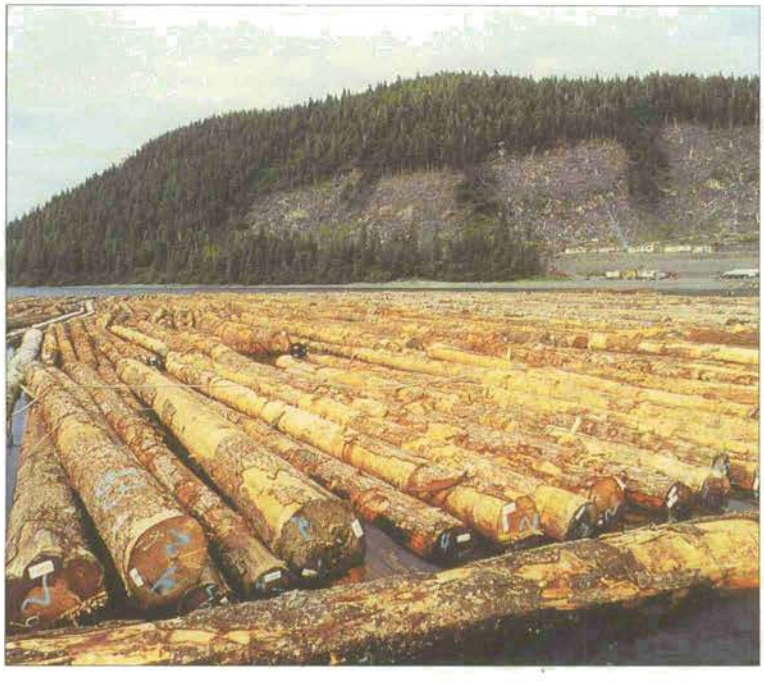
Both wild and cultivated plants supply humanity with a vast range of foods, medicines and raw materials. Although many of the most commonly used wild species are under threat from habitat loss and over-exploitation, plant biodiversity remains an underused global resource with great potential for future development.

Food

The fundamental human use of plants is as food. Crop plants have evolved over the past 5000–10 000 years, and a range of cultivated species now exists.

Originally, plants were gathered from the wild, and this still occurs today in rural areas. Forest foods are used to supplement the staple diet of rural people, and are often collected and stored for later use. These foods can be used as emergency food supplies during drought, famine and war.

Commercial timber plantations, such as this one in Alaska, consist mainly of conifers. Most hardwoods, however, are taken from natural forests that are not sustainably managed.



Greenpeace/Visser

Wild leaves, fresh or dried, are one of the most widely consumed forest foods, and are frequently boiled in stews. Seeds, nuts, roots, tubers, gum and mushrooms are also consumed, and sap is tapped for beverages.

Timber

Wood is one of the most important commodities in international trade, and total worldwide exports of wood in 1989 were worth US$6 billion. The majority of traded wood comes from temperate countries, mainly Canada, Finland, the former Soviet Union and the United States. Wood also accounts for a significant proportion of the export earnings of many developing countries, including Malaysia, Papua New Guinea and Indonesia.

Commercial timber plantations consist mainly of relatively quick-growing softwood species, but most hardwoods come from natural forests. In tropical regions, few natural forests are managed on a sustainable basis. There is little information available on levels of production and trade in individual timber species, but timber resources are under threat in many parts of the world because of inadequate forest management and over-harvesting.

Rattans

About 600 species of rattan (lianoid palms) are native to South and South-East Asia, and are the basis of major rattan industries in China, India, Indonesia, the Philippines, Sri Lanka and Thailand. Rattans are used in these countries to produce mats, baskets, fish traps, dyes and medicines and are used in the manufacture of cane furniture for export. Rattan is the second most important tropical forest product in terms of export earnings.

The centre of diversity for rattans is the Malay Peninsula, where there are 104 species, 38 of which are endemic to the region. A total of 98 of the species in Peninsula Malaysia are categorized as vulnerable or endangered. Rattans are officially, if ineffectively, protected within Malaysia's national park system, but it is not known how many of the species grow within its boundaries. The establishment of rattan cultivation in logged forest land is likely to be the most effective form of rattan genetic conservation.

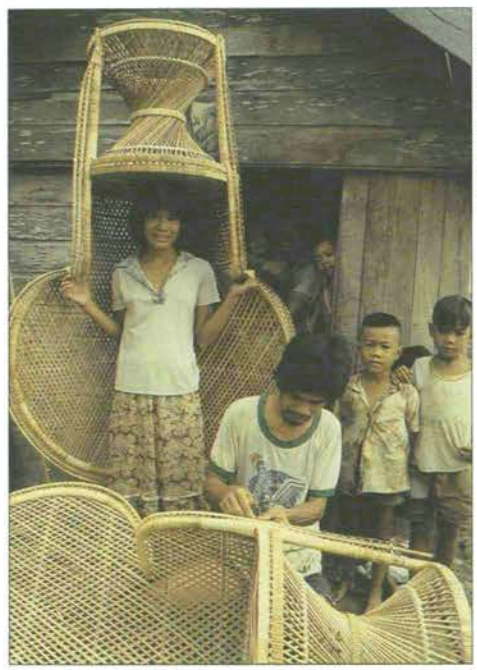
Medicinal plants

Approximately 20 000 species of plants are used as traditional medicines around the world. Only about 5000 species have been thoroughly investigated as a potential source of commercial drugs, and chemicals extracted from about 90 species are used in medicines globally. Most medicinal plants used commercially are temperate species, and the potential of tropical plants is largely unexploited.

Traditional and commercial medicinal plants are mainly collected from the wild, although cultivation of the major plants has developed over the past 20 years. Although the chemicals extracted from plants can often be synthesized artificially, the United States still imports more than US$20 million of rain forest plants for medicinal purposes because it is still expensive to synthesize the complex chemicals they contain.

Central America, Colombia, Ecuador, Mexico and Peru, the Indian subcontinent, West Asia and parts of north-eastern Africa all have important concentrations of major medicinal plants. However, over-exploitation of medicinal plants is eroding genetic resources in some of these regions. One species of plant that grows in the foothills of the Himalayas in northern India is a major source of diosgenin, used in the manufacture of contraceptive pills. The species has been so over-collected in the wild that it is now subject to international trade controls to reduce the decline in its numbers. Another Indian species, a forest shrub known as serpentine root, has been used as a traditional medicine for more than 4000 years to treat snakebite, dysentery, cholera and fever. An extract from the plant has been used as one of the principal substances in commercial tranquillizers for the past 50 years, and the species is under threat in the wild.

In many parts of the tropical world, wild species of medicinal plants are at risk because the production of traditional medicines is becoming highly commercialized and medicinal plant



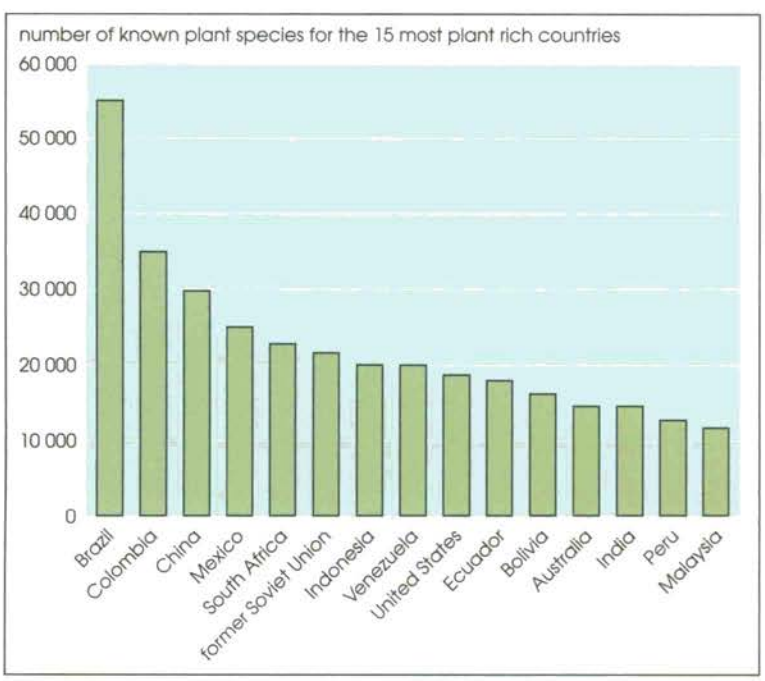
Ron Giling/Panos Pictures

Consumer demand for rattan furniture creates high export earnings for countries such as China, India and the Philippines.

extracts are increasingly used by modern drug manufacturers. Medicinal plants from Thailand are used by more than 1000 traditional and modern drug manufacturing companies, and most of the plants are collected from forests. Producers of herbal medicines within the country are increasingly reliant on imported raw materials as local resources are lost. The production of Indonesian herbal medicines, known as jamu, is becoming increasingly commercialized. Modern jamu industries and commercial pharmaceutical companies are using large quantities of wild species, causing their numbers to fall.

Cinchona trees, the source of the anti-malarial drug quinine, are one of the few medicinal plants to have been cultivated. Initially the world supply of quinine came from wild trees in the Andes, but concern about the possible extinction of the species led to the development of cinchona plantations in the mid-19th century, in countries including India and Indonesia.

Figure 3 shows which countries are richest in known plant species.



Ornamental plants

Ornamental plants have a history of cultivation stretching back more than 2000 years. Today, more plant species are cultivated for ornamental purposes than are commonly grown throughout the world for food. In the United Kingdom, an estimated 3000 ornamental species are widely grown in addition to an extensive range of cultivars and hybrids. In 1985, global imports of cut flowers and live plants came to US$2488 million, the main producers being The Netherlands, followed by Colombia and Denmark. Despite the economic importance of ornamental plants, the conservation of wild species is given low priority, and many wild species around the world are under threat from habitat destruction and over-exploitation.

More than 5000 species of orchid are traded internationally, and the average annual number of plants traded is nearly five million. About 80 percent of these are cultivated, but there remains a significant trade in wild plants. Thailand is the world's major exporter of orchids, and many species are collected from the wild. Some species have been collected almost to extinction, even within national parks, where orchids are protected.

There is also a huge international market in cacti: The Netherlands produces more than 18 million cacti each year and the United States produces 10–50 million. Most traded cacti are cultivated, but Mexico exports about 50 000 cacti per year, most of which are collected from the wild and belong to species that are close to extinction.

Wild animals

The value of wildlife as, for instance, a source of food, ingredients for traditional medicines, skins, furs and—in recent times—tourist revenue, provides an important economic justification for preserving biodiversity.

Food

In many developing countries, wildlife is an important source of food. People in most African countries eat bushmeat, which ranges from small bats and lizards to larger mammals, such as antelope and buffalo. In Rwanda and Zaire, game comprises about one-quarter of the animal protein consumed. In rural or traditional societies, the percentage is often higher—the Mbutu pygmies of Zaire, for example, obtain up to 60 percent of their calorific intake from animals caught through hunting, and in Nicaragua wildlife provides more than 98 percent of the meat and fish consumed by the Miskito Indians.

As well as providing a source of protein, wild meat is traded in local markets and provides a valuable source of income. There is also an extensive international trade in game, involving an average of at least 32 000 tonnes of meat from game animals per year. The main game-exporting countries are Argentina, the United Kingdom and several Eastern European countries.

Molluscs and insects are also a nutritious food source: the giant African land snail, which is popular in West Africa, has a protein value nearly equivalent to beef. About 500 species of insect are commonly consumed worldwide. Termites are easy to collect because they are found together in large numbers, and are popular food items in Africa, Asia and South America. Locusts, which are consumed throughout tropical South America and South-East Asia, occur in large swarms and can easily be gathered by the sackful, dried for storage and eaten in times of food shortage. The larvae of butterflies, moths and beetles are an important source of nutrients in much of Australia, Central Africa, Central America and South-East Asia.

Global fish production exceeds that of cattle or sheep, and is the largest single source of animal protein for the world's population. Fish and shellfish catches have increased more than fourfold in the past 40 years due to improved technology, and the global marine and freshwater catch totalled 99.5 million tonnes in 1989. More than 90 percent of the catch is fish and the rest comprises molluscs and crustacea.

Although there are about 13 000 known species of marine fish, the marine fisheries industry is based on a remarkably small

Table 2 Nutritionally, insects compare well with other animal products.

Nutritional value of selected animal species

	protein (%)	*fat (%)*	*carbohydrate (%)*	*minerals (%)*	*calories (/100g)*
beef	17.4–19.4	15.8–25.1	0	0.8–0.9	225–301
lamb	15.4–16.8	19.4–27.1	0	1.2–1.3	247–310
chicken	20.6–23.4	1.9–4.7	0	1.0	117–130
halibut	20.9	1.2	0	1.4	100
milk	3.5	3.7	4.9	0.7	66
eggs	12.9	11.5	0.9	1.0	163
termite	23.2	28.3	n/k	n/k	347
grasshoppers	15.3–46.1	2.4–9.6	6.8–7.5	0.8–5.0	n/k
butterflies/moths	23.1	14.2	n/k	1.5	207
ants/wasps/bees	18.2	2.4	0.8	2.2	n/k

World trade in live reptiles and primates (1989)

	live reptiles		*live primates*	
	imports	*exports*	*imports*	*exports*
Asia	32 911	5729	4815	26 918
former USSR	0	52 121	1630	0
Europe	131 561	224	14 626	3
North/ Central America	272 038	128 416	26 914	1515
South America	120	57 427	110	3501
Oceania	272	3142	2	272
Africa	1813	140 157	17	9613
other	160	91	135	427
total	438 875	387 307	48 249	42 249

Table 3 The trade in live primates and reptiles is regulated, but markets still exist for a variety of uses, such as ornaments, medicines, pets and animals for the biomedical trade.

number of species. Only 12 species contributed more than 1 percent (1 million tonnes) to total world landings and together these species made up nearly 35 percent of the world catch. The most important species groups are herrings, sardines and anchovies, followed by cod, hakes and haddock.

Marine fishery resources throughout the world are now close to their maximum catch limits, and there is little scope for increasing catches of any of the traditionally-fished marine species. In fact, fish stocks need to be conserved and exploited on a sustainable basis if fish populations are to recover.

Inland fisheries (aquaculture and capture fisheries) increased their production by 32 percent between 1984 and 1988, and contributed 13.8 percent to the global fish catch in 1989. Asia is the main producer of inland fish, most of which are from fish farms. Africa and the former USSR also produced significant quantities of freshwater fish, mainly caught in the wild. Aquaculture is expanding rapidly, particularly in Oceania and Africa, whereas inland fisheries have recently remained stable or declined, particularly in industrialized countries.

Non-food uses

Many industries are based on wildlife and wildlife products but, while some industries are threatening the existence of the species on which they depend, others—such as wildlife tourism—are encouraging the conservation of wild species.

Wildlife products are valued as ornaments and decorations: elephant ivory, tortoiseshell (from the hawksbill turtle), and skins from leopards and other cat species have been traded for many years, but are now regulated by the Convention on International Trade in Endangered Species of Wild Fauna (CITES). Reptile skins, principally from crocodiles, lizards and snakes, are also valuable trade items.

Furs now come mainly from farmed animals. The exceptions are cat species, which are not farmed; all cat furs come from wild animals. In the early 1980s, Latin America was the main source of cat skins, taken from animals such as the ocelot. Trade declined sharply as a result of EC import restrictions in 1985 and the inclusion of many cat species on the CITES list in 1989. China is now the single largest source of cat skins; almost all are from one species—the leopard cat. North American countries are also major fur exporters—mainly the skins of lynx and bobcat. Exports of most skins have declined since the early 1980s because of a fall in demand for furs as fashion items.

In 1989 the main countries continuing to import cat skins were Japan (52 256 skins), Italy (10 290) and Spain (5916).

Animal products are also widely used in traditional medicines in Africa, South America and Asia. The international trade in oriental traditional medicines has expanded significantly in recent years, particularly within Asia, and has become extremely lucrative. International trade in deer antlers, tendons and musk is worth an estimated US$30 million per year. Many rare species are hunted for the market in oriental remedies: the trade in musk (from musk deer), bears' gall bladders, tiger bones and rhino horn has been responsible for a decline in populations of these animals, and has threatened some species with extinction.

The trade in live animals and birds for pets, and to keep in zoos and circuses, is a multi-million dollar business. For instance, the sale of wild and captive-bred parrots in the United States alone generates an estimated US$300 million a year, and exports of parrots earned neotropical countries approximately US$1.6 billion between 1982 and 1986. Reptiles are also in great demand as pets, and more than half a million were traded in 1989, mostly from Africa and Latin America to Europe and the United States.

Live animals, particularly primates, are also used widely as experimental animals in biomedical research. In 1989, about 42 000 animals were traded; the main importers are Europe and the United States, and the main exporters are Indonesia and the Philippines. Most of the exports are of one species only—the cynomologus macaque. Chimpanzees are also widely used in medical research. International trade in chimpanzees is now banned but, because of the high market value of infants (about US$25 000 each), chimpanzees are illegally captured from the wild, and wild populations are declining. Primates are now being bred in captivity for biomedical research in order to reduce the threat to wild species.

Wildlife is also important for the income it generates through recreation and tourism. Sport hunting of animals and birds is often controlled by governments, as it is in the United States, and the selling of hunting licences and permits can generate substantial revenues. Tourists are also willing to pay to observe wild animals in their natural habitat and this is an important source of revenue in a number of developing countries. Visitors pay almost US$200 each to spend one hour observing wild mountain gorilla groups in Rwanda, and this generates nearly US$1 million per year for the park in which the gorillas live.

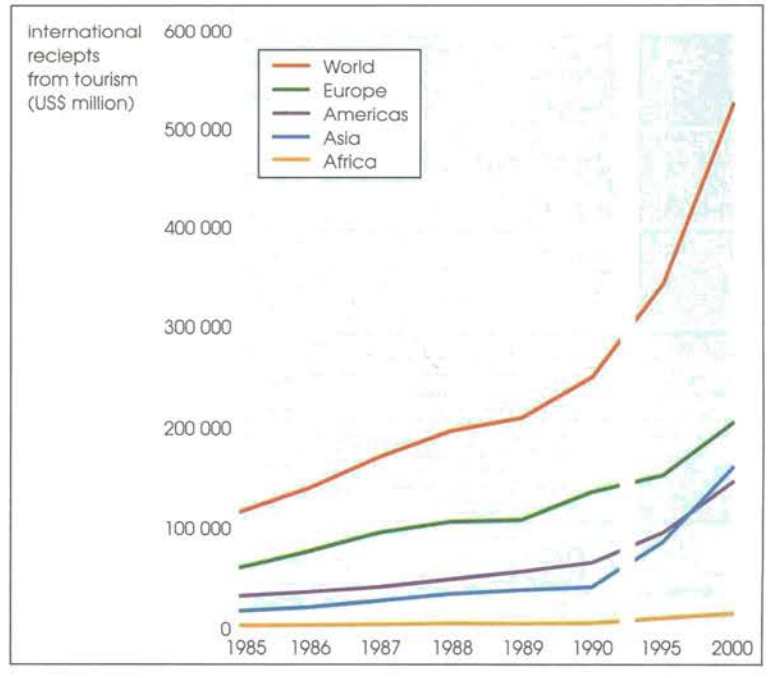


Figure 4 Wildlife tourism is a valuable means of encouraging the conservation of wild animals, and provides much-needed funds to developing countries—even Africa currently earns more than US$5000 a year from wildlife tourism.

Ecosystem diversity

Tropical rain forests

Tropical rain forests are found in equatorial Africa, Central America, South America (which contains more than half the world's tropical forests), and South and South-East Asia. Human occupation of tropical rain forests began in South-East Asia and the Pacific 25 000–40 000 years ago, in the Amazon 10 000 years ago and about 3000 years ago in Africa. The forests now provide millions of people with shelter, food, clothing, fuel, medicines, building materials and many other resources. Countless other people reap the economic and environmental benefits of rain forests without living near them.

Timber is the most economically valuable resource of the forest, although other products such as nuts, fruits, rattans, medicinal plants and rubber also provide economic returns. South-East Asia has successfully exported non-timber forest products including rattans, resins and gums for many years and Latin America's main non-timber forest exports are rubber and brazil nuts. Rain forests also regulate water flow, influencing the local climate and protecting the land against soil erosion.

Rain forests are extremely rich in species. Studies on 10 particularly species-rich areas of tropical forest around the world, covering 292 000 km^2 (0.2 percent of the Earth's land surface), revealed that these areas contained 34 400 endemic plant species—27 percent of all tropical forest plant species and 13 percent of all plant species worldwide. Tropical forests also contain high concentrations of other endemic animal species.

Historically, the effect of humanity on tropical forests has been relatively limited. The real damage started when people began to migrate—from China to South-East Asia, and from Europe to Africa and South America—and to introduce new crops and agricultural methods. After the 17th century, forests were cleared to make way for cash crops—rubber in Indonesia and Malaysia, coffee in Brazil, tea in India and China, sugar in the Caribbean, and tobacco and palm oil in Asia.

Most destruction has taken place within the past 50 years—to provide land for agriculture, and hard currency and vital export earnings from the sale of timber and minerals. Land has also been cleared to build dams, roads and cities to meet the needs of a growing population.

One of the main sources of degradation of the rain forests is the timber trade. Logging has a direct impact on the forests, and indirect damage is caused by timber companies opening up large areas of forest to invasion by settlers and shifting cultivators. In certain regions, poverty,

Tim Whitmore/ICCE

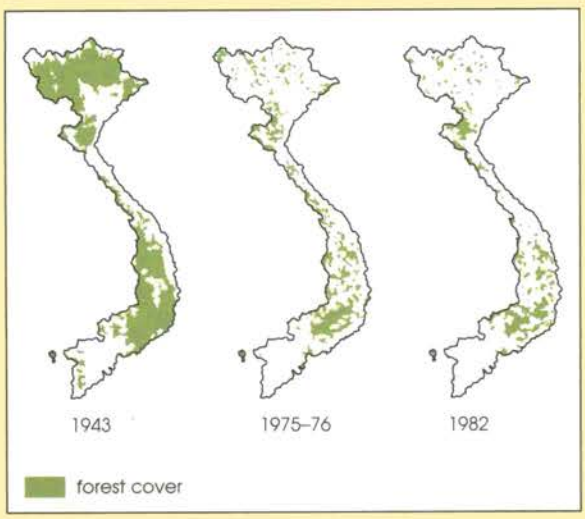
Both direct and indirect damage is caused to tropical rain forests by mining and oil companies; pollution is prevalent and indigenous peoples are often displaced.

population growth and unequal land ownership encourage peasants to move out of highly-populated areas into less developed, usually forested, areas. In some cases, notably Brazil and Central America, tax incentives are offered for people to clear forest for cattle ranches.

Mining and oil companies also leave destruction in their wake. Pollution is a major cause of concern, and the roads built by oil and mining companies attract settlers to the forests, displacing indigenous peoples. Dam construction has also led to forests being destroyed by flooding.

It is difficult to ascertain exactly how extensive tropical forests are, or how quickly they are being destroyed. However, it is clear that the rate of deforestation has increased during the past 10 years in all regions, and FAO has estimated that the loss is greatest in Central America, South-East Asia and West Africa. Improvements in satellite imagery and its interpretation based on ground surveys are helping to increase the accuracy of assessments of forest area and forest loss.

Deforestation in Viet Nam



A 1987 FAO report estimated that forests in Viet Nam covered 61 650 km^2 in 1980 and 48 620 km^2 in 1985. The projection for 1990 was 34 060 km^2.

The population of Viet Nam moved south during historical times, clearing and cultivating the forests of the coastal plains and valleys until reaching the Mekong Delta several hundred years ago. By 1943, 55 percent of Viet Nam's forests had been cleared and, during the French colonial administration, further areas in the south were cleared for commercial plantations of bananas, coffee and rubber.

The uninterrupted warfare in Viet Nam between 1945 and 1975 destroyed 23 000–55 000 km^2 of forests. Deforestation continued after the war: wood was needed for rebuilding and land was cleared to feed the population—which doubled between 1945 and 1985.

Grasslands

Grasslands are areas dominated by grass and grass-like species with fewer than 10–15 trees per hectare, subject to periodic drought. They are known by different names in different parts of the world: savannas in Africa, rangelands in Australia, steppes in Eurasia, prairies in North America, and llanos, cerrados or pampas in South America.

Grasslands can be natural, semi-natural or cultivated. Natural grasslands are unsown, and man has not significantly affected the balance between plant species, or between plants and animals. Cultivated grassland is entirely sown by man and intensively managed, such as the short-term rye-grass ley of Western Europe. This type of grassland plays no part in the maintenance of biodiversity. Between these two extremes are a range of semi-natural grasslands which, although unsown, are highly modified by the grazing of domestic livestock. They are important to biodiversity because a large proportion of the world's grassland species are able to use them and many are, in fact, dependent on them.

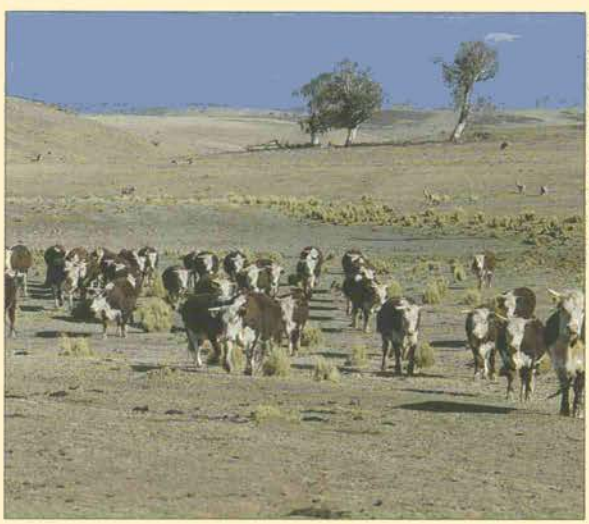
The level of diversity of flora in many natural and semi-natural grasslands may reach that of tropical forests. However, animal species richness is low: less than 5 percent of the world's bird species and 6 percent of mammal species is adapted to or dependent on grasslands.

Grasslands covered about 40 percent of the world's surface before the impact of human activity. Today they cover only about 16–24 percent, and their demise continues as they are overgrazed by domestic animals and converted to arable uses.

Grassland loss in Australia

Before Europeans settled in the state of Victoria, Australia, 40 percent of the region was grassland. Today, little remains. That which does is one of the most threatened ecosystems in the state. At least 31 percent of Victoria's endangered plant species are confined to grassland, and 8 plant species and 26 vertebrate species have already become extinct. Forty percent of threatened or extinct species of vertebrates are also associated with the grasslands.

Habitat loss has occurred because of agricultural development by early settlers. The rich soils of Victoria were ploughed, re-seeded and overstocked with sheep and cattle, with disastrous effects on the native flora and fauna. The loss of grasslands is so great that only 0.3 percent of the original area was incorporated in the major national parks established in the 1970s.



Penny Tweedie/Panos Pictures

Luiz Claudio Marigo/Bruce Coleman Limited

The world's wetlands are an important habitat for wildlife and protect coastal regions from flooding and erosion.

Wetlands

The term 'wetlands' covers a variety of both natural and man-made habitats—mainly permanent and temporary areas of marsh, fen, peat and water. They include estuaries, open coasts, floodplains, marshes, lakes, peatlands and swamps. The area covered by wetlands changes according to season and over longer periods of time, and wetland boundaries are often difficult to define.

Canada has more than 1.2 million km^2 of wetlands—nearly one-quarter of the world's total wetland area. The United States, which has probably lost about half of its original wetlands, has about 1.1 million km^2. Other major wetland sites are in central Africa, Asia (notably China and Indonesia), South America and the former Soviet Union.

Wetland areas provide flood control, water purification, shoreline stabilization and coastal erosion control. They also support vast numbers of fish and other wildlife and many people depend on them for their livelihood.

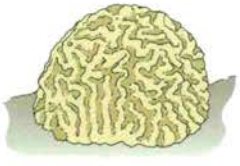
Wetlands are threatened by human activities, including: land drainage for agriculture and forestry; land reclamation for urban, industrial and tourist development; interruption or diversion of the wetlands' water supply through the construction of dams, irrigation systems and sea defences; and the discharge of pesticides, sewage and other pollutants. Wood cutting and over-use of land far from wetland areas cause soil erosion and increased sediment levels in rivers that can affect wetland areas downstream. Wetland species can be depleted through hunting, fishing, woodcutting and grazing by domestic animals.

The extent of the threat posed by each activity varies regionally. In Latin America and the Caribbean, for instance, the major threats to wetlands are pollution, hunting and drainage for agriculture and ranching; in East Asia the major threat is land reclamation for human settlement and industrial development; and in South-East Asia threats to wetland ecosystems include hunting, human settlement, commercial forestry and domestic wood cutting.

At least 50 percent of the wetlands in Asia are moderately or severely threatened, and this figure rises to 86 percent in Malaysia and 82 percent in Bangladesh. Few natural wetlands are left in Europe. By 1980, 60 percent of the wetlands in the United Kingdom and The Netherlands had been drained, and only 58 of the 318 remaining European wetlands are not under threat. Many countries are now taking steps to conserve their wetland areas (see page 34).

Coral reefs

Soft coral
(Sarcophyton)



Stony coral
(Diploria)

Coral reefs are one of the world's most diverse natural ecosystems—the marine equivalent of the rain forests. Globally, there are about 600 000 km^2 of coral reefs; more than half are in the Indian Ocean (including the Red Sea and the Gulf), and the rest are fairly evenly distributed between the Caribbean, the South Pacific (including Australia) and the North Pacific.

Reefs grow in shallow tropical and equatorial waters and provide a wide variety of food and habitats for a great number of species—some of which are found only in these ecosystems. The Great Barrier Reef in Australia is about 3000 km long and is one of the world's most diverse coral reefs: it contains 500 species of coral and supports about 2000 species of fish. Even the tiny coral reefs in Kuwait, which cover no more than 4 km^2, contained 23 coral species and 85 species of fish in 1989.

Most coral areas are important to the local economy: they provide fish, lobsters, prawns, molluscs, squid and turtles for local industries and export markets. In some regions coral itself is mined as a source of limestone and coral rock is used as a building material. Fringing reefs grow close to the shore and protect the coastline from erosion and encourage the formation of sandy beaches and sheltered bays that can be used as harbours.

The reefs within Monroe County, Florida, generate as much as US$50 million a year from fishing, diving, and education and research activities. Many other countries including Bermuda, numerous Caribbean islands, Israel, Malaysia and the Seychelles are developing the economic potential of their coral reefs, particularly through tourism.

Corals can be damaged by storms, changes in sea temperature, disease and predators. They are also sensitive to pollution, sedimentation (often caused by land clearance and increased soil erosion) and intensive recreational use or coral mining. Corals in the Arabian Gulf, for instance, are at risk from sewage and from oil and chemical pollution from urban and industrial coastal development from countries including Saudi Arabia. In other countries including Costa Rica, the Maldives and Sri Lanka the main threat to corals is from over-exploitation of the reefs' resources through fishing, coral mining and tourism.

Coral reefs support a great variety of species and are the basis for fishing and tourist industries in many countries.

Carl Roessler/Bruce Coleman Limited

Mangroves

Mangroves grow along low-lying tropical and subtropical coasts and provide a habitat for many plant and animal species. The largest areas of mangroves are found in Indonesia (where they cover more than 4 million hectares), Africa, Australia, the Caribbean, Central and South America, and Asia (including India and Bangladesh). Mangroves range from dense forests in parts of South America, where the trees grow to a height of 40–50 m, to clumps of shrubs less than 1 m high.

Mangrove areas provide resources for local people, ranging from wood for building and fuel to fodder for domestic animals. International companies harvest the trees on a large scale—mostly for the pulp and particle board industry.

Mangroves are also a breeding ground and habitat for many fish and shellfish that contribute to the diet and income of local people. In Asia, for example, mangroves support an average of 283 species of fish, 229 species of crustaceans and 211 species of molluscs. In Costa Rica, the five million shellfish harvested each year are worth US$85 000 to the local economy. Shrimp and prawn fisheries based in mangrove areas are major sources of export earnings in many tropical countries. Mangroves are essential spawning and nursery areas for many species of marine fish. In the Gulf of Mexico, 90 percent of the fish harvest (worth an annual US$70 million) are species that are dependent on mangroves and coastal wetlands.

Mangroves in some regions are being developed for tourism, education and research. In Trinidad, for example, thousands of tourists every year visit the Caroni Swamp mangrove area to view its large populations of rare birds.

Because mangroves grow along shorelines and on tidal mud flats the trees protect the coast and reduce coastal erosion. They also act as windbreaks and reduce the force of coastal storms.

Vast areas of mangroves have been destroyed, particularly during the past decade. This pattern is continuing in many regions, where mangroves are being deliberately cleared and destroyed by changes in their environment.

Rising populations are increasing the demand for fuelwood and putting increasing pressure on mangroves areas. Commercial tree felling has reached unsustainable levels in some mangrove areas, and the cleared land is unable to regenerate naturally.

Mangrove land is often cleared for agriculture and urban, industrial and tourist development. These developments alter drainage patterns, and affect the quality and quantity of the freshwater supply to any remaining mangroves.

Perhaps the greatest threat to mangroves in Asia is the development of aquaculture. In the Indo-Pacific area, more than one million hectares of mangrove forest have been converted to aquaculture ponds. The ponds cause changes in drainage patterns, nutrient availability and the frequency of tidal inundation, and adversely affect mangrove flora and fauna.

River damming and diversion, which are often carried out in arid and semi-arid regions, reduce the supply of freshwater to mangroves, and more salt-tolerant species gradually replace them. Fish and other animals that depend on the mangroves are also reduced in number.

Red mangrove seedling (Rhizophora mangle) *ready to drop into the water having germinated on the tree.*

Mangrove oysters clinging to mangrove roots.

The loss of biodiversity

The biological resources of genes, species and ecosystems are essentially renewable resources—managed effectively, they can create the basis for sustainable development. However, biodiversity has been eroded faster over the past century than at any time since dinosaurs died out 65 million years ago.

Habitat loss, hunting, over-harvesting and the introduction of non-native species have caused the extinction of many plant and animal species, and many more are threatened with extinction as a result of these factors. The greatest current threat is the human destruction of habitats taking place worldwide. In many countries, little natural vegetation remains. In Bangladesh, a mere 6 percent of original vegetation is left. In the United Kingdom and The Netherlands, all but 4 percent of lowland raised bogs have been damaged.

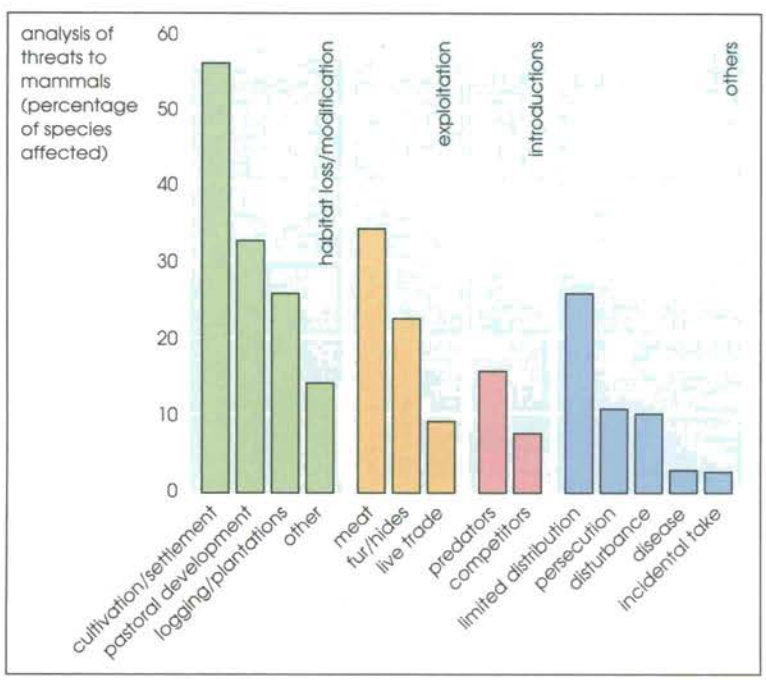


Figure 5 The major threat to mammals is habitat loss and modification, affecting 76 percent of threatened species. This is mostly due to cultivation and settlement.

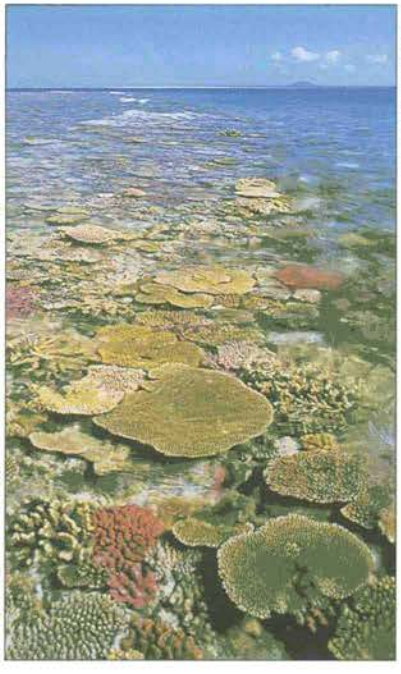
An estimated 17 million hectares of tropical moist forests—an area four times the size of Switzerland—are being cleared annually, and it is estimated that approximately 5–10 percent of tropical forest species may become extinct within the next 30 years. An area of temperate rain forest the size of Malaysia has already been lost, and 1.6 million hectares of temperate forest were cleared between 1977 and 1987 in the United States alone.

This loss of species and ecosystem diversity erodes genetic diversity. For example, worldwide, some 492 genetically distinct populations of tree species are at risk of extinction.

It is not only wildlife that is threatened. Because intensive agriculture is reliant on genetically-uniform crops developed through genetic research, local crop breeds are rapidly disappearing. Major crop plants such as maize and rice have only a fraction of the genetic diversity they held a few decades ago. In Indonesia, 1500 local rice varieties have become extinct in the past 15 years. A similar pattern is evident for domestic animal species: globally, 474 breeds of domestic animals can be regarded as rare, and a total of 617 domestic breeds have become extinct since 1892.

Action can be taken to counteract these threats to global biodiversity. An economic valuation of biodiversity provides one way of taking practical decisions on where conservation action is most needed (see page 28), and a variety of conservation techniques have been developed both *in situ* and *ex situ* (see page 30).

Threatened species



S. Utsuka/UNEP-Select

David Lawson/WWF UK

P. Morris/Ardea London Ltd

A threatened species is one thought to be at significant risk of extinction in the near future. Defining the level of risk and predicting exactly when extinction may occur is difficult. The World Conservation Union (IUCN) publishes a Red List of Threatened Animals. This is the only accepted worldwide attempt to list threatened animal species individually. The animals Red List has been compiled every two years since 1986 by the World Conservation Monitoring Centre, together with the IUCN Species Survival Commission network of Specialist Groups. The latest report was published in 1990 and work is under way for the next edition. The International Council for Bird Preservation (ICBP) lists threatened bird species.

Each species in the animal Red List is assigned a threat category by reviewing different factors affecting it. The main threat categories currently used are: extinct (species not definitely located in the wild during the past 50 years); endangered (in danger of extinction if threats are not removed); vulnerable (likely to move into the endangered category if threats are not removed); and rare (neither endangered nor vulnerable, but considered at risk).

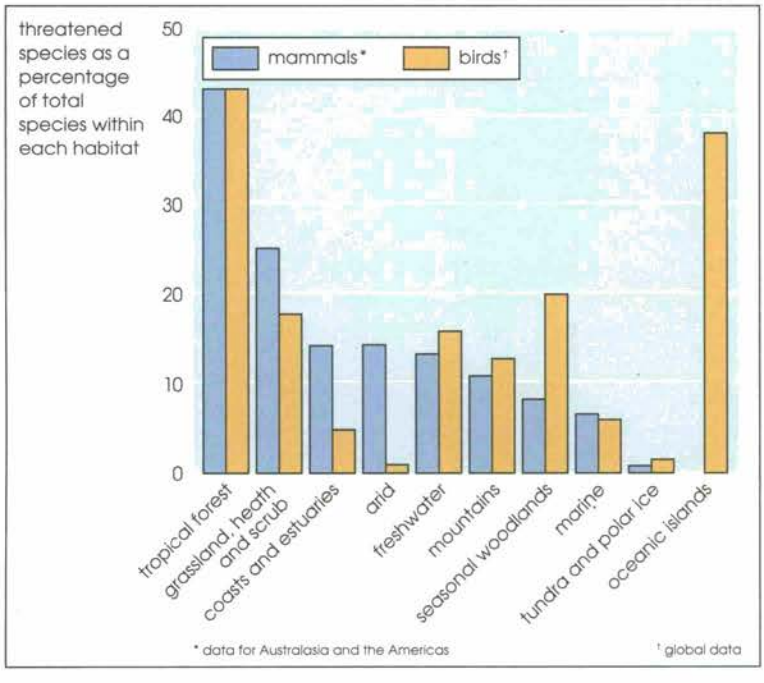
Humanity is mainly responsible for the demise of plant and animal species. Habitat loss or modification; over-exploitation for commercial or subsistence reasons; accidental or deliberate introduction of exotic species; disturbance, persecution and uprooting; and disease: all threaten the survival of species. In many cases more than one of these factors affects individual species at the same time. This often makes it difficult to identify with certainty the main cause of decline. Figure 5 (see page 24) gives a breakdown of the threats to mammals.

There are about 1029 threatened bird species, 507 threatened mammals and 1800 threatened freshwater fish species worldwide. The photographs above show a coral reef, a snow leopard and a Sacramento sucker.

There are 4452 threatened animal species listed in the 1990 edition of the IUCN Red List. The two classes with the greatest number of threatened species are birds (1029) and insects (1083). Other listings include mammals (507), reptiles (169), amphibians (57), fish (713), molluscs (409), corals and sponges (154), annelid worms (139) and crustaceans (126).

Most threatened mammal species live in tropical countries: the highest numbers were recorded in Brazil (40), China (40), Indonesia (49) and Madagascar (53). Other countries with high numbers of species at risk include Australia, India, Mexico, Tanzania, the United States and Zaire, as well as most South American and South-East Asian countries. This is probably because species richness is higher in these areas than in temperate areas. The high rate of human population increase in tropical countries also plays a role.

Figure 6 Threatened mammals and birds live in mainly tropical and subtropical regions. Temperate and polar regions have relatively few numbers of threatened mammals and birds.



Threatened mammals live largely in lowland tropical rain forests (37 percent) and montane tropical rain forests (19 percent). In America and Australia, 43 percent of all threatened mammal species live in these habitats. Other tropical and subtropical habitats—dry savanna, humid savanna, desert and semi-desert—also have large numbers of threatened mammals. Conversely, temperate and polar habitats have relatively few threatened mammals. There are about twice as many threatened bird species as mammals (1029 versus 507), and these show a similar distributional pattern. Figure 7 shows the habitat distribution of threatened mammals and birds.

Mammals and birds are obviously not the only animals under threat of extinction. At least 20 percent (1800) of the world's freshwater fish species are known to be seriously threatened or already extinct. Some of the reasons for this are habitat modification (competition for water, drainage, pollution), introduced species and commercial exploitation.

The numbers of known threatened plants worldwide is also of great concern: Asia has 6608 threatened plants; Europe, excluding Germany, has 2677; North and Central America have 5747; South America has 2061; Oceania has 2673; and Africa has 3308. The true figures may, in fact, be higher than these.

One in three threatened plant species is endemic to oceanic islands; in Bermuda, for example, all but one of the endemic species are threatened, three are extinct and four are endangered. Damage to most island flora began during the era of European colonization, when grazing animals and non-native plants were introduced.

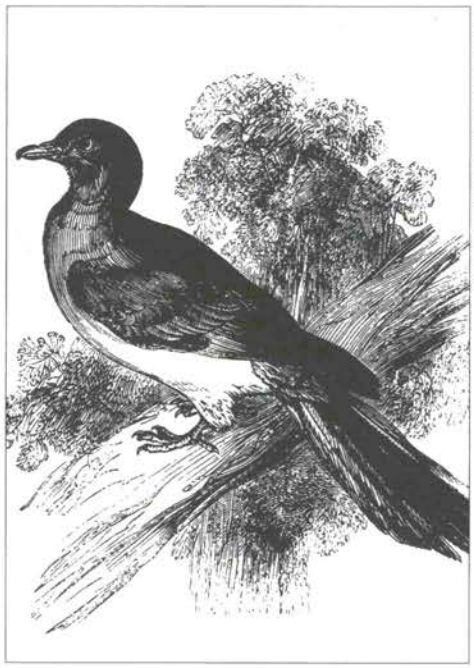
Species extinction

The study of the fossil record suggests that all species have a finite life span, and that species extinction is a process that occurs naturally, without human influence. However, the rate of species extinction has increased and continues to increase rapidly, as a direct result of human actions, particularly as more and more habitats are altered or destroyed.

It is difficult to quantify precisely how many species have become extinct to date. Many species may become extinct even before they have ever been documented and described. Known animal and plant species are considered extinct when they have not been sighted for several decades.

Species extinction appears to be most prevalent on islands (either real islands or 'ecological islands', that is, areas of habitat that are separated from similar areas by inhospitable environments). Seventy-five percent of animal extinctions recorded since 1600 have been in these areas, because island species consist effectively of single populations, more likely to be wiped out as a result of adverse factors. Conversely, continental species occupy larger areas and consist of a number of sometimes isolated sub-populations. The species will therefore survive even if a number of these sub-populations are destroyed. The same applies to aquatic species. Species in isolated inland waters behave in a similar way to terrestrial species on islands, thus explaining the much higher extinction rate for continental freshwater species. Plant species on islands are equally at risk: 108 endemic plant species of Hawaii are already known to have become extinct, for example.

Several factors have contributed to the extinction of animal species. Direct habitat alteration by humans is a major cause, as is the introduction of non-native animals (see



John Burton/Bruce Coleman Limited

That the passenger pigeon of eastern North America (left) became extinct is testimony to the scale of human destruction. A single flock in 1806 consisted of more than 2 billion individuals; by 1914 the last of the species—Martha, born in captivity—had died.

Figure 7)—predators such as cats, rats, mongooses, snails and monkeys, and other animals such as goats, rabbits and pigs. Species extinction also occurs as a result of hunting for food, skin, sport, live trade or feathers, or because of the direct extermination of species that are considered pests. Other causes include introduced disease and natural causes.

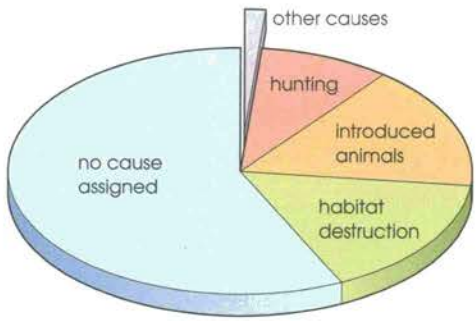


Figure 7 Major causes of animal extinction include direct habitat destruction by humans and introduced animals.

Putting a value on biodiversity

Assessments of the value of biodiversity are often based on the value of products derived from genetic variation. Agricultural crops are some of the few species for which the benefit of genetic diversity can be given a precise commercial value. For example, genetically improved pearl millet in India is worth an annual US$200 million.

The genes of wild relatives of crops can also make a significant contribution to productivity. For instance, genes from Ethiopian wild barley were used to protect California's US$160 million per year barley crop from yellow dwarf virus, and genes from a wild bean variety from Mexico were used to confer resistance to the Mexican bean weevil on bean varieties grown in Africa (where the weevil destroys up to 25 percent of stored beans) and in South America.

An indication of the value of genetic diversity is the amount spent by the top 25 crop breeding firms on research and development: US$330 million in 1988. In 1984, expenditure on cereal research in the United States came to US$100 million. Yet this was money well spent—it generated returns of an estimated US$190 million .

The preservation of crop diversity can be viewed as a form of natural insurance against future events, such as climate variation, that may devastate today's genetically uniform crops. To assess the economic viability of preserving crop species, the costs can be compared with spending on conventional crop insurance. During the 1980s, the US government subsidized crop insurance policies to the tune of US$3.8 billion, and insurance companies paid out nearly US$7 billion to cover farmers' losses.

The financial value of plants and their derivatives to the pharmaceutical industry can also be quantified. A little more than a quarter of all drugs used in the United States are plant-based, and the total retail value of such drugs in 1980 was about US$8 billion. A mere 40 species are the source of these drugs, which means that each species generates about US$200 million a year for the pharmaceutical industry. Worldwide figures are probably three times those of the US market.

The loss of biodiversity has been taking place since humans first learned to harvest natural resources and to manage the land to increase its productivity. In the face of present-day species loss, it is important to ascertain whether the conversion of natural resources to alternative uses is more, or less, beneficial to mankind than the preservation of biodiversity. One method of assessing this is to put a financial value on various biological resources, and to compare these values with the financial benefits that will accrue from their destruction.

... it is important to ascertain whether the conversion of natural resources to alternative uses is more, or less, beneficial to mankind than the preservation of biodiversity.

In an attempt to put a value on biodiversity, a distinction is usually made between biological resources and biodiversity. Two different types of evaluation are therefore required: an assessment of the value of biological resources within a given area, and an estimate of the impact of changes in biodiversity in economic terms.

The value of biological resources

Biological resources that are used directly to generate income, such as trees used in commercial logging, and animals and plants used in agriculture, are easiest to value. Biological resources and processes that make an indirect contribution to the welfare of society—such as the absorption

of atmospheric CO_2 by forests—are more difficult to evaluate in financial terms. The indirect value of biological resources is often neither recognised nor taken into account in development decisions.

Biological resources may also have a value over and above their direct and indirect uses—that is, the value of their potential future use. Humans benefit from protecting such resources because, by doing so, they guarantee access to them in the future. In addition, some resources have an economic value based on their existence alone: many people give money to conserve habitats and species they will never see, simply because they gain satisfaction from their continued survival.

Many habitats and species possess all or many of these values simultaneously. A tropical forest, for instance, is valuable directly in terms of its timber, indirectly in terms of watershed protection and air quality, its species have potential future uses as foods and medicines, and the forest has intrinsic value to many people who will never visit it but provide financial support in order to conserve it. All benefits are taken into account when quantifying the total economic value of environmental resources.

Multi-million dollar species

Many drugs originally based on plant extracts are now synthesized artificially, but plants still provide information on valuable natural compounds which are then used as the blueprint for new drugs. The following calculation of the pharmaceutical value of lost plant species is based on plant species being screened at random (in reality, medically screened plant species are pre-selected).

Some 5000 plant species have been investigated for medicinal properties, and about 40 are used in prescription drugs. Thus, the compounds produced by about 1 in 250 species could be developed into a successful product. At the average retail value of US$200 million a year per prescription drug, the average pharmaceutical loss for each plant species that becomes extinct is US$ 80 000. The profits from a best-selling drug can be much higher than this. In 1990, the world's top-selling drug (Zantac—an ulcer medicine) grossed about US$2.4 billion.

In addition to direct revenue, new drugs generate savings in health care and improve the quality of life. One estimate of the total annual economic benefits of plant-based drugs used in the United States is as much as US$300 billion.

Implications for policy

Conserving biodiversity

The conservation of biodiversity differs from traditional nature conservation in that it is less a defensive mechanism than a pro-active effort—seeking to meet human needs from biological resources, while ensuring the long-term sustainability of these resources. It involves not only the protection of wild species, but the protection of the genetic diversity of both cultivated and domesticated wild species and their wild relatives, in both modified and natural ecosystems.

The need for biodiversity conservation is recognized worldwide; most countries have national parks and national legislation promoting conservation. Most governments have participated in international conservation conventions, and have incorporated environmental issues into the national education system. Furthermore, non-governmental organizations actively promote public awareness of conservation issues.

The World Resources Institute (WRI), the World Conservation Union (IUCN) and the United Nations Environment Programme (UNEP), in consultation with the Food and Agriculture Organization (FAO) and the United Nations Education, Scientific and Cultural Organization (UNESCO), have developed a Global Biodiversity Strategy that deals with all aspects of biodiversity.

To conserve biological diversity requires a sustained effort, and results will not be immediate—both money and time are essential. The Convention on Biological Diversity signed at the UN Conference on Environment and Development (UNCED)

The Global Biodiversity Strategy

The World Resources Institute, the World Conservation Union and UNEP published a Global Biodiversity Strategy in 1992 that puts forward 85 proposals for action on the conservation of biodiversity. It is intended to be complementary to the UNCED Convention on Biological Diversity and is a guide to practical action that can be taken by governments and NGOs while the convention is being ratified.

The strategy recommends that:

- national and international policies are developed to encourage the sustainable use of biological resources and the protection of biodiversity, and to enable countries rich in genetic resources to benefit from developments in biotechnology;
- local communities are involved in conservation programmes and benefit from sustainably managing their local resources and providing local genetic resources for use in biotechnology;
- governments strengthen national conservation efforts by providing more funding for protected areas, and by encouraging other departments, such as forestry and fisheries, to make biodiversity conservation one of their management objectives; and
- the number of skilled personnel working on biodiversity conservation—including biologists, economists, lawyers, resource managers and taxonomists—is increased, particularly in developing countries.

To implement the objectives of the Global Biodiversity Strategy effectively, governments and international bodies will also have to address some of the issues underlying the loss of global biodiversity: world trading patterns and economic policy, debt and technology transfer, population growth, resource consumption and waste, land tenure, education, health care and poverty.

in Rio de Janeiro in June 1992 is the first international treaty on biodiversity and has gone some way to addressing the issues involved (see page 38).

Species and habitat conservation

One of the principal goals of biodiversity maintenance—*in situ* or *ex situ*—is to ensure the long-term survival of as many species as possible. Species survival is highly related to the protection of habitats, and most countries have a network of protected areas. Whereas protecting a single species will normally involve the protection of its habitat, this technique does not necessarily protect habitats which are most rich in species and, furthermore, the occurrence of a species in a protected area does not guarantee its long-term survival. This is true for both animal and plant species.

Research indicates that in countries where there have been long-standing *in-situ* programmes to conserve threatened plants, some success is possible. Additionally, small protected areas are just as, and often more, important than large sites such as national parks. In the United Kingdom, for instance, the small, private nature reserves of the county wildlife trusts are widely recognized as being more important for the protection of threatened plant species than the network of national Nature Reserves.

Biodiversity is not distributed uniformly across the globe; some habitats, especially tropical rainforests, have a greater density of species than others. A 13.7 km^2 area of La Selva forest in Costa Rica contains almost 1500 plant species, more than all those found in Great Britain's 243 500 km^2. Ecuador has more than 1300 bird species, almost twice as many as North America.

A major problem in biodiversity conservation is assessing the relative importance, in terms of diversity, of different areas, habitats and ecosystems. It is not necessarily more important to conserve an area containing many species than one containing only a few. An area of low species diversity may contain rare or unique species and therefore contribute more to the overall diversity of a given region, country or continent than a species-rich area. It is vital to determine which areas contribute most to diversity in order to allocate the limited funds available to maximize species survival.

One way of conserving plant species *ex-situ* is in botanic gardens. There are more than 1500 botanic gardens worldwide. Between them, they have enormous potential for plant conservation, but many are poorly financed, and many of the plants grown are of low conservation priority. This is changing, however, as botanic gardens recognize that priority should be given to plants of known wild origin and to the native flora of their region.

Animal species can also be protected *ex situ*, mainly in zoos and aquaria. At least 83 countries have one or more zoos or aquaria; 65 percent are in the developed world. Traditionally, these institutions have been concerned with public entertainment. However, they are now more involved with conservation, and although their efforts so far have contributed little to the overall conservation of species—only 140 of the 629 threatened mammal species worldwide are actually held in zoos, for example—they do play a vital role in the protection of certain important species.

In-situ conservation efforts include reintroduction programmes designed to rehabilitate animal species to the wild. More than 700 reintroductions take place

annually, mainly in the United States and Canada. However, these programmes suffer a high failure rate and, to ensure success, reintroduction must be better planned, executed and monitored.

Plants and animals conserved *ex situ* face certain problems that need careful supervision if real biodiversity is to be maintained. Plant species grown in captivity soon respond to their new habitat, and relatively quickly begin to differ from those in the wild. Great care and cross-breeding of stock between genders is necessary to preserve the full wild variability. The same applies to animals bred in captivity, and animal breeders and zoos now have studbooks of major species and exchange breeding stock to prevent inbreeding problems. One way of determining the variation within a species is chromosome nucleic acid analysis; this will eventually become standard for all animals and plants bred in captivity.

Genetic conservation

The rates of genetic erosion occurring as a result of habitat destruction, agricultural mechanization and crop uniformity are highest in areas with the most fertile land, especially near urban centres and markets.

The genetic diversity of crops and their wild relatives can be protected to some extent *in situ*: in areas with traditional farming systems, in genetic reserves and managed protected areas, and in internationally monitored protected areas, such as Biosphere Reserves. Although many of these areas have some economically important species that are relatively protected, improvements can be made by extending monitoring and management programmes. Without this action, the erosion of genetic resources will continue to accelerate both outside and within protected areas.

For millenia, farmers have selected and bred crop and livestock varieties for their own use. Technology has now made it possible to store genetic material from both crops and livestock *ex situ*, and this is an important development in the effort to preserve genetic diversity.

Ex-situ conservation can be carried out by a variety of institutions, including botanical gardens, forestry institutes and agricultural research centres. These institutions have recognized the importance of maintaining the genetic diversity of plant species, and many incorporate field gene banks and seed banks to this purpose. Field gene banks are areas of land in which collections of growing plants have been established. As many individuals of one species as possible are included, in order to maintain the highest possible level of genetic diversity. Field gene banks are highly suitable for long-living perennial trees and shrubs which cannot be preserved either in the wild or in seed banks, so this form of conservation is especially important to forestry. They are also used to provide germplasm for tropical crops, such as cocoa, rubber and mango, and to hold the wild relatives of economically important species. They do have some disadvantages, however: they require a lot of space, and collections are susceptible to disease and are easily destroyed by natural disasters.

Seed banks have been developed over the past 20 years, and have the advantages of ease of storage, economy of space, relatively low labour demands and economic viability. Their disadvantages include dependence on secure power supplies, the need to monitor the viability of seeds and the need for periodic

regeneration: all seeds have a limited life span, so seeds have to be replaced from time to time from outside sources. Additionally, up to 15 percent of plant species have seeds that are easily destroyed by the normal techniques of storing under reduced temperature and humidity.

There are more than 50 seed banks worldwide, more than half of them in developing countries. Some seed banks specialize in a specific geographical area or species, and these banks may be coordinated to make the best use of resources. More than 90 percent of the species of the major staple food crops have now been preserved in *ex-situ* collections. However, the wild relatives of crops are poorly represented in seed banks, and far more work needs to be done in this field.

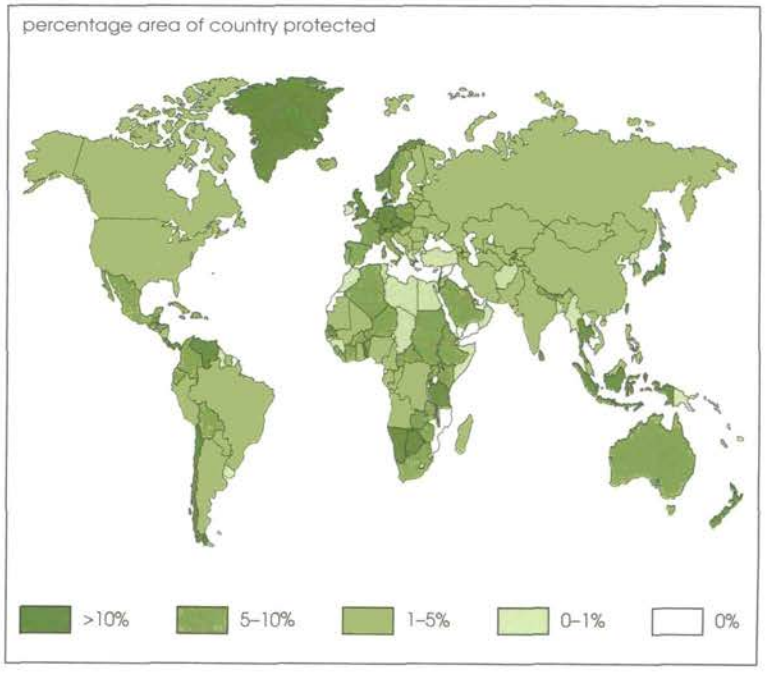
Livestock genetic resources are less well protected than crop genetic resources. This century, meat and milk have come to play larger dietary roles throughout the world, and new livestock breeds have been introduced to meet demand. This has led to a rapid loss of indigenous breeds of domestic animals. NGOs often play a vital role in protecting such breeds; the UK Rare Breeds Survival Trust, for example, runs breeding programmes for rare and endangered livestock breeds. However, cooperation is needed to establish regionally based programmes for conserving domesticated species. Emphasis should focus on endangered or obsolete breeds or on breeds uniquely adapted to specific ecological conditions and uses.

The costs of both gene banks and living collections for domesticated animals are much higher than those for conserving plants. For example, if 8 regional centres were established to conserve 10 domesticated species, with approximately 1000 breeds per species, each centre would need some US$200 000 each year for operating costs. In comparison, recurring costs for maintaining a single crop in a seed bank are about US$50 per sample—less than 5 percent of the cost for animals.

Public research institutions need to increase their capacity to assess patterns of genetic diversity, backed by a strengthened crop and livestock germplasm conservation system. Rapid screening techniques now make it easier to collect target samples, to establish the limits of variation in the collection and to monitor genetic diversity in the field.

Given the long-term responsibility of gene banks, stable sources of funding are essential. Endowments or trust funds could be established for significant germplasm collections, particularly those held in developing countries.

Figure 8 Most countries have a network of protected areas that contribute to the conservation of genetic, species and ecosystem diversity.



National and international action

Action by national governments, either individually or in cooperation with other governments, can be effective in conserving biodiversity. National and international NGOs have also made a significant contribution by providing support to governments to enable them to implement conservation programmes. UNEP is overseeing the initial stages of the Convention on Biological Diversity signed at UNCED in June 1992.

National action

Action to protect wild flora, fauna and natural habitats is often taken by national governments. Although national policy and legal measures vary from country to country depending on the social, political and economic environment, there are a number of common legislative techniques in use throughout the world.

The conservation of wild flora has generally been given low priority, and there is little legislation specifically dealing with the protection of wild flora on a national level. The little that does exist is mainly, though not wholly, confined to the developed world.

Wild flora are mainly protected in four ways: by restricting the collection of specimens; by restricting trade in specimens; by prohibiting the destruction of specimens; and by controlling the introduction of exotic species.

The protection of wild fauna has always been given higher priority than the protection of wild flora. Legislation has existed for centuries, and the mechanisms used are often similar to those for wild flora and may cover both flora and fauna. Legislation often prohibits the taking of wild fauna—this covers a range of activities from recreational hunting to the commercial exploitation of wild species; and restricts the trade of certain wild species and their products.

The protection of natural ecosystems and habitats is vital for the conservation of biodiversity. Restricting the use of land is one way of managing and protecting it. In many countries, legislation is in place to protect areas that are essential to the conservation of a threatened species.

Additionally, there is a worldwide protected area network, which plays a vital role in the conservation of ecosystems and habitats. Some 169 countries have recognized protected area networks. This legislation is easy to enforce on public land, and on private land governments have a variety of mechanisms to establish the necessary protection.

International action

International measures to protect biodiversity can take the form of multilateral treaties, international policy and legal assistance, and international aid.

A multilateral treaty is an international agreement between three or more countries, governed by international law. There are several such treaties dealing with biodiversity either in whole or in part. Although their evolution has been uncoordinated, some of these treaties now play a powerful role in the protection of biological diversity—especially the Convention on International Trade in Endangered Species of Wild Fauna (CITES), the Convention on Wetlands of International Importance (Ramsar) and the Convention Concerning the Protection of the World Cultural and Natural Heritage.

CITES, which had a total of 117 parties in 1992, is the most important international agreement to regulate trade in wildlife

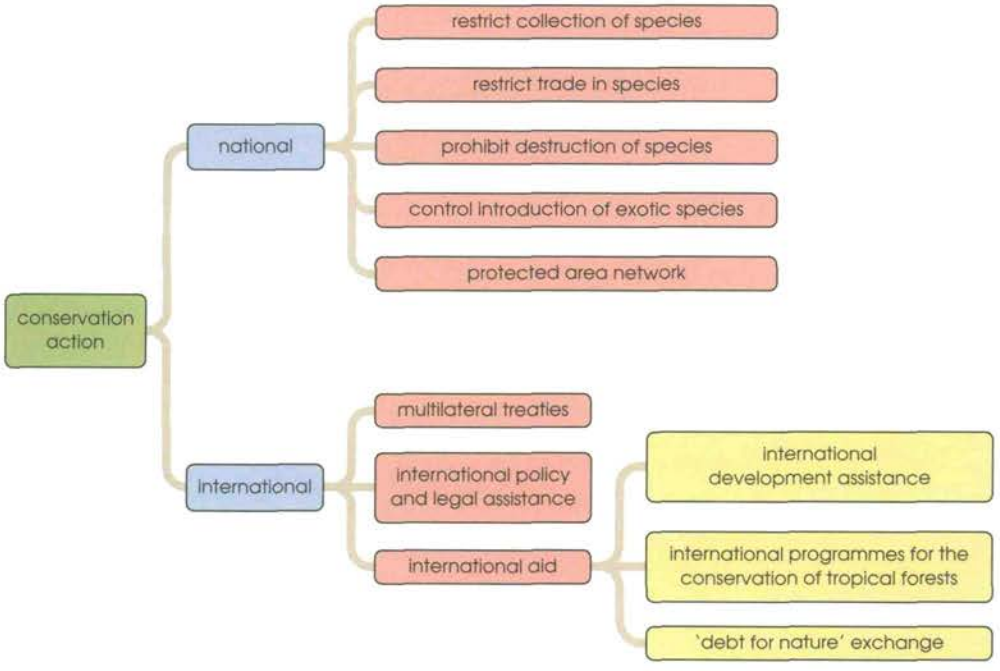


Figure 9 indicates the most common national and international measures taken to conserve biodiversity.

products. CITES aims specifically to prevent commercial trade in species of wildlife which are under threat of extinction. This covers not only live animals and plants, but also products and derivatives of the species listed.

Although national and international measures exist, they do not guarantee that biodiversity is adequately managed and protected. Much of the world's biological diversity is in developing countries which often cannot devote adequate resources to conservation management. Therefore, additional international measures to support and fund national legislation are imperative.

The most direct means of assistance is a 'funding mechanism', which provides support for national conservation programmes. A well-known international environment trust fund is the World Heritage Fund (WHF). WHF grants financial assistance to protect cultural and natural heritage of outstanding universal value. WHF's annual budget of US$2 million is raised by a combination of voluntary and compulsory contributions from contracting parties, and support is available for members in the form of studies, access to experts, staff training, equipment, loans and non-repayable subsidies. Other funding mechanisms include the International Oil Pollution Fund, the Wetlands Conservation Fund, the Kuwait Fund and the Global Environment Facility (GEF).

GEF is jointly administered by the World Bank, UNDP and UNEP. As of March 1991, 21 countries had committed some US$1.4 billion to the fund over a three-year pilot stage for funding in four areas, including global biodiversity. GEF's mandate with respect to biodiversity is to preserve specific areas that contribute goods or services such as harvestable material for medicines or industrial products, genetic resources for food production, and the regulation of climatic and rainfall patterns.

The proportion of international aid set aside specifically for the conservation of biodiversity is small, but its value is enormous. There are three main types of assistance: international development assistance, international programmes for the conservation of tropical forests, and a form of debt purchase known as the 'debt-for-nature' exchange.

International development assistance is concessional aid provided by governments to developing countries either directly through bilateral aid or through multilateral institutions such as the United Nations, and the major development funds and banks.

Established debt-for-nature agreements

debtor country	*date established*	*debt (US$ million)*	*conservation investor*
Argentina	December 1989	no transactions	Argentina's National Development Bank
Bolivia	July 1987	0.65	Bolivian Academy of Sciences, Ministry of Agriculture and Peasant Affairs
Costa Rica	August1987–January 1991	79.85	National Parks Foundation of Costa Rica, government of the Netherlands, The Nature Conservancy (TNC), government of Sweden, Rainforest Alliance, Monteverde Conservation League/TNC
Dominican Republic	March 1990	0.58	Puerto Rican Conservation Trust (PRCT)
Ecuador	October 1987	10.00	Fundación Natura
Guatemala	October 1991	0.10	TNC
Jamaica	October 1991	0.44	TNC, United States Agency for International Development, PRCT
Madagascar	August 1989 May 1990	3.02 0.12	World Wildlife Fund of the United States (WWF-US) Conservation International
Mexico	February 1991	0.50	Conservation International
Peru	July 1989	5.00	International Foundation for Education and Self-Help
Philippines	June 1988	0.48	WWF-US
Poland	November 1989	0.05	World Wide Fund for Nature-International, WWF Sweden
Sudan	December 1988	0.80	United Nations International Children's Fund
Zambia	August 1989	2.27	WWF Netherlands

Table 4 The 'debt-for-nature' exchange enables developing countries to convert their external debt into specific programmes to protect biodiversity.

The 'debt-for-nature' exchange was established to convert the external debt of a developing country into a domestic obligation to support a specific programme to protect biodiversity. An international conservation group raises funds in order to 'purchase' a debtor country's foreign debt. A favourable rate is then fixed for the repayment of the debt. Lastly, the debtor country's government issues bonds to the value of the debt, which are then used to finance conservation projects through local organizations (see Table 4).

Finally, two other international issues connected with biodiversity deserve mention: the need to make a register of genetically engineered organisms, and the need for a global assessment of biodiversity.

Recent advances in the field of biotechnology have enabled scientists to manipulate organisms artificially as never before. Already, thousands of organisms have been modified. An International Register of Genetically Engineered Organisms is urgently needed to contain information on the numbers and types of organisms modified, the methodology used, the reasons for the modification and the organization responsible. This may become a political and a commercial issue, but it is vital for the safety and genetic future of our planet.

To conserve biodiversity adequately, relevant national and international institutions require accurate and complete information, yet current knowledge of the extent of biodiversity is extremely poor. To redress this problem, an international cooperative venture is urgently needed to assess the biological diversity of the planet as a whole and of all its regions.

Convention on Biological Diversity

The Convention on Biological Diversity started life as a document drawn up by the World Conservation Union (IUCN) on the *in situ* conservation of biodiversity. It broke new ground in that it recognized the rights of producer countries to an equal share of the benefits arising from the use of their resources. The document was submitted to the UNEP Governing Council, which accepted the need for an international biodiversity convention and accepted responsibility for drafting it. The draft convention was broader than the IUCN document and covered *ex situ* conservation, wild species of commercial crops, and the transfer of technology, biotechnology and expertise to developing countries. Formal negotiations, involving representatives from some 75 countries, started in November 1990 and a final version of the convention was signed by 156 nations and the EC at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro 1992. The Convention on Biological Diversity aims to save species of animals and plants from extinction, and their habitats from destruction.

Human beings have, for many centuries, exploited the commercial value of biological resources in their own and other countries. It is only recently that developments in biotechnology have opened up the possibility of using the genetic characteristics of plant and animals to create commercially valuable species.

Both developing and developed countries want to see international regulations on the use of the world's biological resources—usually for differing reasons. Developed countries, as the main consumers of biological resources, are concerned with sustainability of supplies and unrestricted

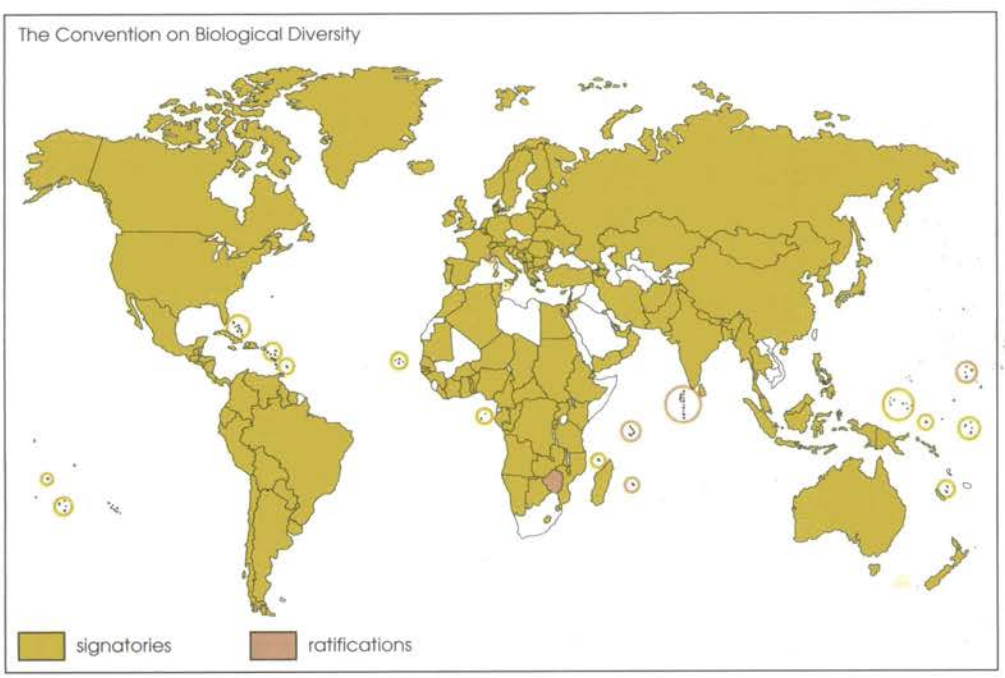


Figure 10 The Convention on Biological Diversity was signed by 156 nations and the EC in Rio de Janeiro, June 1992. By December 1992, only 6 countries had ratified the convention: 30 countries are required to do so for the convention to come into force.

access to genetic materials, whereas developing countries, which often contain valuable biological resources, want to see an increase in technology transfer so that they can exploit their national resources. They also want the equitable distribution of any financial benefits arising from the commercial development of their genetic resources.

Many developing countries, lacking the technology to exploit their natural resources on a large scale, have allowed companies from the developed world to move in. Most of the economic benefits from the country's natural resources have, in this way, been channelled out of the country. A similar pattern of events has occurred in respect of the exploitation of genetic resources. Many of the genes used to improve crops grown in developed countries came originally from plants found in the developing world. Developing countries are now demanding a greater share of the economic benefits accrued from their biological resources and are introducing legislation to ensure this.

At the same time, developed countries have become concerned about the unsustainable exploitation of areas such as tropical rainforests in developing countries. This is threatening global biodiversity and the continued supply of raw materials from developing countries to industries in the developed world. Developed countries are concerned about any loss of genetic resources and about restrictions on their use introduced by developing countries.

Key points from the Convention on Biological Diversity

The aim of the Convention on Biological Diversity is 'the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources'. The convention stipulates that Parties must:

- develop national strategies for the conservation and sustainable use of biological resources;
- establish protected areas, restore degraded ecosystems, control alien species, and establish *ex situ* conservation facilities;
- establish training and research programmes for the conservation and sustainable use of biodiversity and support such programmes in developing countries;
- promote public education and awareness of the conservation and sustainable use of biodiversity;
- carry out an environmental impact assessment prior to any proposed project that may reduce biodiversity;
- recognize the right of governments to regulate access to their own genetic resources, and, wherever possible, grant other Parties access to genetic resources for environmentally sound uses;
- encourage technology and biotechnology transfer, particularly to developing countries;
- establish an information exchange between the parties on all subjects relevant to biodiversity;
- promote technical and scientific cooperation between parties (particularly to developing countries) to enable them to implement the convention;
- ensure that countries that provide genetic resources have access to the benefits arising from them; and
- provide financial resources to developing countries parties to enable them to carry out the requirements of the convention.

UNEP action

UNEP is acting as an interim Secretariat for the Convention on Biological Diversity until the convention is ratified by 30 parties and comes into force. UNEP is responsible for reporting to the parties; coordinating meetings of the parties and NGOs; keeping issues relating to the convention at the forefront of public and government attention; and encouraging parties to implement the objectives of the convention before it is formally ratified.

The convention outlines the parties' responsibilities for conducting national biodiversity surveys—known as Country Studies— and monitoring species and habitats. Country Studies involve:

- a review of national biological resources;
- the identification of measures necessary for the conservation and sustainable use of national biological resources;
- an assessment of costs and benefits of implementing these measures; and
- an estimation of additional funding required to carry out these measures.

Once completed, Country Studies will be used to create national plans for the conservation and sustainable use of biological resources, including protecting threatened areas eradicating alien species that threaten habitats and introducing legislation to protect threatened species. The studies will also help in estimating the total cost of implementing the convention.

UNEP and the World Conservation Monitoring Centre, with funding from the multi-national Global Environment Facility, have helped 14 countries in Africa, Asia, Europe, Oceania and South America to carry out Country Studies. Further studies are planned for some of the world's most biologically rich countries, including Brazil and Colombia.

On the basis of the Country Studies, the unmet financial requirement of all developing countries was estimated to be approximately US$20 billion a year. At present, US$228 million in aid is channelled to developing countries for the conservation of biodiversity. A 10-fold increase in assistance from donor countries would therefore be needed to cover the estimated cost of implementing conservation strategies in developing countries. Countries are unwilling to commit themselves to spending of this magnitude, but the cost can be put into perspective by comparing it to spending on annual OECD agricultural support programmes (US$245 billion) and global military spending (US$980 billion in 1990).

National Biodiversity Units (NBUs) were established to coordinate data gathering in those countries participating in Country Studies. UNEP recommends that these NBUs be developed into National Biodiversity Monitoring Centres responsible for gathering and analysing national data on biodiversity, linked to a global biodiversity information network. Monitoring centres could provide an early warning system for threats to biodiversity and could also record political, legal and economic changes that may affect biodiversity conservation. The development of national monitoring and assessment programmes would enable governments to target conservation programmes effectively and to monitor their progress over time.

Sources

Boo, E. *Ecotourism: the potentials and pitfalls.* WWF, Washington, 1990.

Clutton-Brock, J. *A natural history of domesticated mammals.* Cambridge University Press, Cambridge and British Museum (Natural History), London, 1987.

Colinvaux, P. *Why big fierce animals are rare.* Pelican Books, London, 1980.

Corbet, G. B. and Hill, J. E. *A world list of mammalian species.* Third edition. Oxford University Press, Oxford, 1991.

Day, David. *The Doomsday book of animals: a unique natural history of vanished species.* Ebury Press, London, 1981.

Dixon, J. A. and Sherman, P. B. *Economics of protected areas: a new look and benefits and costs.* Earthscan, London, 1990.

FAO. *Forests, trees and food.* FAO, 1992.

Finlayson, M. and Moser, M. (eds.). *Wetlands.* Facts on File Limited, Oxford, 1991.

Gaston, K. J. The magnitude of global insect species richness. *Conservation Biology* 5: 283–296, 1991a.

Grassle, J. F. Species diversity in deep-sea communities. *TREE* 4: 12–15, 1989.

Hawkes, J. G. (ed.). *Genetic conservation of world crop plants.* Published for the Linnaean Society of London by Academic Press, 1991.

Hobbelink, H. *Biotechnology and the future of world agriculture.* Zed Books, London, 1991.

IUCN. *1990 IUCN Red List of Threatened Animals.* IUCN, 1990.

IUCN. *1990 United Nations list of national parks and protected areas.* IUCN, 1990.

McNeely, J. A. *et al. Conserving the world's biological diversity.* Gland, IUCN, 1990.

Mather, A. S. *Global forest resources.* Belhaven Press, London, 1990.

Signor, P. W. *The geological history of diversity.* Annual Review of Ecology and Systematics 21: 509–539.

Vane-Wright, R. I. Why not eat insects? *Bulletin of Entomological Research* 81: 1–4, 1991.

World Conservation Monitoring Centre. *Global Biodiversity: status of the Earth's living resources.* London, Chapman and Hall, 1992

WRI. *World resources 1992–1993: a guide to the global environment.* Oxford University Press, Oxford, 1992.

WRI, IUCN, UNEP. *Global Biodiversity Strategy: guidelines for action to save, study and use Earth's biotic wealth sustainably and equitably.* WRI, IUCN, UNEP, 1992.

WWF. *Biological Diversity Briefing Pack.* Compiled by Words and Publications for WWF International, 1989.


UNEP