

# Biodiversity

In this article we will give a definition of biodiversity, discuss the distribution of biodiversity with three illustrative examples from South Africa, Brazil and Madagascar before commenting on the human benefits.

The term was used first by wildlife scientist and conservationist Raymond F. Dasmann in a book advocating nature conservation.

**Biodiversity** is the variation of [life](#) forms within a given [ecosystem](#), [biome](#), or on the entire [Earth](#). Biodiversity is often used as a measure of the health of [biological systems](#). The biodiversity found on Earth today consists of many millions of distinct biological [species](#). The year [2010](#) has been declared as the [International Year of Biodiversity](#).

Biodiversity is not distributed evenly on Earth, but is consistently rich in the [tropics](#) and in specific localized regions such as the [Cape Floristic Province](#); it is less rich in polar regions where fewer species are found.

Rapid environmental modifications typically cause [extinctions](#). Of all species that have existed on Earth, 99.9 percent are now extinct. Since life began on [Earth](#), five major mass extinctions have led to large and sudden drops in the biodiversity of species. The [Phanerozoic](#) eon (the last 540 million years) marked a rapid growth in biodiversity in the [Cambrian explosion](#)—a period during which nearly every [phylum](#) of [multicellular organisms](#) first appeared. The next 400 million years was distinguished by periodic, massive losses of biodiversity classified as [mass extinction](#) events. The most recent, the [Cretaceous–Tertiary extinction event](#), occurred 65 million years ago, and has attracted more attention than all others because it killed the [dinosaurs](#).

Today there is concern that the period since the emergence of [humans](#) is part of a mass reduction in biodiversity, the [Holocene extinction](#), caused primarily by the impact humans are having on the environment, particularly the destruction of plant and animal [habitats](#). In addition, human practices have caused a loss of [genetic biodiversity](#). The relevance of biodiversity to human health is becoming a major international issue, as scientific evidence is gathered on the global health implications of biodiversity loss.

Biologists most often define biodiversity as the "totality of genes, species, and ecosystems of a region". An advantage of this definition is that it seems to describe most circumstances and present a unified view of the traditional three levels at which biological variety has been identified : 1) [species diversity](#) 2) [ecosystem diversity](#) and 3) [genetic diversity](#). But Professor [Anthony Campbell](#) at [Cardiff University, UK](#) and the [Darwin Centre, Pembrokeshire](#), has defined a fourth, and critical one: [Molecular Diversity](#)

## Distribution

Nevertheless, biodiversity is not distributed evenly on Earth. It is consistently richer in the [tropics](#) and in other localized regions such as the [Cape Floristic Province - please see example one below](#). As one approaches polar regions one generally finds fewer species. Flora and fauna diversity depends on [climate](#), altitude, [soils](#) and the presence of other species. In the year 2006 large numbers of the Earth's species were formally classified as [rare](#) or [endangered](#) or [threatened species](#); moreover, many scientists have estimated that there are millions more species actually endangered which have not yet been formally recognized. About 40 percent of the 40,177 species assessed using the [IUCN Red List](#) criteria, are now listed as [threatened species](#) with extinction - a total of 16,119 species.

Even though biodiversity declines from the equator to the poles in [terrestrial ecoregions](#), whether this is so in [aquatic ecosystems](#) is still a hypothesis to be tested, especially in [marine ecosystems](#) where causes of this phenomenon are unclear. Please see Dr Simon Harding's articles on marine, life, ocean formation and food webs in the sea. In addition, particularly in marine ecosystems, there are several well stated cases where diversity in higher latitudes actually increases. Therefore, the lack of information on biodiversity of [Tropics](#) and [Polar Regions](#) prevents scientific conclusions on the distribution of the world's aquatic biodiversity. Lets us now consider three examples of biodiversity:

## Example One Cape Floristic Province

### Location and description

The Region covers the [Mediterranean climate](#) region of South Africa in the [Western Cape](#) in the southwestern corner of the country, and extends eastward into the [Eastern Cape](#), a transitional zone between the winter-rainfall region to the west and the summer-rainfall region to the east in [KwaZulu-Natal](#).

Most of the region is covered with [fynbos](#), a [sclerophyllous shrubland](#) occurring on acid sands or nutrient poor soils derived from Table Mountain Sandstones (Cape Supergroup). Fynbos is home to an amazing diversity of plant species including many members of the Protea family ([Proteaceae](#)), Heath family ([Ericaceae](#)), and Reed family of restios ([Restionaceae](#)). Other vegetation types are [strandveld](#), a soft coastal [scrubland](#) found mostly on the west-facing coast of the Western Cape Province, on tertiary sands. [Renosterveld](#) is a grassy shrubland dominated by members of the Daisy family ([Asteraceae](#) - particularly [renosterbos](#), graminoids and geophytes, occurring on the base-rich shaley soils of the coastal forelands. Small pockets of [Afromontane forest](#) can be found in humid and sheltered areas.

## Example Two - Brazil's Atlantic Forest

Brazil's [Atlantic Forest](#) is considered a hotspot of biodiversity and contains roughly 20,000 plant species, 1350 vertebrates, and millions of insects, about half of which occur nowhere else in the world.

The Atlantic Forest ([Portuguese](#): 'Mata Atlântica') is a region of [tropical and subtropical moist forest](#), [tropical dry forest](#), [tropical savannas](#), and [mangrove forests](#) which extends along the [Atlantic coast](#) of [Brazil](#) from [Rio Grande do Norte](#) state in the north to [Rio Grande do Sul](#) state in the south, and inland as far as [Paraguay](#) and the [Misiones Province](#) of [Argentina](#).

The Atlantic Forest region includes forests of several variations. 1) The coastal [restingas](#) are low forests which grow on stabilized coastal dunes. 2) The coastal forests, also known as [Atlantic moist forests](#), are evergreen tropical forests with structures. 3) Inland are the interior forests, also known as the [Atlantic semi-deciduous forests](#), where many trees drop their leaves during the dry season. 4) Further inland are the [Atlantic dry forests](#), which form a transition between the arid [Caatinga](#) to the northeast and the [Cerrado](#) savannas to the east. 5) Montane moist forests occur in the [Serra do Mar](#) and across the mountains and plateaus of southern Brazil, and are home to [Araucaria](#) and evergreen trees of the laurel ([Lauraceae](#)) and myrtle ([Myrtaceae](#)) families. 6) Shrubby montane savannas occur at the highest elevations.

The Atlantic Forest is unusual in that it extends as a true *tropical* rainforest to latitudes as high as 24°S. This is because the [trade winds](#) produce precipitation throughout the southern winter. In fact, the northern [Zona da Mata](#) of northeastern Brazil receives much more rainfall between May and August than during the southern summer.

The [Dunas Park](#) in [Rio Grande do Norte](#) is one of the largest units of conservation of atlantic forest in Brazil. The Atlantic Forest is now designated a [World Biosphere Reserve](#), which contains a large number of highly [endangered species](#) including the well known [marmosets](#) and [lion tamarins](#). It has been extensively cleared since colonial times, mainly for the farming of [sugar cane](#) and for urban settlements. The remnant is estimated to be less than 10% of the original and that is often broken into hilltop islands.

## Example Three Madagascar

The island of [Madagascar](#) including the unique [Madagascar dry deciduous forests](#) and lowland rainforests possess a very high ratio of species [endemism](#) and biodiversity, since the island separated from mainland [Africa](#)  $\square$  million years ago, most of the species and ecosystems have evolved independently producing unique species different from those in other parts of Africa.

Madagascar's long isolation from the neighboring continents has resulted in a unique mix of plants and animals, many found nowhere else in the world; some ecologists refer to Madagascar as the "eighth continent".- Of the 10,000 plants native to Madagascar, 90% are found nowhere else in the world. Madagascar's varied fauna and flora are endangered by human activity, as a third of its native vegetation has disappeared since the 1970s, and only 18% remains intact. Since the arrival of humans 2000 years ago, Madagascar has lost more than 90% of its original forest.<sup>1</sup>The [elephant birds](#), which were giant [ratites](#) native to Madagascar, have been extinct since at least the 17th century. [Aepyornis](#) was the world's largest bird, believed to have been over 3 metres (10 ft) tall.

Most [lemurs](#) are listed as [endangered](#) or threatened species. Many species have gone extinct in the last centuries, mainly due to habitat destruction and hunting.

The eastern, or [windward](#) side of the island is home to [tropical rainforests](#), while the western and southern sides, which lie in the [rain shadow](#) of the central highlands, are home to [tropical dry forests](#), thorn forests, and [deserts and xeric shrublands](#). Madagascar's dry deciduous rain forest has been preserved generally better than the eastern rainforests or the high central [plateau](#), presumably due to historically low population densities. Madagascar has [several national parks](#).

## Human benefits of biodiversity

Biodiversity also supports a number of natural ecosystem processes and services. Some ecosystem services that benefit society are air quality, climate (both global CO2 sequestration and local), water purification, pollination, and prevention of erosion. Since the [stone age](#), species loss has been accelerated above the geological rate by human activity. The rate of species extinction is difficult to estimate, but it has been estimated that species are now being lost at a rate approximately 100 times as fast as is typical in the geological record, or perhaps as high as 10 000 times as fast. To feed such a large population, more land is being transformed from wilderness with wildlife into agricultural, mining, lumbering, and urban areas for humans. Non-material benefits that are obtained from ecosystems include spiritual and aesthetic values, knowledge systems and the value of education.

## Agriculture

The economic value of the reservoir of genetic traits present in wild varieties and traditionally grown [landraces](#) is extremely important in improving crop performance. Important crops, such as the potato and coffee, are often derived from only a few genetic strains. Improvements in crop plants over the last 250 years have been largely due to harnessing the genetic diversity present in wild and domestic crop plants. Interbreeding crops strains with different beneficial traits has resulted in more than doubling crop production in the last 50 years as a result of the [Green Revolution](#). For more information on agriculture please see Dr Simon Harding's introductory article in this series.

[Crop diversity](#) is also necessary to help the system recover when the dominant crop type is attacked by a disease. We can look at three examples of this: 1) The [Irish potato blight](#) of 1846, which was a major factor in the deaths of a million people and migration of another million, was the result of planting only two potato varieties, both of which were vulnerable. 2) When [rice grassy stunt virus](#) struck rice fields from Indonesia to India in the 1970s, 6273 varieties were tested for resistance. One was found to be resistant, an Indian variety, known to science only since 1966. This variety formed a hybrid with other varieties and is now widely grown.

3) [Coffee rust](#) attacked coffee plantations in Sri Lanka, Brazil, and Central America in 1970. A resistant variety was found in Ethiopia. Although the diseases are themselves a form of biodiversity.

[Monoculture](#), the lack of biodiversity, was a contributing factor to several agricultural disasters in history, the European wine industry collapse in the late 1800s, and the [US Southern Corn Leaf Blight](#) epidemic of 1970. Higher biodiversity also controls the spread of certain diseases as pathogens will need to adapt to infect different species. Biodiversity provides food for humans. Although about 80 percent of our food supply comes from just 20 kinds of plants such as rice and wheat, humans use at least 40,000 species of plants and animals a day. Many people around the world depend on these species for their food, shelter, and clothing. There is untapped potential for increasing the range of food products suitable for human consumption, provided that the high present extinction rate can be stopped.

## Human health

The relevance of biodiversity to human health is becoming a major international political issue, as scientific evidence builds on the global health implications of biodiversity loss. This issue is closely linked with the issue of climate change, as many of the anticipated health risks of climate change are associated with changes in biodiversity (e.g. changes in populations and distribution of disease vectors, scarcity of fresh water, impacts on agricultural biodiversity and food resources etc.). Some of the health issues influenced by biodiversity include dietary health and nutrition security, infectious diseases, medical science and medicinal resources, social and psychological health. Biodiversity is also known to have an important role in reducing disaster risk, and in post-disaster relief and recovery efforts.

One of the key health issues associated with biodiversity is that of drug discovery and the availability of medicinal resources. A significant proportion of drugs are derived, directly or indirectly, from biological sources; Chivian and Bernstein report that at least 50% of the pharmaceutical compounds on the market in the US are derived from natural compounds found in plants, animals, and microorganisms, while about 80% of the world population depends on medicines from nature (used in either modern or traditional medical practice) for primary healthcare.

Moreover, only a tiny proportion of the total diversity of wild species has been investigated for potential sources of new drugs. Through the field of [bionics](#), considerable technological advancement has occurred which would not have without a rich biodiversity. Please see Dr Simon Harding's introductory article on botanicals in this series for more information.

It has been argued, based on evidence from market analysis and biodiversity science, that the decline in output from the pharmaceutical sector since the mid-1980s can be attributed to a move away from natural product exploration ("bioprospecting") in favour of R&D programmes based on genomics and synthetic chemistry, neither of which have yielded the expected product outputs; meanwhile, there is evidence that natural product chemistry can provide the basis for innovation which can yield significant economic and health benefits. Marine ecosystems are of particular interest in this regard, however unregulated and inappropriate [bioprospecting](#) can be considered a form of [over-exploitation](#) which has the potential to degrade ecosystems and increase biodiversity loss, as well as impacting on the rights of the communities and states from which the resources are taken.

## Business and Industry

A wide range of industrial materials are derived directly from biological resources. These include building materials, fibers, dyes, resins and oil. There is enormous potential for further research into sustainably utilizing materials from a wider diversity of organisms. In addition, biodiversity and the ecosystem goods and services it provides are considered to be fundamental to healthy economic systems. The degree to which biodiversity supports business varies between regions and between economic sectors, however the importance of biodiversity to issues of resource security (water quantity and quality, timber, paper and fibre, food and medicinal resources etc.) are increasingly recognized as universal. As a result, the loss of biodiversity is increasingly recognized as a significant risk factor in business development and a threat to long term economic sustainability. A number of case studies recently compiled by the World Resources Institute demonstrate some of these risks as identified by specific industries.

## Other ecological services

Biodiversity provides many [ecosystem services](#) that are often not readily visible. It plays a part in regulating the chemistry of our [atmosphere](#) and [water supply](#). Biodiversity is directly involved in [water purification](#), recycling [nutrients](#) and providing fertile soils. Experiments with controlled environments have shown that humans cannot easily build ecosystems to support human needs; for example [insect pollination](#) cannot be mimicked by human-made construction, and that activity alone represents tens of billions of dollars in [ecosystem services](#) per year to humankind.

The [stability of ecosystems](#) is also related to biodiversity, with higher biodiversity producing greater stability over time, reducing the chance that ecosystem services will be disrupted as a result of disturbances such as extreme weather events or human exploitation.

## Leisure, cultural and aesthetic value

Many people derive value from biodiversity through leisure activities such as [hiking, birdwatching](#) or natural history study. Biodiversity has inspired [musicians](#), painters, sculptors, writers and other artists. Many culture groups view themselves as an integral part of the natural world and show respect for other living organisms. Popular activities such as gardening, caring for aquariums and collecting butterflies are all strongly dependent on biodiversity. The number of species involved in such pursuits is in the tens of thousands, though the great majority do not enter mainstream commercialism.

The relationships between the original natural areas of these often 'exotic' animals and plants and commercial collectors, suppliers, breeders, propagators and those who promote their understanding and enjoyment are complex and poorly understood. It seems clear, however, that the general public responds well to exposure to rare and unusual [organisms](#)—they recognize their inherent value at some level. A family outing to the [botanical garden](#) or zoo is as much an aesthetic or cultural experience as it is an educational one.

Philosophically it could be argued that biodiversity has intrinsic aesthetic and spiritual value to [mankind in and of itself](#). This idea can be used as a counterweight to the notion that [tropical forests](#) and other ecological realms are only worthy of conservation because they may contain [medicines](#) or useful products.

## Conclusion

We can see from the above examples that an understanding of biodiversity is fundamental to the survival of the entire planet - not only physically but also culturally. Number of species, threats to biodiversity, destruction of habitat, exotic species, genetic pollution, climate change, and means of conservation will be discussed in part two of this series.