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THREATS TO BIODIVERSITY

What is biodiversity?

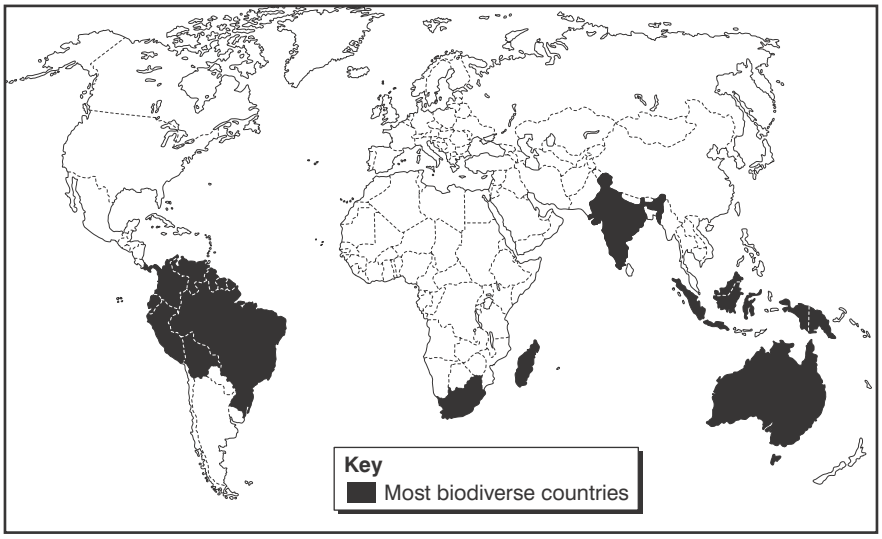
Biodiversity, or biological diversity, can be simply defined as the variety of life found on this planet. A more detailed definition can be found in the 1992 Convention on Biological Diversity, which states:

> 'Biological diversity means 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.'

Figure 1 shows the countries that exhibit the greatest biodiversity but to these must be added the so-called biodiversity hotspots. These are areas of particularly high biodiversity within countries and where many species are endemic, i.e. not found anywhere else. Twenty-five land-based hotspots have been suggested which take up 1.4% of the Earth's surface yet account for 44% of the its plants, 28% of its birds, 54% of its amphibians and 30% of its mammals.

Globally, almost 1.25 million species have been identified, yet the estimates for the total number of species in the world vary from 3,500,000 to over 100,000,000 (Figure 2).There have been declines in biodiversity in the past; in fact 90% of all the species that have ever lived are now extinct. What is different today is the rate at which extinctions are occurring. Since 1600 there have been 1,000 recorded extinctions of plants and animals, and of these 50% occurred in the twentieth century. Many species must have become extinct before we were even aware of their existence. 'Living dead' species are those that are so reduced in number that they cannot maintain a viable population – they are heading for extinction. An example is the **white wartyback mussel** found in Tennessee, USA. Once found widely in the waters of the Ohio river system, it has virtually disappeared throughout its range, affected by water pollution and the impact of dam construction on water and sediment flows. The last two aged adults of the species were recorded in 1987, and now the species is assumed to be extinct. The question is, does it matter?

Figure 1: World map showing countries with the most biodiversity



Why is biodiversity important?

We do not yet fully understand how biodiversity affects our lives, but we are becoming more aware of the importance of the natural world in sustaining our human existence. Figure 3 illustrates some of the values that biodiversity seems to have. If we do not yet know what we have on our planet in the way of species, it is difficult to identify all the threats and to come up with solutions in order to maintain biodiversity. The **'Rivet Theory'** proposes that the organisms in an ecosystem are like the rivets holding together an aeroplane. You can usually afford to lose a few rivets and the structure of the plane holds but there comes a point at which so many are lost that there is then a catastrophic collapse of the aeroplane (ecosystem). It is generally thought that stability within ecosystems comes from greater not lesser biodiversity. With fewer species, ecosystems cannot recover from disturbance as effectively. The main threats to biodiversity are summarised in Figure 4.

Habitat destruction

Most of the Earth's ecosystems have been modified in some way by human activities, and as the human population reached 6 billion during the final years of the 20th century, even more pressure was put on the natural ecosystems as people struggled to feed themselves and their families. Each year, 13 million hectares of forest are cleared, most of this destruction occurring in Africa and South America. A 5 km square of tropical rainforest contains 1,500 flowering plant, more than 50 tree, 400 bird and 150 butterfly species. Tropical rainforests cover about 7% of the land surface but hold 50% of the world's biodiversity. The loss each year of an area of rainforest equivalent to 31 million football pitches is also compromising the forests' ability to

Figure 2: Number of species identified, estimated total numbers and numbers under threat

Major group	Number identified	Estimated total	Number under threat 2007	% of group under threat
Vertebrates	4,500	50,000	5742	13
Plants	277,326	320,000	8,447	3
Insects	950,000	8,000,000	623	0.1
Bacteria	4,000	100,000	?	?
Viruses	4000	400,000	?	?

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Figure 3: The importance of biodiversity

ECOLOGICAL VALUE	ECONOMIC VALUE	CULTURAL/AESTHETIC VALUE
• The interactions of organisms with each other and their environment help make a stable environment. Loss of biodiversity makes ecosystems less stable and more vulnerable. • The ability of plants to fix the sun's energy and provide the base for food chains. Reduction of biodiversity reduces this ability. • Ecosystems, particularly large forests, act as carbon sinks. Absorb carbon dioxide and release oxygen. • Plant communities are essential in the hydrological cycle. Transpiration recycles water back into the atmosphere. Also act as interceptors and aid infiltration. Can reduce flood impact. • Wastes are broken down within ecosystems by bacteria.	• Healthy forests as a source of fuelwood. • Food supply. 90% of calories in human diet comes from 30 plants. • Maintaining genetic pool means we can access ecosystems for new medicines/foodstuffs. 25% all drugs are from plants (or are chemically modified versions originally from plants). • Only just beginning to understand how species can offer help for future. E.g. horseshoe crab – peptides in its blood look as if they will aid resistance to HIV in humans • Only 1% of rainforest plants have been tested for medicinal use so far. • Pollinators are needed to help maintain fruit orchards, for example. • Humans use large amounts of timber – need to have healthy forests to maintain this production. • A healthy ecosystem can help reduce financial impact of floods (see left).	• Leisure use. Many want access to natural ecosystems for walking, outdoor activities. Adds to quality of life. • Education and research- expanding our understanding of the natural world. • Supporting the lives of local peoples and helping maintain traditional cultures which are usually much more closely linked to nature. • Ethically we should be able to pass on to our grandchildren the same resources that we have had access to without damaging the Earth. • Sustainability.

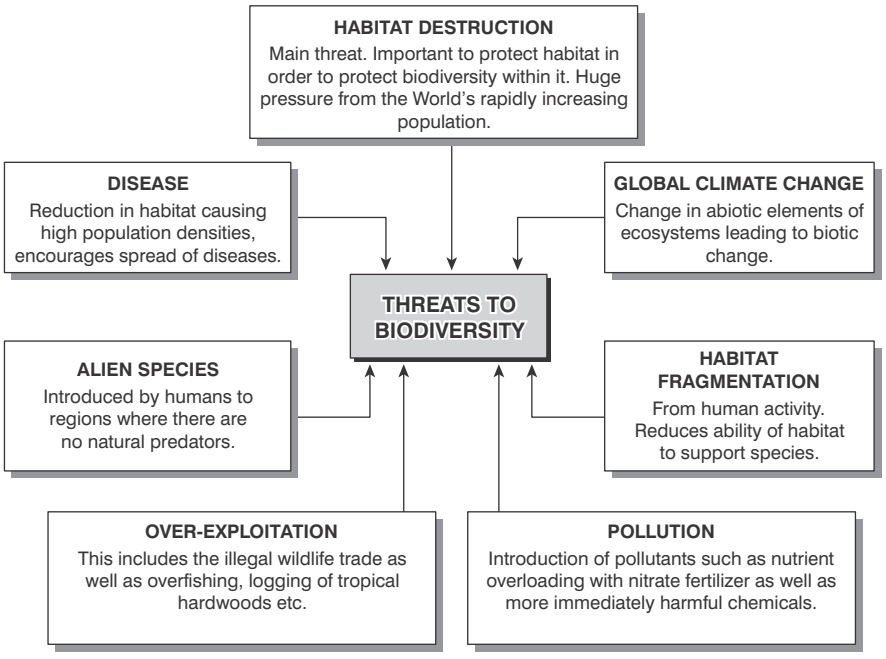
absorb carbon dioxide and to produce oxygen. The tropical forests are easily degraded; because most of the nutrients are in the biomass, when it is cleared, it leaves an impoverished soil which is easily washed away by the heavy rains. This makes it impossible for the original forest species to re-colonise the area.

Coral reefs are being destroyed by direct and indirect human action. They are regarded as the tropical forests of the sea and support a huge range of fish, bivalve and crustacean species. Dynamite fishing, coral mining, unsustainable tourism, pollution, sediment from de-vegetated slopes and damage from boat anchors have taken a heavy toll. As they die, the biodiversity of the seas is reduced.

The giant panda once ranged widely over south and central China but now is reduced to pockets of its habitat in the far west. The bamboo forests on which it depends reduced by 50% between 1974 and 1988. The main threats are logging and population pressure.

In the UK, intensive agricultural practices have led to old, flower-rich meadows being replaced with 'improved' pasture where land has been ploughed up and re-seeded with rye grass. The large biodiversity of the former is replaced in the latter by a vastly impoverished range of species.

Figure 4: The threats to biodiversity



Harvest mice numbers have been reduced, and a breeding programme for the species is now being carried out by Chester Zoo. They need the hedgerows and long stemmed plants found at the edges of fields in more traditionally run farms. Globally it is estimated that 50% of wetland areas worldwide have been lost since 1900 as farming has intensified in order to feed populations with a resultant loss of plants, fish and amphibian species.

The rapid development of countries such as China and India has led to huge demands for ores and minerals. Much of this exploitation is led by TNCs (transnational companies) who may not have a strong commitment to the environments of their host countries. Opencast mining for coltan (used in mobile phone technology) in the Democratic Republic of Congo is destroying large areas of irreplaceable rainforest.

Figure 5: Factors that can affect the vulnerability of species

FACTOR	IMPACT ON SURVIVAL
• Narrow geographic range.	• More easily wiped out. E.g. badwater snail – only found in a few shallow, salty lakes in Death Valley, California.
• Only small populations – maybe only one as in above.	• One event can destroy the majority of the species. E.g. the Rodriguez Island fruit bat. Almost wiped out by hurricanes. Now captive breeding programmes in zoos such as at Chester.
• Small breeding populations.	• Small gene pool. Problems of inbreeding. Species like giant panda also slow to breed.
• Having a very specialised niche.	• Pandas need to feed within bamboo forests, koalas only eat eucalyptus leaves. Vulnerable to habitat destruction.
• Having a need for a large hunting range.	• Species such as cougar/mountain lion need large areas to survive. More likely to come up against human occupation/activity. Seen as a threat.
• Species with large body size.	• Creatures such as elephants. More likely to compete directly with humans.
• Species that are directly used (hunted) by humans.	• Important keystone species such as krill in the Southern Ocean or species such as tigers whose body parts are in high demand for Chinese medicine.

Fragmentation

Closely linked to the threat of habitat destruction is the fragmentation of habitats. For example, 80% of the remaining ancient woodlands in England and Wales are individual pockets of less than 20 hectares. Fragmentation impacts on the ranges and breeding ability of some species. It is difficult to maintain breeding populations if habitat is broken up into small units, unless the fragments are linked by green corridors of e.g. hedgerows. The **minimum dynamic area** (MDA) is the smallest area needed for a species or an ecosystem to maintain itself independently: for example, the pine marten needs 230 hectares in order to set up a breeding territory, and the dormouse prefers woodland sites of more than 50 hectares.

Disease

Habitat fragmentation can lead to high densities of a species building up. This can cause a greater susceptibility to parasites and for disease to be transmitted. As wild species come into more contact with domestic animals there is a greater likelihood of diseases being transmitted, such as the TB link between domestic cattle and badgers, or canine distemper transmitted by dogs to the black footed ferrets of the USA (now thought to be virtually extinct in the wild). Higher densities also increase competition for food, and weaker animals may lose out on nourishment and succumb more readily to disease.

Climate change

Recent apparent warming of the climate in Europe is changing biodiversity. Flowers in the UK now often have a second 'spring' in autumn as a reaction to warmer temperatures. Some species of plant such as the bluebell are slowly moving northwards towards cooler temperatures. Early droughts in Europe are reducing toad and frog populations as ponds and other water bodies disappear or are greatly reduced in size. The problem for polar bears and the lack of ice floes in the summer Arctic is well documented. There is no longer enough ice for them to hunt seals from, and consequently bears are not laying up enough fat deposits for their winter hibernation, and mother bears cannot adequately feed their newborn cubs in the spring.

Global warming is melting the ice caps and causing glaciers to retreat, affecting many species, but also as sea levels rise, this is having a negative impact on coral reefs, which cannot survive in deep water. In some cases the sea level is rising faster than the corals can grow, leading to a loss of one of our most diverse ecosystems.

Global climate change also seems to be impacting on the frequency of the El Niño phenomenon and there are serious reductions in the size and variety of fish populations off the coast of Peru. Increased frequency of hurricanes is also being linked to climate change. This can affect many species, but especially those with a very limited range (see Figure 5).

Pollution

Human activity has added many new chemicals to the environment, often with negative impacts on natural systems. Use of nitrogen and phosphorus in chemical fertilisers has led to a nutrient overload in some water bodies and the serious problem of **eutrophication**, with its consequent reduction, sometimes total, of aquatic life. Some pesticides such as DDT, used in the control of mosquitoes, can build up through the food chain (**biomagnification**) and cause difficulties or even death for the top predators. In the case of DDT it led to birds such as ospreys and peregrine falcons laying eggs with abnormally thin shells, which were destroyed by the weight of the female incubating them. These species are only recently returning to secure numbers in the UK.

Acid rain, caused by the burning of fossil fuels, has caused a reduction of productivity in the boreal forests of Sweden and Norway as well as Germany and Poland. It can also cause some lakes to become so acidified that most aquatic life dies, leaving the water a lovely clear blue but devoid of life.

Over-exploitation

Logging, hunting and fishing are direct ways we use the natural ecosystems, but over-exploitation of these resources is leading to extinctions or massive reductions of species. In some cases it is realised later that an individual species has a greater importance because of its pivotal role within an ecosystem (known as keystone species). This is shown by the relationship of the sea otter with the forests of giant kelp off the west coast of the USA (Figure 6). The kelp, which

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is the base of a diverse and complex ecosystem, is continuously grazed by sea urchins, which are in their turn predated upon by the otter. Thus the kelp forests and all the associated fauna are maintained in balance. However, in the early twentieth century the otters were hunted almost to extinction for their fur, and as a result the sea urchin population exploded, destroying the kelp and its dependent ecosystem. This then impacted on the local fishing industry. The equilibrium is dependent on the otter, whose conservation is paramount to the kelp ecosystem. In the mid-twentieth century, sea otters were released near Monterey Bay and very soon the kelp forests began to return.

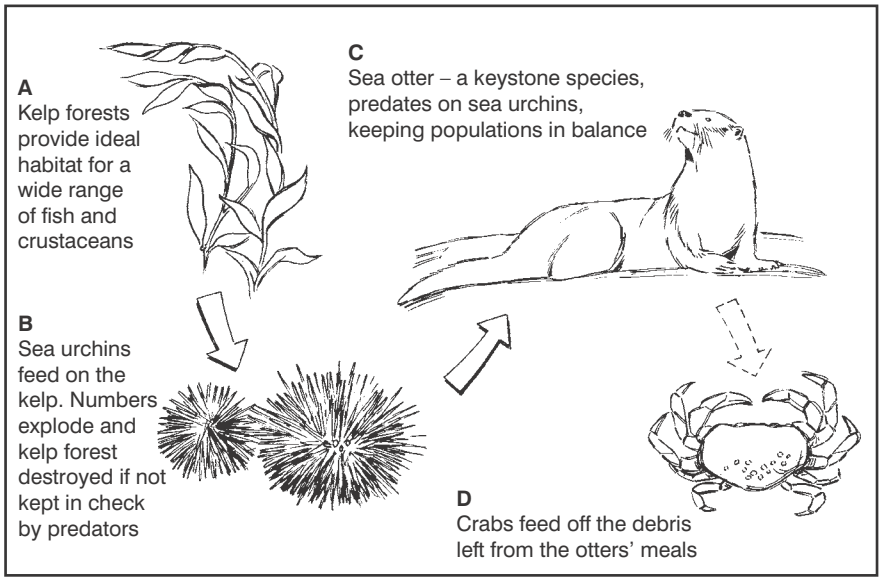
About 20% of the human population are dependent on fish as a main source of protein, but during the latter part of the twentieth century large-scale factory ships began to replace the more sustainable small-scale fishing that was carried out to serve local markets. It has been estimated that if fishing continues at its present rate, within 50 years the oceans will have reached the point of no return. The Grand Banks area off Newfoundland was once one of the most productive fishing areas of the world, but with the introduction of factory trawlers in the 1950s, over-fishing began. The cod stocks collapsed completely during the 1980s and there was a ban on all cod fishing from 1992, which resulted in 30,000 job losses. The cod stocks have still not recovered. The fishermen now say this is because of predation by harp seals, but cod only forms 3% of their diet. The trawl nets dragged along the seabed have destroyed huge swathes of marine ecosystem off Newfoundland and elsewhere where this type of fishing is also carried out, such as in the North Sea.

The UN Food and Agriculture Organisation (FAO) suggests that more than 70% of fish species are fully exploited or are depleted, and as yet we do not fully understand the impact this is having within the ocean ecosystems. As fishermen try to maintain their incomes there is an increase in illegal fishing, leading to further depletion.

Alien species

As humans have spread across the globe, they have transferred species from one area to another – sometimes deliberately, sometimes accidentally, as in ballast water in boats. Purple Loosestrife, an attractive wild flower of Europe, was introduced into the USA. However, it has few insect predators in its new home and has spread to all but the desert states and has earned the name of 'the purple peril'. One plant can produce 2.5 million seeds and it invades wetland habitats, shading out the local plants and affecting the ecosystem, reducing its biodiversity.

Figure 6: Food chain in the kelp forests, California



In New Zealand the introduced brushtail possum is an ecological nightmare. Protected in Australia, in New Zealand it has no predators and is causing widespread damage to the indigenous ecosystems. Each night the estimated 70 million possums eat 21,000 tonnes of vegetation, leaving large areas of forest damaged. This causes stress to the trees and dieback results. Possums are known to eat bird eggs and are also fond of nectar-filled flowers, which means that the indigenous birds are deprived of their food source and have declined hugely.

The zebra mussel was accidentally introduced into the USA in the 1980s in ballast water from the Caspian Sea. Today they form huge populations (up to 700,000 per square metre) within the freshwater lake and river systems, damaging fishing, reducing the capacity of dams and power plants, and dominating the local mussel species, to the detriment of the local ecosystems. Again they have no major predator in the USA.

Conclusion

The Earth's biodiversity is under threat from all sides, and in many cases those threats are increasing. However, at the same time we are beginning to understand more of the complexity of our ecosystems and the importance of preserving all species. The idea of sustainabilty is becoming embedded in much government planning and there is still a hope that we can leave a reasonably intact biosphere for future generations. We now understand that 'Extinct is for ever'.

Focus Questions

1. Outline some of the threats to biodiversity at the beginning of the 21st century.

2. To what extent can human use of biotic and abiotic resources impact negatively on the biodiversity of the world?

3. If biodiversity continues to decline, what are the likely implications for humans?