Points you may want to consider in your discussions:

- Unsustainable development can lead to species extinction. Given the five mass extinctions of the past, is this something that the human race should be concerned about?
- What effects could species extinctions have on human societies in years to come?

3.3 Threats to biodiversity

Significant idea

Global biodiversity is difficult to quantify but is decreasing rapidly due to human activity. Classification of species conservation status can provide a useful tool in conservation of biodiversity.

Big questions

As you read this section, consider the following big questions:

- To what extent have the solutions emerging from this topic been directed at preventing environmental impacts, limiting the extent of the environmental impacts, or restoring systems in which environmental impacts have already occurred?
- How are the issues addressed in this topic of relevance to sustainability or sustainable development?
- In what ways might the solutions explored in this topic alter your predictions for the state of human societies and the biosphere some decades from now?

Knowledge and understanding

- Estimates of the total number of species on the planet vary considerably. They are based on mathematical models, which are influenced by classification issues and lack of finance for scientific research, so many habitats and groups are significantly under-recorded.
- The current rates of species loss are far greater now than in the recent past, due to increased human influence. The human activities that cause species extinctions include habitat destruction, introducing invasive species, pollution, overharvesting, and hunting.
- The International Union of Conservation of Nature (IUCN) publishes data in the Red List of Threatened Species in several categories. Factors used to determine the conservation status of a species include: population size, degree of specialization, distribution, reproductive potential and behaviour, geographic range and degree of fragmentation, quality of habitat, trophic level, and the probability of extinction.
- Tropical biomes contain some of the most globally biodiverse areas and their unsustainable exploitation results in massive losses in biodiversity and their ability to perform globally important ecological services.
- Most tropical biomes occur in LEDCs and, therefore, there is conflict between exploitation, sustainable development and conservation.

How many species are there on Earth?

There are approximately 1.8 million described species stored in the world's museums. The actual number of species on the planet will be much larger than this, although the real figure can only be guessed at currently. It is impossible to get an accurate count on the number of species because the majority of the species that have yet to be discovered and described are very small: insects, and bacteria and other microbes.

Estimates of the total number of species on the planet vary considerably. They are based on mathematical models, which are influenced by classification issues and lack of finance for scientific research, so many habitats and groups are significantly under-recorded.

Estimates of global species numbers are based on mathematical models that extrapolate from known information. Lack of exploration of the deep sea and rainforest canopies, for example, means that knowledge of the total number of species on Earth is poorly understood, although estimates give an indication of the possible scale. Estimates range from 5 million to 100 million, with the scientific consensus currently being around 9 million species. This estimate is broken down as follows:

- animals: 7.77 million (12 per cent of which are described)
- fungi: 0.61 million (7 per cent of which are described)
- plants: 0.30 million (70 per cent of which are described)
- other species: 0.07 million.

Most described species belong to groups that have been studied extensively in the past – these tend to be the larger organisms (e.g. mammals, birds, flowering plants). Scientists have also focused on what they see as more appealing groups (e.g. those with fur or feathers). Smaller species that are more difficult to identify and study are less well represented, including some of the most species-diverse groups on the planet (insects, spiders, bacteria, fungi, etc.). Funds for taxonomic work (i.e. research into classifying organisms) in natural history museums and universities are generally limited. The lack of finance for scientific research, in terms of collecting specimens from the more inaccessible regions of the Earth and the necessary work needed to identify new species, means that many habitats and groups are significantly under-recorded. Estimations of total species numbers (and current extinction rates) are therefore based on limited data.

To learn more about the diversity of life on Earth through the Natural History Museum website, go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 3.4.

CONCEPTS: Biodiversity

The total number of species on the planet is unknown. Many areas remain unexplored, and research funding is limited.

Only 1 per cent of described species are vertebrates (Figure 3.16), yet this is the group that conservation initiatives are often focused on.

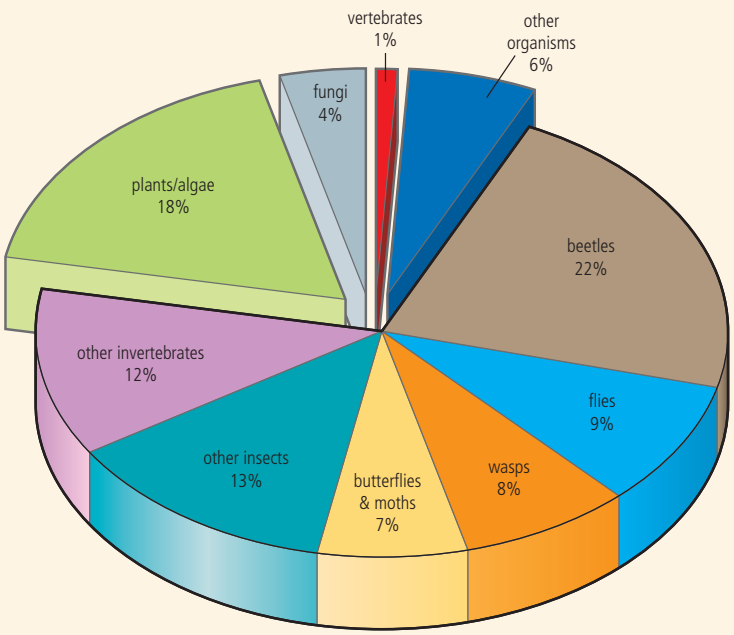


Figure 3.16 Of the total number of described species (about 1.8 million), excluding microbes, over three-quarters are invertebrates. Over half are insects. The most successful group are the beetles, which occupy all ecosystems apart from oceanic ones.

What are the current rates of species loss?

In order to understand how many species are currently going extinct, existing species must be identified and named. Experts who study specific groups of organisms (e.g. moths, beetles, and birds) are found in centres of excellence around the world, as are reference collections. For taxonomy to succeed, scientists from around the world must work together, and major surveys must be carried out using international teams of specialists.

Estimates of extinction rates are varied, but current extinction rates are thought to be between 100–10 000 times greater than background rates. Estimates range from 30 000 to 60 000 species a year.

We know that mass extinction events have happened in the past, but what do we know of current extinction rates? Throughout the history of the Earth, diversity has never remained constant; there have been a number of natural periods of extinction and loss of diversity. More recently, humans have played an increasing role in diversity loss, especially in biodiverse ecosystems such as rainforests and coral reef.

The background (natural) level of extinction known from the fossil record is between 10 and 100 species per year. Human activities have increased this rate. Because the total number of classified species is a small fraction of the estimated total of species, estimates of extinction rates are also varied. Estimates from tropical rainforest suggest the Earth is losing 27 000 species per year from those habitats alone. The rate of extinction differs for different groups of organisms, but examining the figures for one group (mammals) gives an indication of the extent of the problem. Mammal species have an average species lifespan, from origin to extinction, of about 1 million years. There are about 5000 known mammalian species alive at present. The background extinction rate for this group should be approximately one species lost every 200 years. Yet the past 400 years have seen 89 mammalian extinctions, almost 45 times the predicted rate, and another 169 mammal species are listed as critically endangered.

Causes of species loss

Natural causes

Natural hazard events such as volcanoes, drought, ice ages, and meteor impact have led to periods of loss of diversity. The eruption of Krakatau caused a dust plume that reduced sunlight over large areas of the globe, reducing surface temperatures. Changes in the Australian climate through tectonic movement and global warming have caused increased frequency of fires and a general drying of the continent that have led to the prevalence of drought and fire-tolerant species (e.g. *Acacia* and *Eucalyptus*) and the extinction of other species.

Changes in the orbit of the Earth and its tilt, plus tectonic movement, have led to repeated long-term cold periods (Figure 3.17),

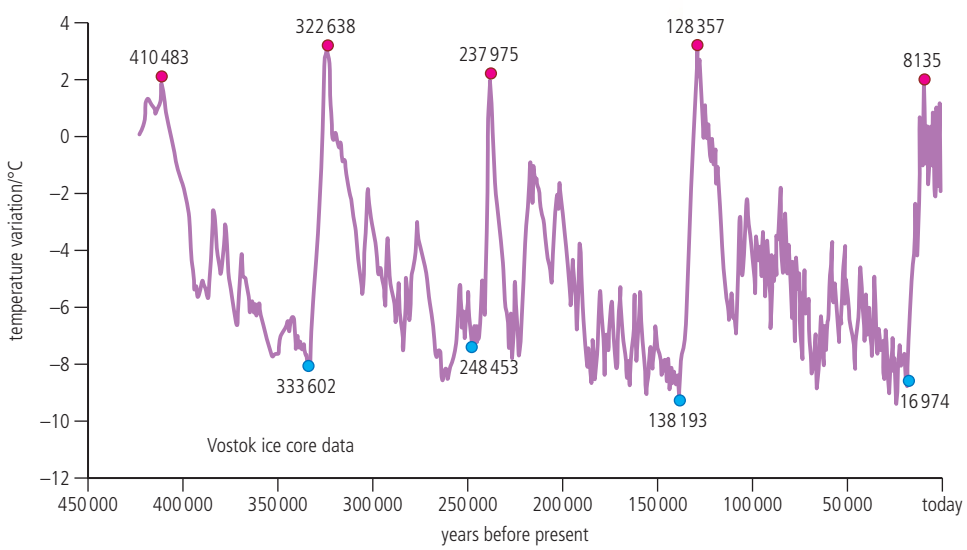


Figure 3.17 Variation in the temperature of the Earth taken using data from ice in the Antarctic. Major ice ages have occurred about every 100 000 years.

which have resulted in the selection of species adapted to the colder conditions and extinction of less-adapted species. One reason for the success of mammals is their ability to generate their own heat and control their temperature, which has enabled them to survive in colder environments and through ice ages.

The current rates of species loss are far greater than in the recent past, due to increased human influence. The human activities that cause species extinctions include habitat destruction, introduction of invasive species, pollution, overharvesting, and hunting.

Human causes

CONCEPTS: Biodiversity

Global biodiversity is difficult to quantify but is decreasing rapidly due to human activity.

Habitat destruction

This includes habitat degradation, fragmentation, and loss. Agricultural practices have led to the destruction of native habitats and replaced them with monocultures (i.e. crops of only one species). Monocultures represent a large loss of diversity compared to the native ecosystems they replace. However, increasing awareness of this has led to the re-establishment of hedgerows and undisturbed corridors that encourage more natural communities to return.

Hedgerows (left of photo) provide habitats for native species. They also act as corridors for the movement of species from one area to another.

Non-specific pesticides used in agriculture can wipe out native as well as imported pest species (i.e. alien species that have been introduced into a country), which again leads to an overall loss of diversity.

Habitats can be lost through mining activities. Mobile phones contain an essential element (tantalum) which is obtained by mining coltan (a metallic ore that contains the elements niobium and tantalum). Coltan is found mainly in the eastern regions of the Democratic Republic of Congo – mining activities in these areas have led to extensive habitat destruction of forests that contain gorillas and other endangered animals.

Natural habitats have also been cleared to make way for plantation crops. Sugar plantations have replaced tropical forest ecosystems, such as mangrove in Australia (page 185), and oil palm plantations throughout South East Asia have led to the widespread loss of tropical forests (page 174).

Introduction of invasive species

Species that are introduced to areas and compete with endemic (native) species: this can lead to the extinction of the native species. The grey squirrel was introduced into the UK from North America. This species competes with native red squirrel and has led to such a reduction in red squirrel numbers that the animal is now rare. Introduced

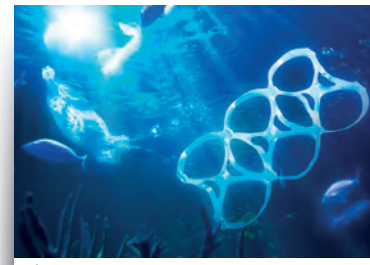
red-clawed signal crayfish (*Pacifastacus leniusculus*), a large, aggressive American species, has wiped out almost 95 per cent of the native UK white-clawed species (*Austropotamobius pallipes*) since its introduction in the late 1970s.

Pollution

Pollution includes chemicals, litter, nets, plastic bags, oil spills, and so on. Pollution damages habitats and kills animals and plants, leading to the loss of life and reduction in species' population numbers.

Overharvesting and hunting

Animals are hunted for food, medicines, souvenirs, fashion, and to supply the exotic pet trade. Overharvesting of North Atlantic cod in the 1960s and 1970s led to significant reduction in population number (Chapter 4, page 240).



Sea polluted with plastic garbage

TOK

Why do people continue to damage the environment even when they know the effects on natural systems? Do people truly understand the consequences of their actions?

Threats to tropical biomes

A mangrove forest

Tropical biomes contain some of the most globally biodiverse areas and their unsustainable exploitation results in massive losses in biodiversity and their ability to perform globally important ecological services.

Tropical biomes include some of the most diverse on Earth, such as tropical rainforests (page 104) and coral reef (page 110). Coastal areas may have areas of mangrove forest that provide natural protection against the sea: mangroves provide a natural filter to sediment run-off from the land and stop erosion into the sea. Many are found within tropical biomes are termed 'biodiversity hotspots' (page 153) as they contain large numbers of species, often endemic to the area (i.e. not found anywhere else).

Tropical rainforests are characterized by long wet seasons and tall trees and plants that grow year-round. These forests presently cover 5.9 per cent of the Earth's land surface (around 1.5 per cent of the entire Earth's surface). In the tropics, the Sun's rays are the most concentrated and shine for nearly the same number of hours every day of the year: this makes the climate warm and stable. About 33 per cent of all rainforest is in the Amazon Basin, 20 per cent is found in Africa and a further 20 per cent in Indonesia (Figure 2.35, page 104). The remainder is scattered around the world. High levels of light and water make rainforests very productive. This explains why they can support such high biomass and wide diversity of life.

As you saw in Chapter 2, rainforests are complex ecosystems with many layers: emergent trees, the canopy, the understory and the ground (page 105). The complex layered structure of rainforests enables them to support many different niches (i.e. many different ways of living). Over 50 per cent of the world's plant species and 42 per cent of all terrestrial vertebrate species are endemic to 34 identified biodiversity hotspots (the majority of which are rainforests). In addition to their biodiversity value, tropical biomes such as rainforest provide many ecosystem functions. For example, they prevent soil erosion and nutrient loss, control the local water cycle (water evaporates from leaves in rainforest and falls locally as rain), act as carbon sinks (locking up in trees and other vegetation carbon that would otherwise be in the atmosphere), and so on. You can remind yourself of ecosystem services on page 43).

Human impact, both direct and indirect, on the world's rainforests is having a major effect on species survival. Uncontrolled hunting (for bush-meat and reasons such as the exotic pet trade) is removing large species and creating an 'empty forest syndrome' – the trees are there but the large species have disappeared. The replacement of natural tropical rainforest by oil palm plantations is replacing a diverse ecosystem with a monoculture ecosystem.

Tropical biomes are under constant threat, with large areas are being lost. An average of 1.5 ha (the size of a football pitch) of tropical rainforest is lost every 4 seconds. Deforestation and forest degradation are driven by external demands for timber, beef, land for crops such as soya and oil palm, and biofuels. Developing 'carbon markets' – which value ecosystems as stores of carbon (in vegetation) – could provide the means to give sufficient monetary value to rainforests to help protect them.

Rainforests have thin, nutrient-poor soils (Chapter 2, page 105). Because there are not many nutrients in the soil, it is difficult for rainforests to re-grow once they have been cleared. Studies in the Brazilian Atlantic forest have shown that parts of the forest can return surprisingly quickly – within 65 years – but for the landscape to truly regain its native identity takes a lot longer – up to 4000 years. Recovery depends on the level of disturbance – a large area of cleared land will take a lot longer to grow back (if at all) than small areas which have been subject to shifting cultivation (Chapter 5, pages 287–288). Forest which has been selectively harvested for timber (only large trees have been removed) can grow back rapidly if not too much timber has been removed. A larger amount of timber removal may mean that the forest never fully recovers because fast-growing, light-loving species (such as vines and creepers) block out the light for slow growers, so the forest remains at a sub-climax level.

Case study

Oil palm and habitat destruction

By 2020, Indonesia's oil palm plantations are projected to triple in size to 16.5 million hectares. Many conservationists believe that this, in Indonesia and other countries, will lead directly and indirectly to the further clearance of a huge area of rainforest.

Oil palm is the second most traded vegetable oil crop after soy. Over 90 per cent of the world's oil palm exports are produced in Malaysia and Indonesia, in areas once covered by rainforest and peat forest. Oil palm is traditionally used in the manufacture of food products, but is now increasingly used as an ingredient in bio-diesel. It is also used as biofuel burned at power stations to produce electricity. This new market has the potential to dramatically increase the global demand for oil palm. In the UK, the conversion of just one oil-fired power station to palm oil could double UK imports. The 6.5 million hectares of oil palm plantation across Sumatra and Borneo is estimated to have caused the destruction of 10 million hectares of rainforest – an increase in demand for palm oil as a biofuel would further increase the threat to natural ecosystems unless checks and balances are put in place.

Land use in tropical areas is a contentious issue. The widespread clearance of natural ecosystems so that land can be made available for plantations leads to biodiversity loss, although the plantations provide valuable financial income (something that the natural ecosystems on their own may not do). Diversification of the local economy into areas such as ecotourism can provide alternative sources of income and take pressure off local habitats, as would the development of conservation areas (page 194).

Some species, such as tree frogs, spend all their time in the rainforest canopy; they never reach the forest floor, so are not commonly seen. *Rhacophorus gadingensis* was recently discovered in a remote forest reserve in the centre of the island of Borneo.

The recently discovered rainforest tree frog, *Rhacophorus gadingensis*

TOK

In order to establish the species that exist in an area, populations must be sampled. When sampling populations of abundant, small, and poorly understood species (e.g. insects), specimens must be returned to natural history museums for identification – animals are killed in the process. Does this raise ethical issues, or does the end justify the means?

The rate of loss of biodiversity may vary from country to country depending on the ecosystems present, protection policies and monitoring, environmental viewpoints, and the stage of economic development.

Conflict between exploitation, sustainable development, and conservation in tropical biomes

MEDCs have the luxury of being able to preserve their remaining natural ecosystems as they do not rely on these areas to provide income. In addition, MEDCs cleared the majority of their natural ecosystems (i.e. climax communities) in the past (e.g. in the UK the native forests were cleared to provide land for agriculture and timber to build ships) and so the argument for preserving the remaining diversity is on a different scale to the needs of LEDCs where most tropical biomes are found. For sustainable development to take place in LEDCs, there needs to be a balance between conserving tropical biomes and using the land to provide income for the local economy.

One of the traditional incomes from tropical rainforests was timber. At the peak of logging operations in Borneo, for example, trees were removed in large numbers: in terms of volume, up to 100 m^3 of wood per hectare. Conventional logging methods were not selective and caused damage to the remaining forest. More recently, selective logging methods (also known as reduced-impact logging – RIL) have been used. These techniques cause less damage, allow faster regeneration of forest, and preserve forest structure and biodiversity better than conventional methods.

Most tropical biomes occur in LEDCs and therefore there is conflict between exploitation, sustainable development, and conservation.

You need to be able to evaluate the impact of human activity on the biodiversity of tropical biomes. You also need to be able to discuss the conflict between exploitation, sustainable development, and conservation in tropical biomes.

Ecotourism is also a way of providing ongoing income without destroying natural capital (e.g. the Great Barrier Reef, page 184).

LEDCs obviously wish to grow their economies and head towards MEDC status, but the resulting conflict between exploitation, sustainable development and conservation can always be resolved providing there is local support and the political will to protect biodiversity before it is lost forever.

Case study

CAMPFIRE in Zimbabwe

The Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) is a Zimbabwean community-based management programme, which assists rural development and conservation. CAMPFIRE is helping people manage their environment in a sustainable way. Approximately 12 per cent of the natural habitats of Zimbabwe are in **protected areas** and when these were set up, local people were relocated to surrounding areas. When wildlife, such as elephants, leave the parks and enter inhabited areas, conflicts can arise. CAMPFIRE encourages people to see their local wildlife as a resource rather than as a nuisance.

Five main activities help provide extra income to local communities.

- Trophy hunting – professional hunters and safari operators are allowed into the areas; 90 per cent of CAMPFIRE's income is raised this way.
- Sale of wildlife – some areas with high wildlife populations sell animals to national parks or game reserves (e.g. one district raised US$50 000 by selling 10 roan antelope).
- Harvesting natural resources – a number of natural resources such as river-sand and timber are harvested and sold.
- Tourism – income from tourists is now being redirected to local communities; some local people are employed as guides or run local facilities for tourists.
- Selling wildlife meat – some species are abundant (e.g. impala); the National Parks Department supervise killing and selling skins and meat.

The International Union of Conservation of Nature (IUCN) publishes data in the Red List of Threatened Species in several categories.

Determining conservation status

The Red List

For more than four decades, IUCN (page 193) has published documents called the *Red Data Books*. The books assess the **conservation status** of particular species in order to highlight plants and animals threatened with extinction, and to promote their conservation. Known informally as the **Red List**, the books are essentially an inventory of all threatened species. The genetic diversity represented by these plants and animals is an irreplaceable resource which the IUCN is looking to conserve through increased awareness. These species also represent key building blocks of ecosystems, and information on their conservation status provides the basis for making informed decisions about conserving biodiversity from local to global levels.

The purposes of the Red List are:

- to identify species requiring some level of conservation
- to identify species for which there is concern about their conservation status
- to catalogue plants and animals facing a high risk of global extinction
- to raise awareness of animals and plants that face a higher risk of global extinction than others and require conservation efforts.

Factors used to determine a species' Red List conservation status

Various factors are used to determine the conservation status of a species, and a sliding scale operates (from severe threat to low risk). The range of factors used to determine conservation status includes the following.

- *Population size*
  Smaller populations are more likely to go extinct. Species with small populations also tend to have low genetic diversity – inability to adapt to changing conditions can prove fatal. Many of the large cat species are in this category (e.g. cheetah, snow leopard, and tiger).

- *Trophic level*
  Top predators are sensitive to any disturbance in the food chain and any reduction in numbers of species at lower trophic levels can have disastrous consequence (e.g. snow leopard, Chapter 2 page 85). Also, because of the '10 per cent rule' of energy loss through ecosystems (Chapter 2, pages 89–90), large fierce animals tend to be rare and are therefore particularly sensitive to hunters and reductions in population size.

- *Reduction in population size*
  A reduction in population size may indicate that a species is under threat. For example, numbers of European eel (*Anguilla anguilla*) are at their lowest levels ever in most of its range and it continues to decline.

- *Degree of specialization*
  Many species have a specific diet or habitat requirements: if their specific resource or habitat is put under threat, so are they. Some animals can only live on certain tree species, such as the palila bird (a Hawaiian honeycreeper), which is dependent on the mamane tree (*Sophora chrysophylla*) for its food and is losing habitat as the mamane tree is cut down. Other examples include the giant panda (dependent on bamboo) and the koala (dependent on a particular eucalypt).

- *Geographic range*
  Species that occupy a restricted habitat are likely to be wiped out. For example, the slender-billed grackle (*Cassidix palustris*), a bird which once occupied a single marsh near Mexico City, was driven to extinction when a reduction in the water table drained the marsh.

- *Distribution*
  Species that live in a small area are under greater threat from extinction than those that are distributed more widely. Loss of the area they live in will lead to loss of the species. Golden lion tamarin monkeys (*Leontopithecus rosalia*) are only found in one small area of southern Brazil, and are therefore especially prone to extinction. Any change in the habitat of a species with a limited area of occupancy (e.g. deforestation of the Mata Atlântica), or a small decrease in population size, could lead to their extinction.

- *Reproductive potential and behaviour*
  Animals that live a long time and have long gestation times, for example elephants and rhinos, have low rates of reproduction, and can take many years to recover from any reduction in population number. This makes them vulnerable to extinction. If a change in habitat or the introduction of a predator occurs, the population drops and there are too few reproductive adults to support and maintain the population.

Factors used to determine the conservation status of a species include: population size, degree of specialization, distribution, reproductive potential and behaviour, geographic range and degree of fragmentation, quality of habitat, trophic level, and the probability of extinction.

Because they are slow-reproducing, any loss in numbers means a fast decline. The Steller's sea cow was heavily hunted and unable to replace its numbers fast enough. Orang-utans have one of the slowest reproductive rates of all mammal species: they give birth to a single offspring only once every 6 to 8 years; with such a low reproductive rate, even a small decrease in numbers can lead to extinction.

- *Degree of fragmentation*
  Species in fragmented habitats may not be able to maintain large enough population sizes. The Sumatran rhinoceros (*Dicerorhinus sumatrensis*) lives in tropical rainforest in South East Asia. Fragmentation of the forest through deforestation and conversion to plantation forest, has led to a reduction in habitat area for this species.

- *Quality of habitat*
  Species that live in habitats that are poorer in quality are less likely to survive than species in habitats that are better in quality. For example, the fishing cat (*Prionailurus viverrinus*) is found in South East Asian wetland areas where it is a skilful swimmer: drainage of wetlands where it lives for agriculture has led to a reduction in habitat quality.

- *Probability of extinction*
  Even without human intervention, many species are likely to go extinct and so are of especial need of conservation efforts.

Irrespective of human interference, any animal or plant which is rare, has a restricted distribution, has a highly specialized habitat or niche, or a low reproductive potential, or is at the top of the food chain, is prone to extinction.

Puya raimondii, also known as 'Queen of the Andes', is a spectacular high-Andean plant found from Peru to Bolivia. Reasons for being on the Red List: isolated and very small population size; seeds only once in 80 years before dying; climate change may be limiting its ability to flower.

The peacock parachute tarantula (*Poecilotheria metallica*) is known from a single location in the Eastern Ghats of Andhra Pradesh in India. Reasons for being on the Red List: restricted range and habitat loss caused by logging for firewood and timber.

The Indri (*Indri indri*) is a primate from Madagascar. Reasons for being on the Red List: loss of its rainforest habitat (to supply fuel and timber and to make way for slash-and-burn agriculture); greatly reduced population numbers (estimated to be a 50 per cent reduction over the last 36 years).

The fishing cat (*Prionailurus viverrinus*) is found in South East Asian wetland areas where it is a skilful swimmer. Reasons for being on the Red List: loss of habitat (due to human settlement, draining of wetlands for agriculture, pollution, excessive hunting, woodcutting); over-fishing leading to a reduction in fish stocks is likely to be a significant threat to this species as it relies heavily on fish for its survival.

The European eel (*Anguilla anguilla*) is at an historical low in most of its range and it continues to decline. Reasons for being on the Red List: low population number caused by over-fishing; the introduction of a parasitic nematode which may affect the ability of eels to reach their spawning grounds; dam construction for hydropower has blocked migration routes.

Sometimes conservation actions come too late. Below are listed some common reasons for extinction and examples of species that went extinct because of them.

- Small habitat area (not enough area for species to survive) – Holdridge's toad, St Helena olive, Percy Island flying fox.
- Narrow geographic area – golden toad (page 184).
- Poor competitor – Holdridge's toad (deaf and mute), dodo (cannot fly).

A dodo

- Human intervention – dodo (introduction of rats), thylacine (introduction of non-native species such as dogs), desert rat kangaroo.

A thylacine (Tasmanian tiger)

- Disease (the introduction of a non-native disease so no local immunity) – Darwin's Galápagos mouse.
- Hunting (over-hunting of species to extinction) – Bali tiger, passenger pigeon, thylacine, western black rhino, Queen of Sheba's gazelle, Madagascan pygmy hippo, Steller's sea cow.

A passenger pigeon

- Shallow gene pool (little or no genetic variation so little chance to adapt to changing environment) – north elephant seal, saiga antelope.
- Coextinction (loss of one species causes extinction of another) – the bird lice found on passenger pigeons went extinct when their hosts did.

This topic raises some engaging issues of debate concerning the moral justification for exploiting species and the moral imperative for conserving them. Think carefully about the following questions (there are no correct answers).

TOK

- Do some organisms have more of a right to conservation than others? How can this be justified?
- Do pandas have a greater right to conservation than lichens?
- Do 'pests' or pathogenic organisms have a right to be conserved?
- To what extent are these arguments based on emotion and to what extent on reason? And how does this affect their validity?

Extinct, critical, and back from the brink

You need to be able to discuss the case histories of three different species: one that has become extinct due to human activity, another that is **critically endangered**, and a third species whose conservation status has been improved by intervention. In each case, the ecological, socio-political or economic pressures that are impacting on the species should be explored. The species' ecological roles and the possible consequences of their disappearance should be considered.

Case study

Extinct: Falkland Islands wolf

The Falkland Islands wolf

Description

The Falkland Islands wolf was the only native land mammal of the Falkland Islands. The islands were first sighted in 1692. In 1833, Charles Darwin visited the islands and described the wolf as 'common and tame'.

The genus name, *Dusicyon*, means 'foolish dog' in Greek (Dusi = foolish, cyon = dog).

Ecological role

The Falkland Islands wolf is said to have lived in burrows. As there were no native rodents on the islands (the usual wolf prey), it is probable that its diet consisted of ground-nesting birds (such as geese and penguins), grubs, insects, and some seashore scavenging.

Pressures

The many settlers of the Islands (mainly the Scottish inhabitants, but also the French and some English) considered the Falkland Islands wolf a threat to their sheep. A huge-scale operation of poisoning and shooting the wolf began with the aim of leading it to extinction. The operation was successful very rapidly, assisted by the lack of forests and the tameness of the animal (due to the absence of predators, the animal trusted humans who would lure it with a piece of meat and then kill it).

Consequences of disappearance

The Falkland Islands wolf was not particularly threatening nor was it a significant predator, although the removal of a top predator would have had an impact on the rest of the food chain (e.g. increase in population of its prey).

Case study

Critically endangered: Iberian lynx

The Iberian lynx

Description

The Iberian lynx (*Lynx pardinus*) is also known as the Spanish lynx and is native to the Iberian Peninsula. It has distinctive, leopard-like spots with a coat that is often light grey or various shades of light brownish-yellow. It is smaller than its northern relatives such as the Eurasian lynx, and so typically hunts smaller animals, usually no larger than hares. It also differs in habitat choice, inhabiting open scrub whereas the Eurasian lynx inhabits forests.

Ecological role

The Iberian lynx is a specialized feeder, and rabbits account for 80–100 per cent of its diet. Lynx often kill other carnivore species, including those regarded as pests by humans, such as feral cats and foxes, but do not eat them.

Pressures

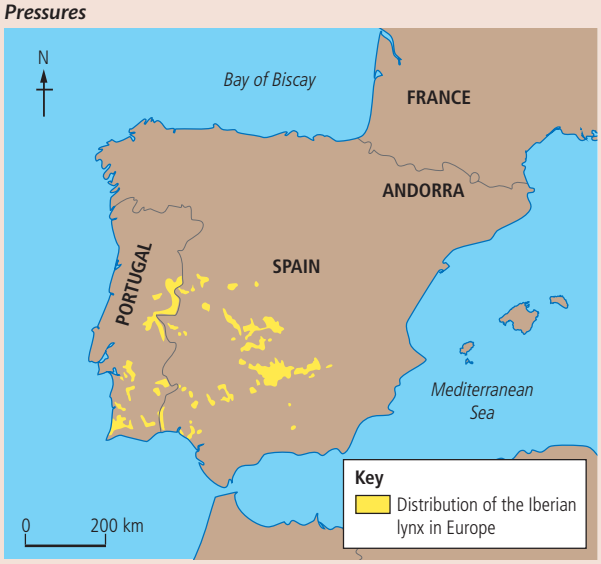


Figure 3.18 The present day distribution of the Iberian lynx in Europe

The lynx's highly specialized diet makes it a naturally vulnerable species and the rapid decline in rabbit populations since the 1950s has had a direct impact on lynx numbers. The Iberian lynx occurs only in isolated locations of Spain and possibly Portugal (Figure 3.18). Habitat destruction, deterioration, and alteration have impacted negatively on the lynx for centuries. The Iberian lynx were protected from hunting in the early 1970s, since when hunting has declined. Some lynxes are still shot and killed in traps and snares set for smaller predators, particularly on commercial hunting and shooting estates.

Methods of restoring population

The Iberian lynx is fully protected under national law in Spain and Portugal, and public awareness and education programmes have helped to change attitudes towards the animal, particularly among private landowners. Two international seminars have been held (2002 and 2004) to establish a coordinated strategy to save the Iberian lynx from extinction. A captive breeding programme has been started in Spain. In Portugal, the National Action Plan foresees a reintroduction programme. The construction of facilities for breeding and reintroduction has been prepared. Further protection stems from the fact that one lynx's endemic areas has been turned into the Doñana National Park.

Case study

Improved by intervention: American bald eagle

The American bald eagle

Description

The bald eagle (*Haliaeetus leucocephalus*), also known as the American eagle, was officially declared the National Emblem of the United States in 1782. It was selected by the Founding Fathers of the USA because it is a species unique to North America. It has since become the living symbol of the USA's spirit and freedom.

Bald eagles are one of the largest birds in North America with a wing span of 6–8 feet. Females tend to be larger than males. They live for up to 40 years in the wild, and longer in captivity. Bald eagles are monogamous and have one life partner.

Ecological role

Bald eagles live near large bodies of open water such as lakes, marshes, seacoasts, and rivers. They nest and roost in tall trees. The eagles live in every US state except Hawaii. They use a specific territory for nesting, winter feeding, or a year-round residence. Their natural domain is from Alaska to California, and from Maine to Florida. Bald eagles that live in the northern USA and Canada migrate to the warmer southern areas during the winter to obtain easier access to food. Some bald eagles that live in the southern states migrate slightly north during the hot summer months. They feed primarily on fish, but also eat small animals (ducks, coots, muskrats, turtles, rabbits, snakes, etc.) and occasional carrion.

Pressures

Bald eagle population numbers have been estimated to have been 300 000 to 500 000 birds in the early 1700s. Their population fell to fewer than 10 000 nesting pairs by the 1950s, and to fewer than 500 pairs by the early 1960s. This population decline was caused by the mass shooting of eagles, the use of pesticides on crops, the destruction of habitat, and the contamination of waterways and food sources by a wide range of poisons and pollutants. For many years, the use of DDT pesticide on crops caused thinning of eagle egg shells, which often broke during incubation.

Methods of restoring population

The use of DDT pesticide was outlawed in the USA in 1972 and in Canada in 1973. This action contributed greatly to the return of the bald eagle.

The bald eagle was listed as 'endangered' in most of the USA from 1967 to 1995. The number of nesting pairs of bald eagles in 48 of the states increased from fewer than 500 in the early 1960s to over 10 000 in 2007. That was enough to remove them from the list of threatened species on 28 June 2007.

Since de-listing, the primary law protecting bald eagles has shifted from the Endangered Species Act to the Bald and Golden Eagle Act. Although bald eagles have made an encouraging comeback throughout the USA since the early 1960s, they continue to be face hazards that must be closely monitored and controlled. Even though it is illegal, bald eagles are still harassed, injured, and killed by guns, traps, power lines, windmills, poisons, contaminants, and destruction of habitat.

CONCEPTS: Strategy

Carefully planned strategies are needed to improve the conservation status of critically endangered species: these strategies need to address the ecological, socio-political or socio-economic pressures that are impacting on the species.

The golden toad

A species first discovered in 1966 was recorded as extinct by the IUCN in 2004. The golden toad (*Incilius periglenes*) was a small, shiny, bright toad that was once common in a small region of high-altitude, cloud-covered tropical forests, about 30 km^2 in area, above the city of Monteverde in Costa Rica. The last recorded sighting of the toad was in 1989. Possible reasons for its extinction include a restricted range, global warming, airborne pollution, increase in UV radiation, fungus or parasites, or lowered pH levels.

CHALLENGE YOURSELF

ATL Research skills

Research and summarize the case history of three different species: one that is extinct, one that is critically endangered, and a third species whose conservation status has been improved by intervention. For each, list the ecological, socio-political, and economic pressures that are involved, and outline the possible consequences of their disappearance on the ecosystem.

You need to be able to describe the threats to biodiversity from human activity in a given natural area of biological significance or conservation area.

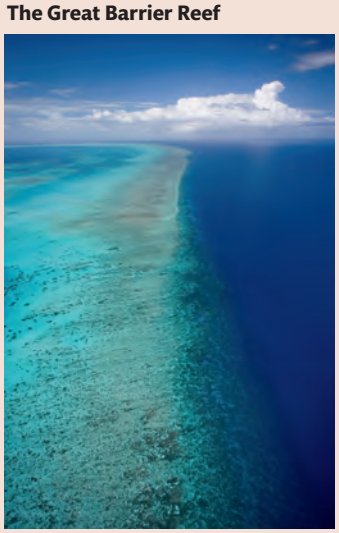
Threats to an area of biological significance

The Great Barrier Reef Marine Park is 345 000 km^2: larger than the entire area of the UK and Ireland combined. The reef is the world's biggest single structure made by living organisms and is large enough to be seen from space. The Great Barrier Reef is an important part of the Aboriginal Australian culture and spirituality. It is also a very popular destination for tourists, especially in the Cairns region, where it is economically significant. Fishing also occurs in the region, generating AU$1 billion per year.

Case study

The Great Barrier Reef

The Great Barrier Reef



Coral reef, like rainforest, is amazingly diverse (and for similar reasons – such as its location, complexity, and high productivity). The Great Barrier Reef stretches 2300 km along the Queensland coastline of northern Australia. It is home to 1500 species of fish, 359 types of hard coral, a third of the world's soft corals, 6 of the world's 7 species of threatened marine turtle and more than 30 species of marine mammals including vulnerable dugongs (sea cows). In addition, there are 5000 to 8000 molluscs and thousands of different sponges, worms and crustaceans, 800 species of echinoderms (starfish, sea urchins) and 215 bird species, of which 29 are seabirds (e.g. reef herons, ospreys, pelicans, frigate birds, and shearwaters).

There are many and varied threats to this ecosystem.

Human threats

Ecological, socio-political, and economic pressures are causing the degradation of the coral reef, and as a consequence are threatening the biodiversity of the area. Tourism is now a major contributor to the local economy, but tourism can have

negative impacts: coral is very fragile and is easily damaged by divers' fins and anchors. Although it is illegal to take pieces of coral from the country of origin, tourism inevitably leads to coral being damaged as tourists break bits off for souvenirs. As the sea is rich in fish, over-fishing can disrupt the balance of species in the food chain and there may also be accidental damage from anchors and pollution from boats. Seafloor trawling for prawns is still permitted in over half of the marine park, resulting in the unintentional capture of other species and also the destruction of the seafloor.

Land use in Australia has shifted from low-level subsistence agriculture to large-scale farming. Queensland has extensive sugar plantations where once forests stood. The plantations need heavy input of fertilizers and pesticides, so now run-off from the soils into the sea has caused inorganic nitrogen pollution to increase by 3000 per cent. Combined with sewage and pollution from coastal settlements such as Cairns, this means there are excessive nutrients in the water and algal blooms occur.

In addition, sedimentation (leading to mud pollution) has increased by 800 per cent due to deforestation of mangroves to make space for tourist developments, housing, and farming. Traditionally, coastal wetland ecosystems provided a natural filter to sediment run-off. Extensive mangrove forests along the coast chiefly fulfilled this function, but clearance has caused serious mud pollution issues. Mud pollution makes the water cloudy and reduces coral reef productivity thus disrupting the interdependence of the coral ecosystem with sea-grass beds and mangrove ecosystems.

Socially, there is pressure to raise important revenues for the country through agriculture, which is backed-up politically at the national level. Increasing awareness of the effect of this agriculture on the environment is causing people to rethink their priorities.

Global warming (Chapter 6, pages 313–314) is also affecting the reef. Increases in sea temperature have caused two mass coral bleaching events (plant and algal life on the reef dies, so the reef loses colour) in 1998 and 2002. Bleaching was more severe in 2002, when aerial surveys showed that almost 60 per cent of reefs were bleached to some degree. Increases in sea level and changes to sea temperatures may have a permanent effect on the Great Barrier Reef causing loss in biodiversity and ecological value of the area. In addition, climate change may be causing some fish species to move away from the reef to seek waters which have their preferred temperature. This leads to increased mortality in seabirds that prey on the fish.

The available habitat for sea turtles (e.g. coral reef and seagrass beds) are being damaged by sedimentation, nutrient run-off, tourist development, destructive fishing techniques, and climate change, causing reduction in population numbers.

Natural threats

All the human impacts have knock-on effects and thereby make the coral even more vulnerable to natural threats such as disease and natural predators. One such predator is the crown-of-thorns starfish which preys on the coral polyps (Figure 2.7, page 68) that form the coral reef. The starfish climbs onto the reef and extrudes its stomach over the coral, releasing digestive enzymes that digest the polyps so they can be absorbed. One adult crown-of-thorns starfish can destroy 6 m of coral in a year. Outbreaks of these starfish are thought to be natural, but the frequency and size of outbreaks has increased due to human activity. Reduction in water quality enables the starfish larvae to thrive, and unintentional over-fishing of natural predators (e.g. the giant triton, a large aquatic snail) is believed to have caused an increase in starfish numbers.

Crown-of-thorns starfish is one of the threats to the Great Barrier Reef.

continued

CHALLENGE YOURSELF

ATL Research skills

Research and describe a local example of a natural area of biological significance that is threatened by human activities. List the ecological, socio-political, and economic pressures that caused or are causing the degradation of the area, and outline the possible impacts on biodiversity.

Structural damage to coral can be caused by storms and cyclones, which are becoming intensified and more frequent due to climate change. Another key atmospheric effect, linked to changes in seawater temperature, is El Niño. In this regular event, fluctuations in the surface waters of the tropical eastern Pacific Ocean lead to increases in sea temperature across the east–central and eastern Pacific Ocean area, including Australian waters. Increased sea temperature, as we have already seen, can lead to coral bleaching – this has knock-on effects on the fish species that depend on the reef for food and protection, and for nurseries for their young.

Consequences

Coral reefs are able to withstand some threats, but the current combined effect of human and natural processes can lead to irreversible damage to the reef, and the species that depend on it. In turn, these effects can lead to the breakdown of the reef ecosystem. When a 'critical threshold' is reached, the problems may well become irreversible and the ecosystem will not recover even if the threats stop. Loss of biodiversity and the valuable role that the ecosystem provides (e.g. in conjunction with mangroves and sea-grass beds as a line of coastal defence against erosion and sediment run-off) will inevitably lead to a reduction in its value as an economic resource.

A tourist watches a green turtle on the Great Barrier Reef.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) encourages the protection and preservation of cultural and natural heritage sites considered to be of outstanding value to humanity. There are 679 cultural and 174 natural World Heritage sites so far listed, including the Great Barrier Reef, Yosemite National Park and the Galápagos Islands.

Exercises

1. List five factors that lead to the loss of diversity. How does each result in biodiversity loss?
2. Why is rainforest vulnerable to disturbance?
3. Evaluate the impact of human activity on the biodiversity of tropical biomes.
4. Discuss the conflict between exploitation, sustainable development, and conservation in tropical biomes.
5. What factors are used to determine a species' Red List status? List five.
6. Which types of species are common in the Red List, and which are less common? What implication does this have for the conservation of biodiversity?

Big questions

Having read this section, you can now discuss the following big questions:

- To what extent have the solutions emerging from this topic been directed at preventing environmental impacts, limiting the extent of the environmental impacts, or restoring systems in which environmental impacts have already occurred?
- How are the issues addressed in this topic of relevance to sustainability or sustainable development?
- In what ways might the solutions explored in this topic alter your predictions for the state of human societies and the biosphere some decades from now?