BIODIVERSITY UNDER THREAT

DEFINING BIODIVERSITY

There are different ways of defining biodiversity in terms of genetic, species and ecosystem diversity; each has its own merits.

Defining biodiversity

The biosphere is the layer of the earth where there is life and it includes parts of the atmosphere and lithosphere. Here there is an amazing variety of life forms, only some of which have been recorded by humans. The term biodiversity is a shortening of 'biological diversity'. The 1992 Convention on Biological Diversity in Rio de Janeiro defined biodiversity as the "variability among living organisms from all sources… terrestrial, marine and aquatic ecosystems and the ecological complexes of which they are a part: this includes diversity within species, between species and of ecosystems". Biodiversity is the sum of all three definitions: species, genetic and ecosystem diversity.

Types of biodiversity

Species diversity

Order: Kingdoms, Phyla, Families, Genera, Species, Subspecies, Populations, Individuals.
Species diversity looks at the range and variety of species from the kingdom down to the individuals. It is linked to species richness. It is a good general measure of biodiversity. On a basic level, areas can be compared. It is sometimes better if a range of indicator species is specified (ones that suggest a richer system if they are present). It is also better to use taxonomic diversity (rodents, lizards, birds etc). However, care must be taken when assessing area as large areas tend to be more diverse. Like must be compared with like. Many species as yet undiscovered are likely to be microscopic. This might skew a biodiversity index based on species. Species richness does not cover the distribution of the species or the interactions between species.

Genetic diversity

Order: Populations, Individuals, Chromosomes, Nucleotides.
Genetic diversity looks at variety within species. This can be in populations that have been separated geographically, but also amongst individuals within single populations. Variation in genetic make-up more easily allows populations to adapt in changing environments. Measuring genetic diversity allows an accurate picture of the diversity within a population. It helps explain how isolated groups e.g. finches on the Galapagos have adapted to new environments. However, it is difficult to assess without high-level biological skills as DNA has to be analysed.

Ecosystem diversity

Order: Biomes, Bioregions, Landscapes, Ecosystems, Habitats, Niches, Populations.
This looks at the variety of different ecosystems or habitats that occur within an area and takes into account biotic and abiotic factors. It involves the interaction of species with each other and their environment, so is a more complex measure of biodiversity. It may be more useful when assessing areas to protect as it has a wider focus than the other definitions. However, it is difficult to know where to place the boundaries for the area under investigation as ecosystems merge into one another. A consistent set of criteria is needed to demarcate an ecosystem.

Key terms

Phyla: the major subdivisions of a Kingdom (e.g. animals) such as insects and vertebrates.

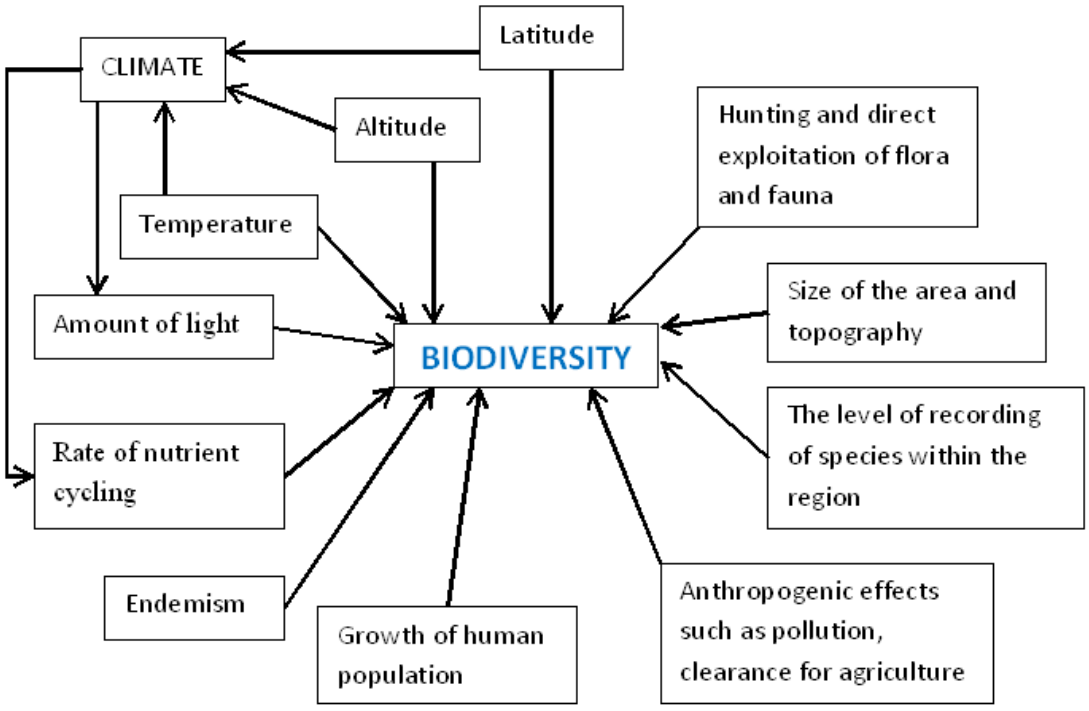
Nucleotides: pivotal in development of life and are important in formation of DNA which provides information for the replication of cells.

There are a range of key processes and factors that influence biodiversity; such as the role of endemism, climate and human activity and actions.

Factors influencing biodiversity

Biodiversity is not evenly spread out across the earth. Some areas are more diverse as they have fewer limiting factors. The size of the area is important as generally more species can live and interact within a larger area. A growth in human population has an impact on biodiversity because we are in competition with other species for space and resources as human numbers increase. Biodiversity will decrease if there is a lack of management.

There are also certain human activities, such as hunting, that target specific species and can lead to their extinction if unregulated. As humans practice agriculture the multi-layered natural system is changes into a single-layered one, a monoculture, and thus reduces the biodiversity of an area. In more recent times industrial activity has led to the pollution of water courses and seas with impacts on the life forms that live within them, often reducing their numbers directly or their ability to breed. Some regions, particularly islands, have species that are found nowhere else as they are endemic to that area and this increases biodiversity.



The most important impact on the level of biodiversity is the location's climate. This can be regarded as a limiting factor. Overall there is an increase in the number and variety of organisms towards the Tropics and this is also true for marine ecosystems. For example, there are 50 genera of reef corals at the northern end of the Great Barrier Reef in Australia (the end nearest the Equator), whereas there are only 10 genera at the southern end.

Nearer the equator (at lower latitudes) the climate is warmer and usually more humid. These are ideal conditions of dead biotic and also abiotic material and subsequently rapid nutrient cycling. In the Tropics there can be tropical rainforest with high species richness at the foot of the mountains, moving through several vegetation types until alpine tundra with its lower biodiversity is found near the peaks.

In some areas of the world biodiversity is low because the climate is too dry (deserts) and/or too cold (polar and tundra regions). Climatic extremes usually have low biodiversity because there are not enough food sources to support large populations and often only specialised organisms can survive. Plants form the base of all terrestrial food chains and grow best in warm, moist conditions.

The rate at which they fix the sun's energy (photosynthesise) is measured in grams per square metre per year (or tonnes per square kilometre per year) and is known as gross primary productivity (GPP). Net primary productivity (NPP) is GPP minus the energy lost via respiration.

New Zealand's biodiversity was severely affected by several factors.

- 80 million years ago New Zealand broke away from the ancient supercontinent of Gondwanaland. This isolation and relatively late arrival of humans on its islands led to a high level of endemic species. The warm to cool moist climate supported dense forests on both islands. As no large mammals were on the islands when they broke away, its ecosystems were dominated by birds.
- With no mammal predators, the birds grew to a large size, e.g. the 2 metre tall Giant Moa. Even the parrots became large and with no predators some lost the ability to fly, e.g. the nocturnal and ground-dwelling Kakapo and the Kiwi. Birds adapted to new environments and the Kia, the only alpine parrot in the world, lives on the Southern Alps. The forests ranged from tall Kauri forests on North Island to temperate rainforests on the west coast of South Island.
- After the Maori arrived in 1000AD rapid changes occurred. By the late 17th century the Moa was extinct and the dogs and rats the Maori brought with them hugely reduced the numbers of ground-dwelling birds. With the arrival of the Europeans a few hundred years later the changes were more severe. Huge areas of the Canterbury Plain, South Island, were cleared for sheep farming. Settlers brought plants they were familiar with to use as field boundaries such as gorse, but given the lack of pests or diseases it was usually subject to it spread widely and out-competed indigenous vegetation.
- Weasels and stouts were also introduced as post control, but they reduced the numbers of the indigenous birds as they are notorious egg thieves and again had no predators.
- New Zealand has 30,000 named indigenous land species, 29 indigenous freshwater fish species and 8,000 marine species have been recorded in New Zealand waters.

Key terms

Biotic: the living components of an ecosystem such as plants.

Abiotic: the non-living components of an ecosystem such as water and soil.

The global distribution of biodiversity and biodiversity hotspots reveals important patterns, and suggests that pivotal areas exist.

Distribution of biodiversity

Tropical rainforests are the most biodiverse. These occur in South and Central America, Madagascar, Malaysia and Indonesia. They have a high primary productivity, which supports a complex food web with many trophic levels and ecological niches.

India has a high level of biodiversity as it has a large area as well as a range of climates and relief. This is because it covers many degrees of latitude and has the Himalayas in the north of the country. As the Himalayas have a large altitude range, there are many different habitats and niches in a relatively small area.

The reason for high biodiversity in the Himalayas is due to many different habitats over one area.

- The Himalayas cover approximately 2,400km, passing through India, Pakistan, Afghanistan, China, Bhutan and Nepal. The range is made up of three parallel ranges referred to as the Greater Himalayas, the Lesser Himalayas and the Outer Himalayas.
- Climates range from tropical at the base of the mountains to perennial snow and ice at the highest elevations. There are many parts to the Himalayan ecology:
    - *Montane grasslands and shrublands*: found in the west, and have cold winters and mild summers that allow for plant growth. Rhododendrons cover the lower shrublands, while the alpine meadows directly above host a range of flora in the warmer months. Animals found here include the snow leopard, Himalayan tahr, musk deer and pikas.
    - *Temperate coniferous forest*: found in the northeast inner valley area, and are protected from harsh monsoon conditions by surrounding mountain ranges. Dominant trees are pine, hemlock, spruce and fir. Animals found in this region include red pandas, takins and musk deer.
    - *Temperate broadleaf and mixed forests*: found in the eastern region which receives more than 2000mm of rain per year, mostly during the monsoon season. In addition to indigenous oaks and maples, plants like orchids, lichen and ferns also grow here. 500 species of birds are found here during the cooler seasons before they migrate to higher elevations to escape the hot summers. This is the primary home for golden langur monkeys.
    - *Tropical and sub-tropical broadleaf forests*: found along a narrow strip along the Outer Himalayan range where there is a wide range of plant life thanks to the areas' varied topography, soil types and rainfall levels. Many types of forest are found here. Wildlife includes many threatened species including tigers and Asian elephants. More than 340 different species of birds can be found in this region.

Although dry, Australia has a high number of endemic species in the forests to the north, which add to the importance of its biodiversity. As well as this, the Great Barrier Reef is a biodiversity hotspot and attracts many different marine species.

Coral reefs are known as the rainforests of the sea. Warm oceans are needed for the growth of the reefs, but they are rich in nutrients. They are found in the Pacific Ocean around Malaysia, Indonesia, the Philippines and North-eastern Australia.

Coastal areas are rich in nutrients due to estuaries, and have high rainfall and sunshine. This makes them rich in biodiversity as mangroves flourish, especially in tropical climates. The mangroves provide protection for the coast, so other plants and animals can live there.

Animal diversity is greatest where there are more plants e.g. forests, therefore more food. Marine ecosystems support the most trophic levels due to the least loss of GPP between the trophic levels as there is less energy lost for temperature maintenance: water has a high specific heat capacity so there is little temperature change between the seasons. Species diversity is lower in cold areas in the high latitude regions and desert areas. This is because there is less sunlight so plants are able to grow less, and because the temperatures are extreme. This also occurs in high altitude areas.

Overall, the greatest biodiversity is found in areas of tropical rainforest with over half of the earth's species, even though they cover only 7% of the planet's surface. They generally have the highest diversity of plants within them, which then support a wide range of insect, bird and mammal life forms.

Biodiversity hotspots

Several bodies such as the World Conservation Monitoring Centre and Conservation International have tried to identify such areas which are known as 'biodiversity hotspots'. In 1999, 25 terrestrial hotspots were identified, which covered the range of the earth's species. Subsequently marine hotspots were identified, including coral reefs. 1.4% of the earth's surface is covered by terrestrial hotspots. They are widely distributed, and are often tropical islands and highlands. They are areas of the developing world where poverty leads to the destruction of ecosystems. The majority of hotspots lie between the warm tropics of Cancer and Capricorn.

The UK has 5 marine hotspots.

- The hotspots are: Plymouth Sound, South Devon; Blackwater Estuary, Essex; Dogger Bank, the southern North Sea; Rathlin Island, Northern Ireland and the Menai Straight, Wales.
- The hotspots were chosen for their diverse populations of wildlife and rich habitat, including rare fan mussels, cold water corals, fireworks anemone, saltmarshes and killer whales.
- The species known to be rare and/or threatened in the identified marine hotspots are:
    - Plymouth Reefs: sunset cup coral, pink seafan and seafan anemone.
    - Rathlin Island: branching sponges (over 143 species) and burrowing anemones.
    - Blackwater Estuary: saltmarshes and native oyster species.
    - Menai Strait: honeycomb worm, burrowing anemone and grey seals.
    - Dogger Bank: sand and gravel communities, potentially an important area for harbour porpoise and spawning grounds for herring.
- The marine hotspots were identified in a 2007 WWF report.

The Galapagos Islands are a biodiversity hotspot.

- The Galapagos archipelago is situated at a point where major ocean currents converge, mixing nutrient rich cool waters from the south, warm currents from the north, and a deep cold current from the west.
- Climatic conditions are affected significantly by el Niño.
- Nearly ¼ of the Galapagos marine life is endemic, including the world's only marine iguana, angelfish, Moorish idols, fur seals, tunas, manta rays, sea turtles and hammerhead sharks.
- Significant human settlements of the Galapagos did not occur until the 1900s, making it possible for 97% of the Islands' original biodiversity to remain today.
- Fishing was very small-scale until 1999, and as global over-fishing grew and Peruvian coastal fisheries collapsed. Markets for sea cucumbers and shark fins raised the exploitation of marine resources. Much of this fishing was illegal and remained uncontrolled. Large-scale commercial fleets from mainland Ecuador and elsewhere fish for tuna in Galapagos waters. This illegal fishing increased pressure on marine resources and impacted marine mammals and birds that were caught and drowned.
- Tourism began to flourish in the 1970s when charter flights began bringing small groups of adventure tourists to the islands. It became the main economic activity of the archipelago, employing almost 70% of the economically active population. While strict measures have been long in place to control tourism, the sheer number of visitors increases pressure on the marine environment.
- Population growth is considered one of the main problems for conservation in Galapagos.

They are used to assess conservation priorities, to see where there is high biodiversity that is under threat. Conservation International has recently updated an analysis of the earth's biodiversity and has identified 34 hotspot areas, which are home to over 50% of the planet's birds and 77% of terrestrial vertebrates between them. The location of hotspots does not correlate exactly with the location of the greatest biodiversity that is shown on a map of biodiversity by country as they have a much wider locational spread. For example, France does not have a particularly high biodiversity, yet its southern shores are part of the Mediterranean Basin Hotspot. Biodiversity hotspots allow areas with very high biodiversity to be identified, as well as endemism that may not be within a region of high diversity.

However, the majority of hotspots are between the Tropics in the warmer areas of the world. Hotspot areas are important for the range of diversity they contain, often in quite small regions. If they are not protected, the survival of a large number of organisms is threatened. One such hotspot is the Atlantic Forest of Brazil, a newly industrialising country.

There are many reasons an area may be designated as a hotspot, especially in the Atlantic Forest of Brazil.

- There are 1,300 vertebrates (500 endemic), 20,000 plants (6,000 endemic), 950 bird species (55 endemic) and 269 mammal species in the forest. 458 tree species can be found in under a hectare.
- The forest is situated in South-eastern Brazil, largely, but not entirely, long the coast.
- Only 8% of its original extent remains and it's under constant threat from urbanisation by Brazil's large cities of Rio di Janeiro and São Paolo.

- There is constant pressure from illegally built housing and also using the resources of the forest such as timber for fuel and for construction.
- Its present day area covers 99,944km^2 and of this 50% is now protected.
- Its biodiversity led to the forest being designated a Brazilian National Heritage Site in 1968 and a UNESCO World Biosphere Reserve in 1992. In 1999 it was highlighted as a biodiversity hotspot.

We do not know how many species exist on earth. This renders the mapping of biodiversity at best incomplete and at worst inaccurate. The mapping of such distributions is only a guideline to the more obvious areas of high biodiversity.

Criteria for hotspot designation

Hotspots must have a species richness of 0.5% or 1,500 of the world's recorded plant species, high levels of endemism usually above 50%, and severe levels of threat from human actions.

Ecosystems have value and importance in terms of biodiversity and ecological resources which should be illustrated with reference to a named global ecosystem, in terms of the goods and services that they provide to different groups. This includes recognition that biodiversity is not equally valued by all.

The value of ecosystems

Ecosystems are of enormous value to human wellbeing because of the range of services they offer. They provide the basic materials needed or subsistence such as food, freshwater, shelter and fuel, as well as contributing to human security, e.g. by mitigating the impact of disasters, and health e.g. through access to clean air and water.

Direct use values are the uses humans put biodiversity to in terms of consumption or production. Indirect uses include the services that biodiversity provides such as soil formation, supporting the food chain and the hydrological cycle. Aesthetic uses could be regarded as indirect uses or even as non-uses.

Researchers have attempted to quantify the direct and indirect values of ecosystem, but often players have very different views as to which is the greatest value of a particular ecosystem. This can lead to conflicts over their use.

Value of coral reefs

Coral reefs have a very high level of biodiversity. Vertical reefs rising from 25 metres offer a range of habitats and niches for an array of organisms, with some reefs being more biodiverse than others. South-East Asia is home to 30% of the world's coral reefs and has more than 700 species of coral out of an estimated world total of 1000. Overall, the coral reefs that are in or border the Pacific Ocean have the greatest biodiversity. They are thought to be older than those in the Atlantic Ocean.

Coral reefs are found in shallow seas (no deeper than 25 metres) with an average annual temperature of 18^{o}C. Corals are adversely affected if there is too much sediment flowing off the

land, perhaps due to deforestation, as it smothers and kills them. Where rivers flow off the land into the sea, there are no corals as they can only survive in saline water, but they also require a certain amount of wave action to oxygenate the water. Corals are animals, but they have a symbiotic relationship with algae known as zooxanthellae, for which coral acts as a host. The algae photosynthesise, therefore needing high light levels, and produce 95% of the nutrition for the coral.

Economic value

Coral reefs are worth US$352,250 per hectare per year. Healthy marine ecosystems mean food supply via fish and crustaceans. Healthy marine systems mean food supply via fish and crustaceans. We are only just beginning to understand how species can offer help for the future, such as the horseshoe crab, which has peptides in its blood which look like they may aid resistance to HIV in humans. A healthy ecosystem can reduce the financial impact of floods. Coral reefs provide a gene pool we may need to access in the future. The reefs provide coral and fish for the aquarium industry.

Cultural and aesthetic value

Coral reefs are an important attraction for tourism, which is a growing sector of the market. Snorkelling and scuba diving bring in income. Coral and shells are used for traditional crafts, although it is illegal to trade internationally in the raw material. The reefs also support education and scientific research, which is expanding our understanding of the natural world. A healthy ecosystem is required to support the lives of local people and help maintain traditional cultures which are usually more closely linked to nature. We should be able to pass on to our grandchildren the same resources we have had access to without damaging the earth.

Ecological value

Coral reefs are highly biodiverse ecosystems, known as the rainforests of the sea. A stable ecosystem is more likely as more organisms interact with each other and their environment. Loss of biodiversity makes ecosystem less stable and more vulnerable.

Value of forests

Forests are important for a number of reasons, including biodiversity, carbon storage and sequestration, watershed protection and wood products. However, in the past, forests provided an important springboard for northern hemisphere countries. Forests are now playing a similar role in many developing nations. That role is more critical in these regions because forests supply industrial wood, both for domestic consumption and for export to obtain foreign currency. At the same time, traditional goods and services such as fuel wood, food and medicines, continue to support the livelihoods of many rural populations. Millions of people in tropical and subtropical countries still depend entirely on forest ecosystems to meet their every need.

Economic value

Tropical rainforests are worth US$3013 per hectare per year. Healthy forests are a source of firewood. 90% of calories from the human diet come from 30 plants. Maintaining a genetic pool means we can access ecosystems for new medicines or foodstuffs – 25% of all drugs are from plants or are chemically modifies versions originally from plants. Only 1% of rainforest plants have been tested for medicinal uses. Pollinators, such as bees, are needed to help maintain fruit orchards. Resins, rubber and timber products can be extracted from healthy rainforests.

Cultural and aesthetic value

Recreational uses, such as walking and outdoor activities, are a common use of forests which add to the quality of life. A healthy ecosystem is required to support the lives of local people and help maintain traditional cultures which are usually more closely linked to nature. We should be able to pass on to our grandchildren the same resources we have had access to without damaging the earth.

Ecological value

Plants' ability to photosynthesise provides the base for food chains. Reduction of biodiversity reduces this ability. Ecosystems, particularly large forests, act as carbon sinks. Plant communities are essential components in the hydrological cycle – transpiration recycles water back into the atmosphere. Trees also act as interceptors and aid infiltration of rainfall. Can reduce flood impact. Wastes are broken down within ecosystems by bacteria as part of the nutrient cycling processes.