

Conservation of biodiversity

Revision notes • IB Biology A4.2: biodiversity, causes of the sixth mass extinction and ecosystem loss, evidence for a biodiversity crisis, and conservation approaches.

For IB Diploma Biology, Standard Level and Higher Level (first assessment 2025). **HL only** is additional higher level content, for HL students only.

Conservation of biodiversity **Spec A4.2**

Biodiversity and the number of species **Spec A4.2.1, A4.2.2**

Biodiversity is the variety of life in all its forms, levels and combinations. It is usually considered at three levels.

Three levels of biodiversity		
Level	Meaning	Example
Ecosystem diversity	The variety of habitats and ecosystems in an area	A coastline with coral reefs, seagrass beds, mangroves and desert
Species diversity	The number of different species (richness) and how evenly individuals are spread between them (evenness)	A tropical rainforest has more tree species than a pine plantation
Genetic diversity	The variety of alleles within a species or population	The many varieties of rice; the low genetic diversity of cheetahs

Genetic diversity matters because a population with more alleles is more likely to include individuals that can survive a new disease or a change in conditions.

How many species are there?

About two million species have been **discovered, named and described**, but there are **many more species to be discovered**. Most estimates of the total run to several million eukaryote species, and most bacteria and archaea have not been described. Many undescribed species are insects, fungi and organisms of tropical forests and the deep sea.

Evidence from fossils suggests that there are **more species alive on Earth today than at any time in the past**. Over long periods speciation has outpaced extinction, despite five earlier mass extinctions. The fossil record is incomplete, so past numbers are estimates.

Exam tip: Nature of science: classification is pattern recognition, and the same observations can be classified differently. Splitters recognise more species than lumpers in a taxonomic group, so species counts depend partly on who does the counting.

Anthropogenic species extinction and ecosystem loss **Spec A4.2.3, A4.2.4**

The current **sixth mass extinction** is **anthropogenic**: it is caused by human activity, unlike the earlier mass extinctions. Brief case studies show a range of causes.

North Island giant moa: loss of terrestrial megafauna

The North Island giant moa (*Dinornis novaeseelandiae*) was a very large flightless bird of New Zealand, where the only native land mammals were bats. It became extinct within about two centuries of the arrival of Polynesian settlers, the ancestors of Māori, around 1300 CE.

- Hunting for meat, and collection of eggs, by people.
- Burning and clearing of forest habitat.
- Slow breeding: small clutches and many years to reach maturity, so populations could not recover from hunting.
- No evolved fear of land predators, so birds were easy to kill.

Caribbean monk seal: loss of a marine species

The Caribbean monk seal (*Neomonachus tropicalis*) lived on beaches, islands and reefs of the Caribbean Sea and Gulf of Mexico. The last confirmed sighting was in 1952, and it was declared extinct in 2008.

- From the late 15th century, European settlers hunted it for oil from its blubber, and for meat and skins. Seals resting on beaches were easy to kill.
- Overfishing of reef fish and invertebrates reduced its food.
- Disturbance of the beaches where it rested and bred.

A local case study: the Arabian ostrich

The Arabian ostrich (*Struthio camelus syriacus*), a subspecies of ostrich, lived in the deserts of the Arabian Peninsula and nearby regions. It was hunted for meat, feathers and eggs for centuries, and declined rapidly in the 20th century once firearms and motor vehicles made hunting far easier. The last reliable records are from around 1939 to 1941, and a single dying bird reported in Jordan in 1966 is the date usually given for its extinction. Any species lost from an area you know can be used as the third case study.

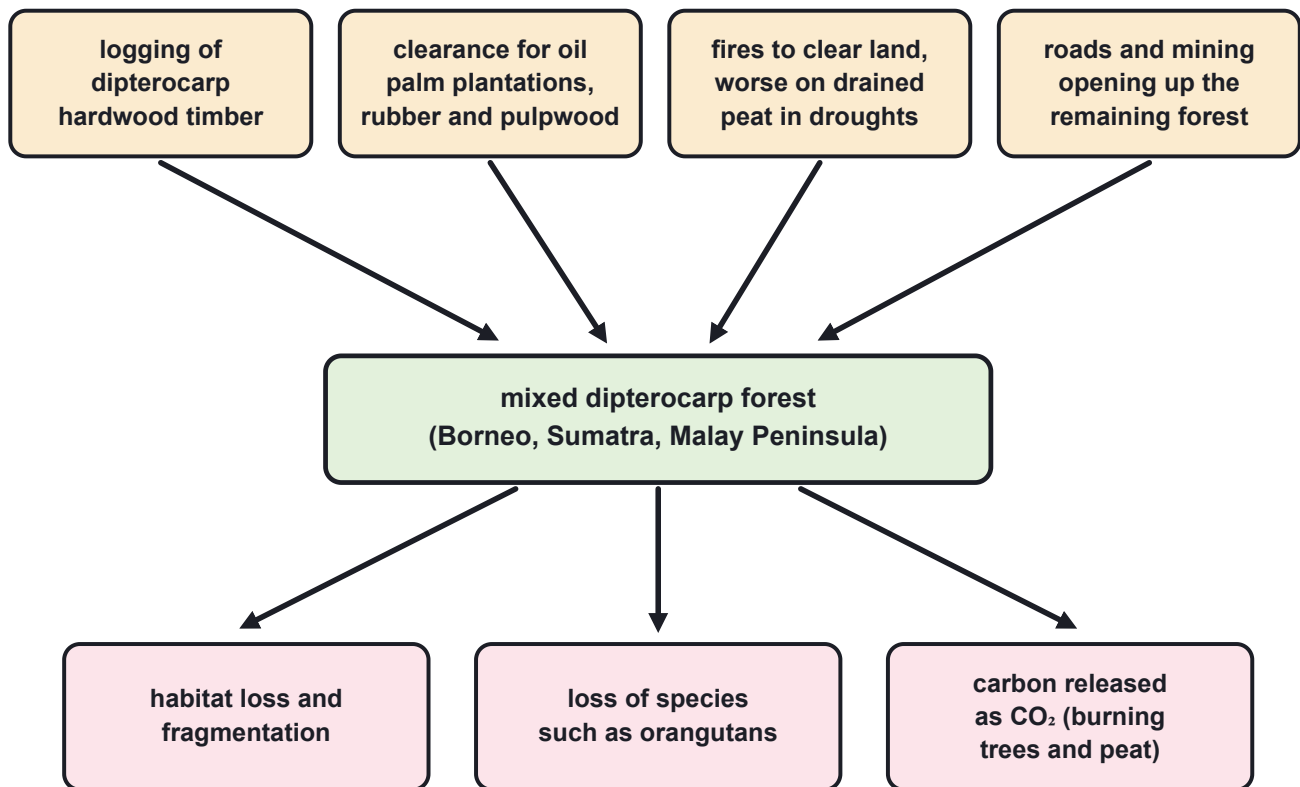
Ecosystem loss

An ecosystem is lost when its community and abiotic conditions are changed so much that it no longer functions as before. Only causes that are directly or indirectly **anthropogenic** are studied here.

Mixed dipterocarp forest in Southeast Asia. These lowland rainforests of Borneo, Sumatra and the Malay Peninsula are dominated by tall trees of the family Dipterocarpaceae and are home to very many species, including orangutans. Large areas have been lost.

- Logging of valuable dipterocarp hardwood timber.
- Clearance of land for oil palm plantations, and for rubber and pulpwood.
- Fires set to clear land, which spread further in drought years and on drained peat soils.
- Roads and mining that open up remaining forest, leaving small fragments too small for many species.

A local case: coral reefs of the southern Arabian Gulf. Reefs off the UAE already live close to the upper temperature limit for corals. In summer 2017, weak winds failed to cool the shallow sea, and water stayed hot enough for long enough to bleach about 95 % of the corals off Abu Dhabi. By April 2018 about three-quarters (73 %) of them had died, including normally heat-tolerant species. The causes are indirectly anthropogenic, as climate change makes marine heatwaves more frequent, and directly anthropogenic, as dredging, land reclamation for coastal development and sewage discharge add stress. Another well-known example is the Aral Sea in Central Asia, whose lake ecosystem largely collapsed after its feeder rivers were diverted to irrigate cotton from the 1960s.



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Anthropogenic causes and effects of the **loss of mixed dipterocarp forest** in Southeast Asia.

Exam tip: Give the specific cause for each case study: overhunting of a slow-breeding bird for the moa, hunting for oil and loss of food for the monk seal, and logging, plantations and fire for dipterocarp forest.

Evidence for and causes of the biodiversity crisis Spec A4.2.5, A4.2.6

Evidence for a crisis

The **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)** assesses published evidence on the state of biodiversity. Its 2019 global assessment concluded that around one million animal and plant species are threatened with extinction, and that the current global rate of extinction is already at least tens to hundreds of times higher than the average over the past ten million years.

Such conclusions rest on **reliable surveys** of biodiversity in a wide range of habitats around the world. One survey is only a snapshot: surveys must be **repeated** to show change in two measures:

Species richness	The number of different species present in an area.
Species evenness	How similar the population sizes of the different species are. A community dominated by one species has low evenness.

Practical skill: Repeated surveys are only comparable if the method is standardised: same sites, same season and time of day, same sampling effort and same identification methods.

Percentage change from a repeated survey

A butterfly survey on the same transect recorded 240 individuals in 2010 and 150 in 2020. Calculate the percentage change.

1. Change = $150 - 240 = -90$
2. Percentage change = $\text{change} \div \text{original value} \times 100$
3. = $-90 \div 240 \times 100 = -37.5$

Answer: -37.5 % (a decrease of 37.5 %)

Surveys involve both expert scientists and **citizen scientists**. To be verifiable, evidence usually has to come from a published, peer-reviewed source whose methodology can be checked.

Citizen science	
	Detail
Benefits	Many observers cover far more sites and years than scientists alone could; it builds public interest in conservation
Methodological concerns	Species may be misidentified; effort and methods vary between observers; records cluster where people live

Causes of the current crisis

Human population growth is the overarching cause. More people need more land, food, water, energy and materials. It acts through these specific causes:

Specific causes of biodiversity loss		
Cause	How it reduces biodiversity	Example
Hunting and other over-exploitation	Removes individuals faster than populations can reproduce	Overfishing of cod; hunting of the moa
Urbanization	Replaces natural habitat with buildings and roads, and fragments what is left	Coastal development replacing mangroves
Deforestation and clearance of land for agriculture	Loss of natural habitat	Dipterocarp forest cleared for oil palm
Pollution	Kills organisms or alters habitats	Fertiliser run-off causing eutrophication; plastics in the oceans
Spread of pests, diseases and invasive alien species by global transport	New species outcompete, prey on or infect native species with no defences	Chytrid fungus in amphibians; brown tree snakes eliminating forest birds on Guam

Exam tip: Linking question: how does variation contribute to the stability of ecological communities? Communities with more species and more genetic diversity are more likely to keep functioning when conditions change.

Approaches to conservation and the EDGE of Existence programme Spec A4.2.7, A4.2.8

No single approach to conservation is sufficient by itself, and **different species require different measures**. A species with a large range needs protected habitat; one reduced to a few individuals may need captive breeding.

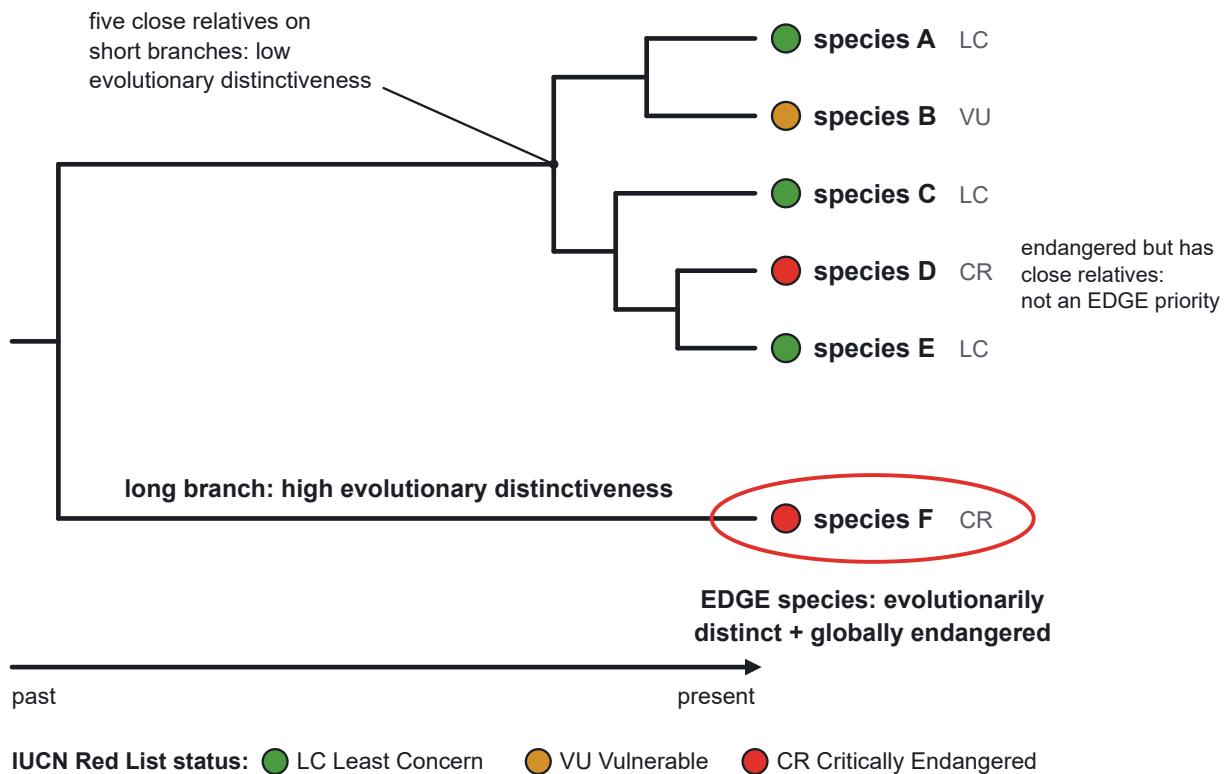
Approaches to conservation		
Approach	What it involves	Strength or limitation
In situ conservation	Protecting species in their natural habitats	Keeps species interacting with their community and still evolving; fails if the habitat is too degraded
Management of nature reserves	Protecting and actively managing land or sea: controlling invasive species, preventing poaching, managing grazing and fire, linking reserves with corridors	Needs long-term funding and enforcement
Rewilding	Reintroducing lost species, often large herbivores or top predators, and letting natural processes restore the ecosystem	Wolves reintroduced to Yellowstone National Park in 1995 changed grazing by elk
Reclamation of degraded ecosystems	Restoring damaged land or water, for example replanting mangroves or re-flooding drained wetlands	Slow and costly, but recovers whole communities
Ex situ conservation in zoos	Captive breeding of threatened animals, then reintroduction	The Arabian oryx, extinct in the wild by 1972, was bred in captivity and reintroduced from 1982
Botanic gardens	Growing rare plants away from their habitat	Small populations have low genetic diversity
Seed and tissue banks	Storing germ plasm: dried seeds kept cold, or tissue samples frozen	Stores huge genetic diversity in a small space, e.g. the Svalbard Global Seed Vault for crop seeds

The EDGE of Existence programme

Conservation money and effort are limited, so species must be prioritised. The EDGE of Existence programme, run by the Zoological Society of London, focuses on species that are both **Evolutionarily Distinct** and **Globally Endangered**.

- **Evolutionarily distinct (ED):** the species has few or no close living relatives, so it sits at the end of a long branch of the evolutionary tree and represents a lot of unique evolutionary history.
- **Globally endangered (GE):** the species is at high risk of extinction, judged by its IUCN Red List category.
- A species scoring high on both is an EDGE species and a high priority.

The rationale: if a species with no close relatives becomes extinct, a disproportionate amount of unique genes, features and evolutionary history is lost, and no similar species remains. Many EDGE species, such as the aye-aye of Madagascar, the Chinese giant salamander, pangolins and the gharial, receive little attention from other programmes.



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An **EDGE** species is both **evolutionarily distinct** (long branch, few relatives) and **globally endangered**.

Exam tip: Nature of science: deciding which species to prioritise has ethical, environmental, political, social, cultural and economic implications. In discuss questions, give arguments for and against the EDGE approach.

Quick check

1. Name the three levels of biodiversity.
2. What does fossil evidence suggest about the number of species alive today?
3. Why must biodiversity surveys be repeated?
4. What is the overarching cause of the current biodiversity crisis?
5. What does EDGE stand for?

Quick check answers

Conservation of biodiversity

1. Ecosystem diversity, species diversity and genetic diversity.
2. There are more species alive today than at any time in the past.
3. To provide evidence of change in species richness and evenness over time.
4. Human population growth.
5. Evolutionarily distinct and globally endangered.