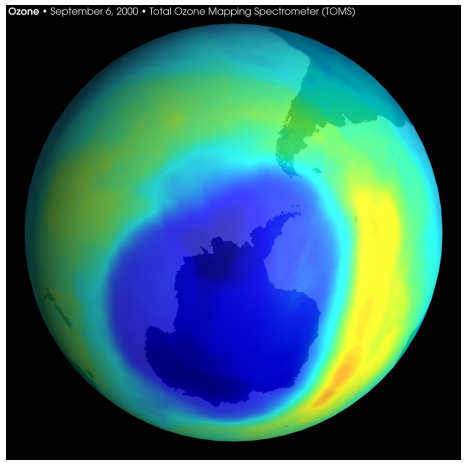
Global Change

AP Environmental Science

Stratospheric Ozone Depletion

The **ozone layer** 臭氧层 high in the stratosphere absorbs harmful **ultraviolet** 紫外线 radiation. **CFCs** 氯氟烃 (chlorofluorocarbons, once used in coolants and sprays) drift up and release chlorine that destroys ozone, thinning it (the Antarctic "**ozone hole**"). More UV reaching the surface raises skin cancer, cataracts, and crop damage.



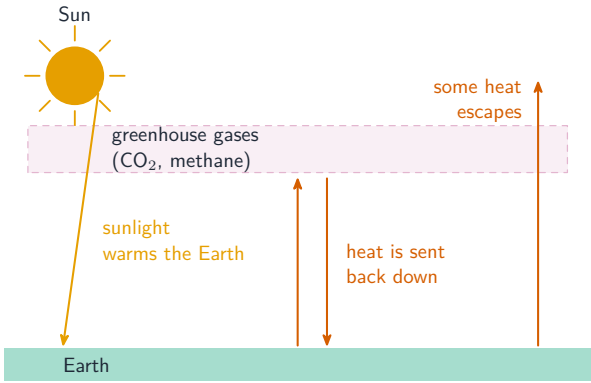
The ozone hole 臭氧洞 *over Antarctica (dark blue) on a NASA map: this is where the ozone layer has thinned the most*

Reducing Ozone Depletion

The **Montreal Protocol** 蒙特利尔议定书 (1987) phased out CFCs worldwide and is a rare environmental success – the ozone layer is slowly recovering. Substitutes (like HFCs and HCFCs) replaced CFCs, though some are themselves greenhouse gases.

The Greenhouse Effect

The **greenhouse effect** 温室效应 keeps Earth warm: **greenhouse gases** 温室气体 let sunlight in but trap outgoing infrared heat. This natural effect makes Earth livable. The problem is the **enhanced** greenhouse effect – humans adding extra gases that trap more heat.



greenhouse gases trap some of the Earth's heat,
so less escapes to space and the Earth warms up

Greenhouse gases absorb the heat the Earth gives off and send some back

Increases in the Greenhouse Gases

Human activities raise greenhouse gases: **CO_2** from burning fossil fuels and deforestation, **methane** 甲烷 from livestock, landfills, and rice paddies, and **nitrous oxide** from fertilizers. Methane traps far more heat per molecule than CO_2 but is less abundant.

To compare gases fairly, we use **global warming potential (GWP)** 全球变暖潜能值 - how much heat one unit of a gas traps over a set time, relative to CO_2. **CO_2 is the reference, with GWP = 1**, so every other gas is measured against it. Ranked by GWP: **CFCs** are highest, then **nitrous oxide**, then **methane** - all trap far more heat per molecule than CO_2. But GWP alone does not decide impact: CO_2 still causes the most warming overall because it is released in vastly greater **quantity**. The exam expects both ideas - a high GWP *and* how much is emitted.

Coal mining and combustion: burning fossil fuels is the main driver of rising atmospheric CO2

Global Climate Change

Global climate change 气候变化 is the long-term shift in climate from the enhanced greenhouse effect: rising average temperatures, melting ice, rising **sea levels** 海平面, more extreme weather, and shifting rainfall. It disrupts ecosystems, agriculture, and human communities worldwide.

A glacier 冰川 breaking apart into the sea. Warming melts land ice, which adds water to the ocean and raises sea level

Ocean Warming

As the climate warms, oceans absorb most of the extra heat. **Ocean warming** causes **coral bleaching** 珊瑚白化 (corals expel their algae and can die), shifts species ranges, reduces dissolved oxygen, and – with melting ice – raises sea level through **thermal expansion**.

A bleached coral colony: warmer water made it expel its colourful algae, leaving the bare white skeleton. If the heat lasts, the coral dies

Ocean Acidification

The ocean absorbs about a quarter of our CO_2, which forms carbonic acid – **ocean acidification** 海洋酸化. Lower pH makes it harder for corals, shellfish, and plankton to build **calcium carbonate** 碳酸钙 shells and skeletons, threatening marine food webs.

Invasive Species

An **invasive species** 入侵物种 is a non-native species that spreads and harms its new ecosystem. With no natural predators, it outcompetes natives, spreads disease, and reduces biodiversity (kudzu, zebra mussels, Burmese pythons). Human trade and travel move them around.

The invasive vine kudzu smothering a stand of trees. With no natural predators in its new home, it blankets and kills what it covers

Endangered Species

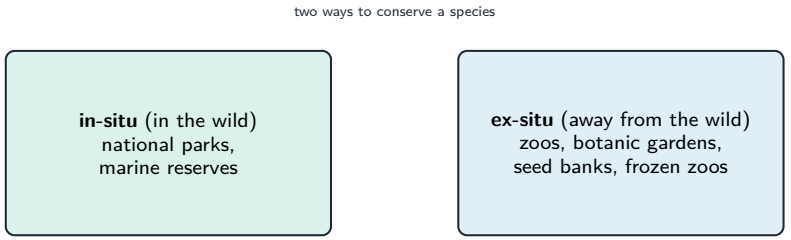
An **endangered species** 濒危物种 is at risk of extinction. Causes are summarized as **HIPPO**: **Habitat** loss, **Invasive** species, **Pollution**, **Population** (human) growth, and **Overharvesting**. Protection includes laws (the Endangered Species Act), protected areas, and captive breeding.

A coral reef: habitat loss, warming and acidification put whole reef communities at risk of extinction

Human Impacts on Biodiversity

Together, habitat loss, climate change, pollution, invasive species, and overexploitation are driving a rapid loss of biodiversity – some call it a sixth mass extinction. Reducing these pressures, conserving habitat, and sustainable practices are the ways to slow it and protect the ecosystem services all life depends on.

A specific and heavily-tested driver is **habitat fragmentation** 栖息地破碎化: large continuous habitats are broken into smaller, isolated patches by roads, pipelines, and development. Fragmentation is worse than simple area loss, because the small patches cut populations off from each other, reduce genetic diversity, and expose more **edge** to predators and invasive species.



In-situ and ex-situ conservation protect species

Worked example. Atmospheric CO_2 rose from about 280 ppm before industrialisation to about 420 ppm today. The percent increase is $\frac{420-280}{280} \times 100\% = \frac{140}{280} \times 100\% = 50\%$. This roughly 50% rise in the main long-lived greenhouse gas is the core driver of the enhanced greenhouse effect and modern warming.

Exam tips

- Keep **ozone depletion** (CFCs let in more UV) and **climate change** (greenhouse gases trap more heat) as **two different problems**.
- Explain the natural greenhouse effect and the **enhanced** version from extra CO_2 and methane.
- Connect ocean warming (coral bleaching) and **ocean acidification** (CO_2 → carbonic acid → weaker shells).
- An **invasive species** is dangerous because it has no natural predators in its new home.

- Summarise threats to biodiversity with **HIPPO** (Habitat loss, Invasive species, Pollution, Population, Overharvesting).