Points you may want to consider in your discussions:

- What indicators can be taken to suggest that a species is at threat from extinction?
- How can the population of a species facing extinction be restored?
- What threats do biologically significant areas face and how can the extent of the environmental impacts be limited?
- What issues arise when attempts are made to balance conservation with economic development? What conflicts exist between exploitation, sustainable development, and conservation in tropical biomes?

3.4 Conservation of biodiversity

Significant ideas

The impact of losing biodiversity drives conservation efforts.

The variety of arguments given for the conservation of biodiversity depend on environmental value systems.

There are various approaches to the conservation of biodiversity, with associated strengths and limitations.

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?
- What value systems can you identify at play in the causes and approaches to resolving the issues addressed in this topic?
- How does your own value system compare with others you have encountered in the context of issues raised in this topic?
- 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

- Arguments about species and habitat preservation can be based on aesthetic, ecological, economic, ethical, and social justifications.
- International, governmental and non-governmental organizations (NGOs) are involved in conserving and restoring ecosystems and biodiversity, with varying levels of effectiveness due to their use of media, speed of response, diplomatic constraints, financial resources and political influence.
- Recent international conventions on biodiversity work to create collaboration between nations for biodiversity conservation.
- Conservation approaches include habitat conservation, species-based conservation and a mixed approach.
- Criteria for consideration when designing protected areas include: size, shape, edge effects, corridors, and proximity to potential human influence.

- Alternative approaches to the development of protected areas are species-based conservation strategies that include:
  - the Convention on International Trade in Endangered Species (**CITES**)
  - captive breeding and reintroduction programmes, and zoos
  - selection of charismatic species to help protect others in an area (flagship species)
  - selection of keystone species to protect the integrity of the food web.
- Community support, adequate funding and proper research influence the success of conservation efforts.
- The location of a conservation area in a country is a significant factor in the success of the conservation effort. Surrounding land use for the conservation area and distance from urban centres are important factors for consideration in conservation area design.

Arguments about species and habitat preservation can be based on aesthetic, ecological, economic, ethical, and social justifications.

Arguments for preserving biodiversity

The value of biodiversity can be difficult to quantify. Goods harvested from an ecosystem are easier to evaluate than indirect values such as the aesthetic or cultural aspects of an ecosystem. For example, it is easy to value rainforest in terms of amount of timber present because this has direct monetary value. But intact rainforests also provide valuable ecosystem services for the local, national and global communities (Figure 3.19). Rainforests are vital to the hydrologic (water) cycle, stabilize some of the world's most fragile soils by preventing soil erosion, and are responsible for regulating temperature and weather patterns in the areas surrounding the forest. In addition, they sequester (isolate) and store huge amounts of carbon from the atmosphere. They cool and clean the world's atmosphere. They are a huge source of the world's biodiversity, and they provide fresh water (the Amazon provides 20 per cent of the world's fresh water).

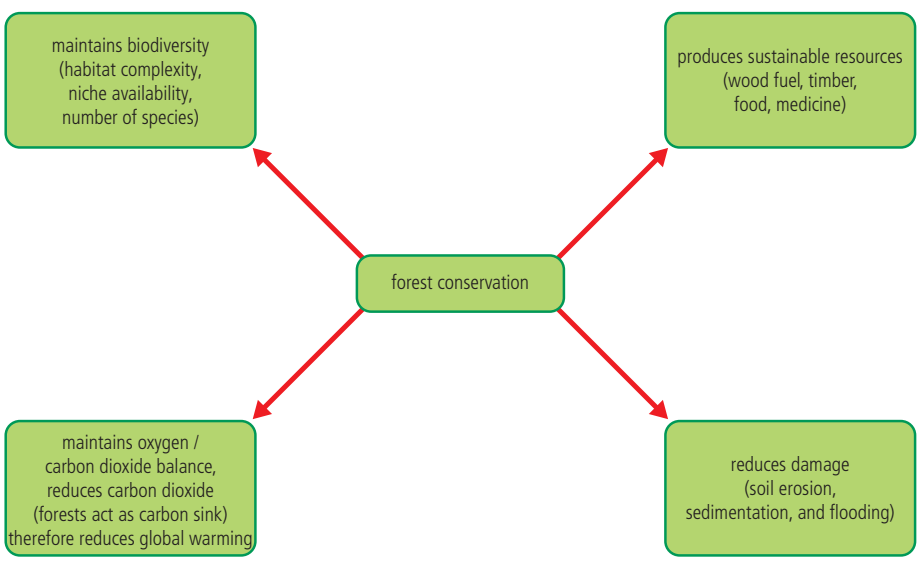


Figure 3.19 The biological significance of a forest

CONCEPTS: Biodiversity

Tropical rainforests should be conserved for a variety of reasons:

- they have an economic value to humans
- they contain food, medicines, and materials for human use
- rainforest has an intrinsic value (page 17)
- they provide life-support function (e.g. water cycles, carbon sink, oxygen provider)

- they contain high biodiversity
- they have aesthetic value
- the tourism function can bring income
- they provide a home to indigenous people
- regeneration rate is slow
- they provide spiritual, cultural, or religious value to local communities
- the current human population has a duty to protect rainforests for future generations.

The Iban are an indigenous people of Sarawak (Malaysia), Brunei, and western Kalimantan (Indonesian Borneo). Traditionally, they live in communal longhouses, hunting and fishing in rainforest areas, and growing crops using shifting cultivation. Pulp and paper companies have cleared Iban land and planted acacia trees, and other areas have been cleared for oil palm. The Iban have appealed against the loss of their traditional lands, although these rights have so far been denied as courts decided that land-ownership based on continuous occupation should 'not be extended to areas where the natives used to roam to forage for their food and building materials in accordance with their tradition'.

Iban woman with baby near her home

Most of these benefits are difficult to give monetary value to: every person on the planet benefits from these services, but none of us pay for them. Intact rainforests are aesthetically pleasing and this makes people want to visit them, which gives rainforest value from an ecotourism point of view. As rainforests contain such a high percentage of the existing global biodiversity, it can also be argued that we have an ethical responsibility to conserve them.

The value of ecosystems depends on cultural background as well as economic status. The value of a rainforest to someone who lives in and relies on it for their livelihood is very different from an outsider who does not have these concerns.

To learn about Survival International (an organization that supports indigenous people's rights), go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 3.5.

To learn about the Forests NOW campaign (which aims to raise awareness of the need to protect forests in order to prevent climate change), click on weblink 3.6.

Forest people are found in rainforests in Brazil, Colombia, Ecuador, Paraguay, Canada, Peru, Argentina, Botswana, Kenya, Ethiopia, Sudan, Central Africa, Australia, Indonesia, the Philippines, India, Bangladesh, Russia, Malaysia, and Sri Lanka. The majority are under threat from logging and rainforest loss, for example the Awá tribe in Brazil. The Awá's territory has been invaded and destroyed. Cattle ranchers illegally occupy Awá land and, in another part of their territory, groups of heavily armed loggers have destroyed much of the forest.

There are many arguments for preserving species and habitats, as we have seen above. These arguments can be divided into five groups.

- *Aesthetic reasons*
  Species and habitats are pleasant to look at and provide beauty and inspiration.

- *Ecological reasons*
  Rare habitats should be conserved as they may contain endemic species that require specific habitats. In addition, ecosystems with high levels of biodiversity are generally more stable and more likely to survive into the future. Healthy ecosystems are also more likely to provide ecosystem services such as pollination and flood prevention. Species should be preserved because if they disappear, they could have effects on the rest of the food chain and ecosystem.

Ecological reasons are concerned with ecosystems and their functioning.

Economic arguments for preservation often involve valuation of ecotourism, the genetic resource, and commercial considerations of the natural capital.

Ethical arguments are very broad, and can include the intrinsic value of the species or the utilitarian (i.e. the usefulness of species).

What is a valuable species to one culture may not be so to another. For example, in South East Asia, elephants are valued by tourists, but to locals they are pests that eat crops and destroy their forest plantations.

TOK

- *Economic reasons*
  Species and habitats provide financial income. Species should be preserved to maintain genetic diversity, so that genetic resources will be available in the future. For example, genetic diversity will allow crops to be improved in the future. Other reasons for preserving biodiversity are that commercial resources (e.g. new medicines) are still waiting to be discovered. The rosy periwinkle, a plant endemic to Madagascar, is used in cancer treatment. Ecotourism is successful when habitats high in biodiversity are preserved because they attract people to visit.

- *Ethical reasons*
  Everyone has a responsibility to protect resources for future generations. Ethical reasons also include the idea that every species has a right to survive.

- *Social reasons*
  Many natural ecosystems around the world provide places to live for indigenous peoples. Loss of these areas would mean loss of these peoples' homes, source of livelihood, and culture. In addition, many areas of great biodiversity provide an income for local people, such as tourism and wildlife protection. These areas therefore support social cohesion and cultural services.

It is easier to give commercial value to resources such as timber, medicine, and food. It is more difficult to give value to ecosystem services, cultural services, and ethical and aesthetic factors, although this does not mean that these are not equally valid reasons for preserving biodiversity.

CONCEPTS: Environmental value systems

Nomadic Penan hunting with blowpipe

The Penan of Borneo are nomadic hunter-gatherers who have historically relied on the rainforests for their survival. They have a comprehensive knowledge of the forest and are highly skilled in surviving there (e.g. a poison-headed dart from a blowpipe can strike an animal 40 m high in the upper canopy.

Forest peoples' views of rainforest differ from the views of people from developed countries. To forest people, the forest is their home, from which they derive food, medicine, and their cultural values. Economically developed countries see the rainforest as an opportunity to exploit natural resources and use land for new settlements. To forest people, losing the forest is losing their home, their source of food, and the destruction of their culture which has developed through generations of forest living.

International, governmental, and non-governmental organizations (NGOs) are involved in conserving and restoring ecosystems and biodiversity, with varying levels of effectiveness due to their use of media, speed of response, diplomatic constraints, financial resources, and political influence.

Conservation organizations

It is often difficult to make your voice heard by those who influence global policies (e.g. national governments). Combined voices are more effective and conservation organizations that work at both local and global levels are good at campaigning on key environmental issues such as climate change and the preservation of biodiversity.

Non-governmental organizations (NGOs) are not run by, funded by, or influenced by governments of any country (e.g. Greenpeace and the World Wide Fund for Nature, WWF). **Intergovernmental Organizations (IGOs)** are bodies established through international agreements to protect the environment and bring together governments

to work together on an international scale (e.g. the European Environment Agency (EEA), United Nations Environment Programme (UNEP), and IUCN).

Each type of organization has its own strengths and weaknesses (Table 3.2). IGOs tend to be more conservative (i.e. have a more conventional approach to conservation and are not likely to be controversial), whereas NGOs tend to be more radical (and often have to be to get their message across and to be heard). NGOs also tend to be field based, gathering information to back up their arguments, whereas IGOs tend to gather information from scientific research which they pay for.

Table 3.2 Differences between IGOs and NGOs

	IGO (e.g. UNEP)	NGO (e.g. Greenpeace)
use of media	• works with media so communicates its policies and decisions effectively to the public	• may gain media coverage through variety of protests (e.g. protest on frontlines) • often run campaigns focused on large charismatic species such as whales/seals/pandas • sometimes access to mass media is hindered, especially in non-democratic countries • public protests put pressure on governments
speed of response	• slow to respond – agreements require consensus from members • can be bureaucratic and take time to act • directed by governments, so sometimes may be against public opinion	• fast to respond – usually its members already have reached consensus (or they wouldn't have joined in the first place)
political pressures	• decisions can be politically (and economically) driven rather than by best conservation strategy	• can be idealistic, and driven by best conservation strategy • focus on the environment • often hold the high moral ground over other organizations, although may be extreme in actions or views
public image	• organized as businesses with concrete allocation of duties • cultivate a measured image based on a scientific and business-like approach	• can be confrontational and have a radical approach to an environmental issue like biodiversity
legislation	• enforce decisions via laws (may be authoritarian sometimes)	• serve as watchdogs (suing government agencies or businesses who violate environmental law) • rely on public pressure rather than legal power to influence governments as they have no power to enforce laws
agenda	• provide guidelines and implement international treaties	• use public pressure to influence national governments • lobby governments over policies and legislation • buy and manage land to protect habitats, wildlife, etc.
funding	• fund environmental projects with monies coming from national budget • usually manage publicly owned lands	• fund environmental projects with monies coming from private donations
extent of geographical influence	• have influence both locally and globally	• focus more on local and/or national information, aiming at education – produce learning materials and opportunities for schools and public

Both IGOs and NGOs are trying to promote conservation of habitats, ecosystems, and biodiversity. Other similarities between the two organizations include the following.

- *Use of media*
  Both provide environmental information to the public on global trends, publishing official scientific documents and technical reports gathering data from a variety of sources.
- *Public image*
  Both lead and encourage partnership between nations and organizations to conserve and restore ecosystems and biodiversity.
- *Legislation*
  Both seek to ensure that decisions are applied.
- *Agenda*
  Both collaborate in global, transnational scientific research projects.

  Both provide forums for discussion.
- *Geographical influence*
  IGOs monitor regional and global trends; NGOs also monitor species and conservation areas at a variety of levels, from local to global.

If you are asked to compare the roles of an intergovernmental organization (IGO) and a named non-governmental organization you need to refer to named examples (e.g. IGO – UNEP; NGO – WWF). Answers should include similarities and differences between the two organizations.

Recent international conventions on biodiversity aim to create collaboration between nations for biodiversity conservation.

International conventions on biodiversity

CONCEPTS: Strategy

International conventions provide governments with strategies for conserving biodiversity.

In Chapter 1, you learned how international conferences have led to international conventions on biodiversity (e.g. the Earth Summit in 1992 led to the Convention on Biological Diversity, page 8).

The IUCN (aka World Conservation Union) was founded in 1948. It is concerned with the importance of conservation of resources for sustainable economic development. You have already seen how the IUCN plays a role in species conservation via the Red List (page 176); the IUCN has also helped establish international conventions to help protect biodiversity.

In 1980, the IUCN established the World Conservation Strategy (WCS) along with UNEP and WWF. The WCS outlined a series of global priorities for action and recommended that each country prepare its own national strategy as a developing plan that would take into account the conservation of natural resources for long-term human welfare. The strategy also drew attention to a fundamental issue: the importance of making the users of natural resources become their guardians. It stressed that without the support and understanding of the local community, whose lives are most closely dependent on the careful management of natural resources, the strategies cannot succeed.

The WCS consisted of three factors:

- maintaining essential life support systems (climate, water cycle, soils) and ecological processes
- preserving genetic diversity
- using species and ecosystems in a sustainable way.

The WCS focused on specific factors for preserving biodiversity. It chose these issues because they are the ones that people with different environmental viewpoints are most likely to agree on. Ethical and aesthetic arguments are more difficult to define and vary between different communities. The arguments used by the WCS are also more scientifically verifiable than ethical or aesthetic arguments. Most nations place more value on scientific validity than other arguments.

History of the IUCN

- *1948*
  Foundation of the organization, named International Union for the Protection of Nature (IUPN).
- *1949*
  Main focus on protecting habitats and species from the exploitative tendencies of humans.
- *1956*
  IUPN seen as too preservationist; changed its name to the International Union for the Conservation of Nature and Natural Resources.
- *1961*
  Lack of funds led to the establishment of an independent fund-raising organization, WWF, to raise funds and support IUCN.
- *1966*
  Species Survival Commission published Red Data Lists to provide detailed information on status, distribution, breeding rate, causes of decline, and proposed protective measures for all endangered species.
- *1967*
  UN List of National Parks and Equivalent Reserves produced (gives definitions and classification of types of protected areas; regularly updated and revised).
- *1973*
  Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES) established.
- *1980*
  World Conservation Strategy (WCS) published.
- *1991*
  Update of the WCS *Caring for the Earth: A Strategy for Sustainable Living* launched in 65 countries. Stated the benefits of sustainable use of natural resources, and the benefits of sharing resources more equally among the world population.
- *1992*
  Global Biodiversity Strategy. The aim of the strategy was to aid countries to integrate biodiversity into their national planning. Three main objectives:
  - conservation of biological variation
  - sustainable use of its components
  - equitable sharing of the benefits arising out of the utilization of genetic resources.

Global and local approaches to environmental problem solving

Some environmental problems are global, so it makes sense that international cooperation is used in addressing them. For example, global warming will have far-reaching global impacts so a united response to monitoring and mitigation is more likely to be effective. International agreements can help to motivate governments to take action and honour their commitments (e.g. to cut carbon dioxide emissions – such action was taken to establish the Kyoto Protocol, page 390). As an international organization, UNEP has the resources to mobilize and coordinate action

(e.g. environmental research) when individual nations, especially LEDCs, might not have access to funds or expertise. When problems cross borders (e.g. smuggling endangered species), international cooperation is vital (e.g. CITES, pages 199–201). On the other hand, problems are often local, so local people should be involved in providing a local solution. This is recognized by the WCS. The motivation for addressing problems often starts at local level, when individuals feel passionately about an issue. Issues such as recycling and landfill are local ones, so a global strategy would be cumbersome, bureaucratic, and inappropriate.

Global summits and the conventions that come out of them have shaped attitudes towards sustainability. The UN Conference on Human Environment (Stockholm, 1972) was the first meeting of the international community to consider global environment and development needs (Chapter 1, pages 7–8). Summits play a pivotal role in setting targets and shaping action at both an international and local level. As you saw in Chapter 1, the UN Rio Earth summit led to Agenda 21 and the Rio Declaration (page 8). The 2000 UN Millennium Summit agreed a set of Millennium Development Goals (MDGs) (Chapter 8, page 410). The subsequent World Summit in New York, USA, recommended that each country developed its own strategy for fulfilling the MDGs. However, should countries break these agreements, there is little the international community can do about it, unless they are legally binding. Even when conventions do not achieve their initial goals, they may act as a catalyst in changing the attitudes of governments, organizations, and individuals.

You need to be able to evaluate different approaches to protecting biodiversity.

In situ vs. *ex situ* conservation

Conservation approaches include habitat conservation, **species-based conservation** and a mixed approach. ***In situ* conservation** is the conservation of species in their natural habitat. This means that endangered species, for example, are conserved in their native habitat. Not only are the endangered animals protected, but also the habitat and ecosystem in which they live, leading to the preservation of many other species. *In situ* conservation works within the boundaries of conservation areas or nature reserves.

***Ex situ* conservation** is the preservation of species outside their natural habitats. This usually takes place in botanic gardens and zoos, which carry out captive breeding and reintroduction programmes. The species-based approach to conservation is an approach that focuses on specific individual species (usually animals) that are vulnerable. The aim is to attract interest in their conservation and therefore funding and public pressure for conservation.

CONCEPTS: Strategy

There are different strategies for conservation: *in situ* conservation preserves biodiversity in natural habitats (e.g. protected areas, safari parks); *ex situ* conservation preserves biodiversity outside natural habitats (e.g. zoos).

You need to be able to explain the criteria used to design and manage protected areas.

Designing protected areas

Most countries have large areas of land that have been cleared of native habitat for development purposes (e.g. cities). The remaining areas of native habitat can be made into protected areas. Protected areas are often isolated and in danger of becoming islands within areas of disturbance, such as cleared land. When protected areas become islands, they lose some of their diversity due to increased **edge effects** (the

impact of changed environmental conditions at the edge of the reserves) and localized extinctions.

'Island biogeography' theory was developed in the 1960s by Robert MacArthur and Edward Wilson. They showed that smaller conservation areas contain comparatively fewer species and lower diversity than larger areas. Ever since, reserve designers have been using these ideas to ensure maximum preservation of species within conservation areas. Size, shape, edge effects, and whether or not reserves are linked by corridors, are all taken into account when designing conservation areas (Figure 3.20).

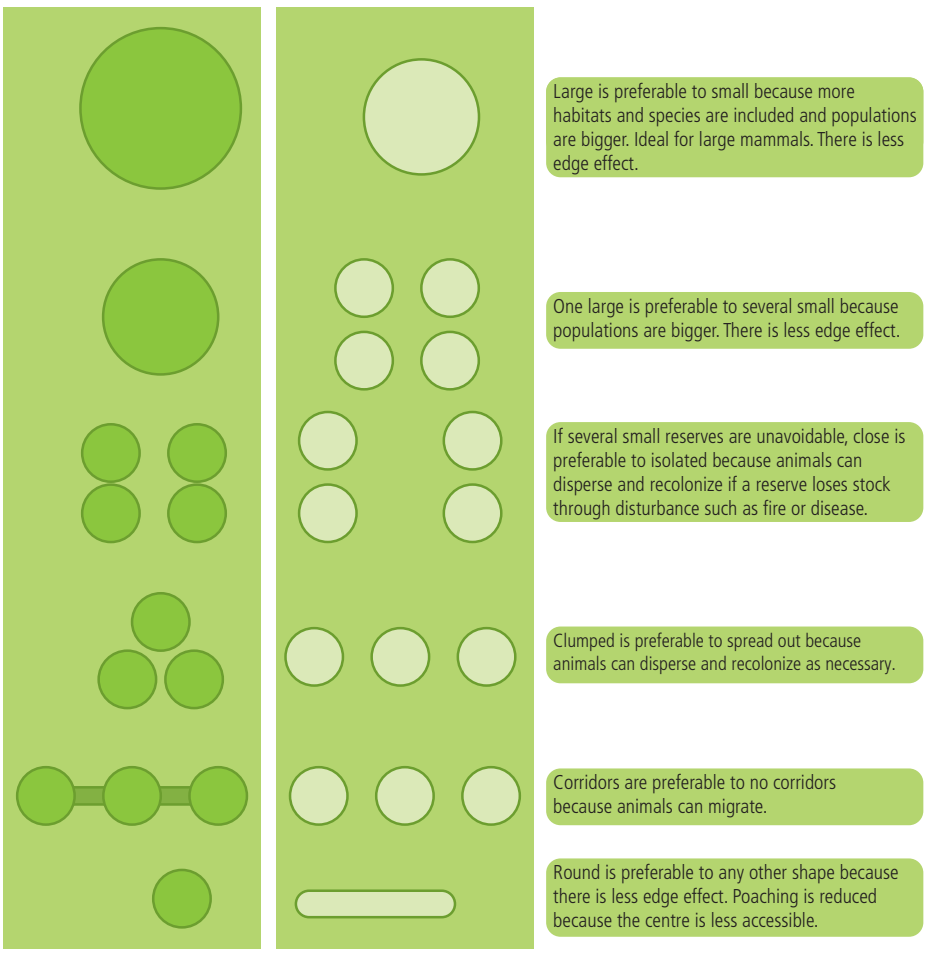


Figure 3.20 The shape, size and connectivity of reserves are important in the design of protected areas.

Area

One of the great debates in reserve design is known as SLOSS (single large or several small): is it better to have one large reserve (e.g. 10 000 ha) or several smaller ones (four at 2500 ha)? Much depends on location of the habitats – if habitats to be preserved are not all found reasonably close together, then several small reserves may be necessary. But overall, bigger is better because one large area can support more species than several smaller areas (they have more habitats and can support more top carnivores). The best indicator of species survival and success of the reserve's size is the population size of individual species. In an ideal situation, several large reserves would allow the protected habitats to be replicated thus guarding against the possible effects of fire or a disease which could lead to the extinction of species contained within the affected reserve.

Edge effects

At the edge of a protected area, there is a change in abiotic factors (e.g. more wind, or warmer and less humid conditions compared to the interior of the reserve). Edge effects attract species that are not found deeper in the reserve, and may also attract exotic species from outside the reserve, leading to competition with forest species and overall reduction in diversity.

Shape

The best shape for a reserve is a circle because this has the lowest edge effects. Long thin reserves have large edge effects. In practice, the shape is determined by what is available and where the habitats to be conserved are located. Parks tend to be irregular shapes.

Corridors

The benefits of linking reserves by corridors include:

- allowing gene flow by immigration and/or emigration
- allowing seasonal movements
- reducing collisions between cars and animals
- having fewer or no roads as these can act as a barrier to some species.

The disadvantages of linking reserves by corridors include:

- some species may breed outside the protected area rather than in it leading to reduction in numbers (this is called 'outbreeding depression')
- invasion of exotic pests or disease from connected reserves
- poachers can easily move from one reserve to another
- corridors may be narrow (30–200 m wide) – this means a big increase in edge conditions rendering the corridors unsuitable for the dispersal of species from the centre of reserves, which normally avoid edge habitat
- corridors may become barriers to some species when protected by fences or obstructions (designed, for example, to deter poachers).

Buffer zone

Areas around conservation areas are called **buffer zones**. They contain habitats and may be either managed or undisturbed. These areas minimize disturbance from outside influences such as people, agriculture or invasion by diseases or pests. For example, a nearby large town or extensive disturbance (e.g. logging) can directly impact a protected area if it is not surrounded by an area that buffers (protects) it from effects of the disturbance. Most successful protected areas are surrounded by buffer zones.

Criteria for consideration when designing protected areas include: size, shape, edge effects, corridors, and proximity to potential human influence. Well-designed protected areas:

- **are large because this promotes large population sizes and high biodiversity; enables protection of large vertebrates/top carnivores; reduces perimeter relative to area, so edge effects and disturbance are minimized**
- **are unfragmented and connected to other reserves (by corridors) to allow movement and migration between reserves**
- **do not have roads that can act as barriers to migration and increase disturbance and edge effects.**

CONCEPTS: Strategy

Protected areas need to be designed following strategies that enable the maximum amount of biodiversity to be conserved.

Evaluating the success of a protected area

You need to be able to evaluate the success of a given protected area. A specific example of a protected area and the success it has achieved should be studied.

Case study

Danum Valley Conservation Area (DVCA), Malaysian Borneo

Danum Valley Field Centre, Malaysia. Research at the centre focuses on local primary forest ecology as well as the effect of logging on rainforest structure and communities.

The Danum Valley Conservation Area (DVCA) is a protected area located in the Malaysian state of Sabah on the island of Borneo, at latitude 5° North. The DVCA and surrounding areas is a model of how effective conservation can be matched with local economic needs.

Granting protected status to a species or ecosystem is no guarantee of protection without community support, adequate funding and proper research. In north-eastern Borneo, the third largest island in the world, a large area of commercial forest is owned by the Sabah Foundation (also known as Yayasan Sabah). The Yayasan Sabah Forest Management Area (YSFMA) is an extensive area of commercial hardwood forest containing within it protected areas of undisturbed forest, areas that are being rehabilitated with 'enrichment planting' (adding seedlings to heavily disturbed logged forest), and areas of commercial softwood forestry. Research of the primary rainforest within the DVCA has established the biological importance of the native forest and acted as a focus for conservation in the region. DVCA covers 43 800 ha (Figure 3.21), comprising almost entirely lowland dipterocarp forest (dipterocarps are valuable hardwood trees). The DVCA is the largest expanse of pristine forest of this type remaining in Sabah.

Figure 3.21 Location of the Danum Valley Conservation Area

Until the late 1980s, the area was under threat from commercial logging. The establishment of a long-term research programme between Yayasan Sabah and the Royal Society in the UK (the oldest scientific body in the world) has created local awareness of the conservation value of the area and provided important scientific information about the forest and what happens to it when it is disturbed through logging. Danum Valley is controlled by a management committee representing all the relevant local institutions – wildlife, forestry, and commercial sectors are all represented.

continued

Two other conservation areas, the Maliau Basin and Imbak Canyon, are linked by commercial forest corridors. To the east of DVCA is the 30 000 ha Innoprise-FACE Foundation Rainforest Rehabilitation Project (INFAPRO), one of the largest forest rehabilitation projects in South East Asia, which is replanting areas of heavily disturbed logged forest. The Innoprise–IKEA project (INIKEA) to the west of DVCA, is a similar rehabilitation project (Figure 3.22).

Figure 3.22 Location of conservation areas, rehabilitation projects and commercial softwood forestry within YSFMA. The combined network of different types of forest has enabled effective conservation of animals and plants important to the region.

Because all areas of conservation and replantation are within the larger commercial forest, the value of the whole area is greatly enhanced. Movement of animals between forest areas is enabled and allows the continued survival of some important and endangered Borneo animals such as the Sumatran rhino, the orang-utan and the Borneo elephant.

Orang-utans are found on the islands of Borneo and Sumatra. They are high-profile animals and are used to promote the conservation of rainforest.

The Borneo Rainforest Lodge – an ecotourism destination at the edge of the DVCA

In the late 1990s, a hotel was established on the north-eastern edge of the DVCA. It has established flourishing ecotourism in the area and exposed the unique forest to a wider range of visitors than was previously possible. As well as raising revenue for the local area, it has raised the international profile of the area as an important centre for conservation and research.

Such projects require significant funding which has come from Yayasan Sabah (a state foundation funded by the Sabah Government and Federal Government of Malaysia) and companies such as Malaysia's Petra Foundation, Shell, BP, the Royal Society, and others. The now high international profile of the Danum Valley, and key research over a long period of time (the programme is now the longest running in South East Asia), have helped to establish the area as one of the most important conservation areas in the region, if not the world.

Community support

The Danum Valley Field Centre is managed and maintained by a large staff of local people. Many are from the nearest town (Lahad Datu) or from east-coast kampongs (villages) such as Kampong Kinabatangan.

The field centre and surrounding conservation area provides opportunities for employment, education, and training. Support from the local community in running the various facilities on site (e.g. field centre office, accommodation, research support, and education centre) and in local towns, and much interest from nature groups in schools, have been important to the success of the project.

As well as the strengths outlined above, Danum Valley does have some limitations.

- Oil palm plantations are being grown near to the northern border of the DVCA. This could affect the ecotourism potential of Danum Valley as tourists do not want to see agricultural areas so close to a protected area. The presence of people so near to the conservation area may also lead to increased poaching activity or illegal logging activity.
- The funding that supports the DVCA has been raised by logging and conversion of land once covered by rainforest to forest plantation. Some conservationists may see a conflict between the activities that have provided revenue for the DVCA and the aims of a protected area.
- The DVCA and surrounding area is currently designated a conservation area, but a change of leadership within those involved with the DVCA could see this designation changed. The establishment of the DVCA as a World Heritage Site would give international protection to the DVCA and ensure its long-lasting protection.

Overall, however, the impacts of the DVCA have been overwhelmingly positive. In June 2013, the Sabah State Assembly reclassified several forests as protected areas in the YSFMA, creating an unbroken stretch of continuous unbroken forest, including Maliau Basin, Imbak Canyon, and Danum Valley. This created the single largest protected area in Malaysia, covering nearly 500 000 ha (about five times the size of Penang Island).

Community support, adequate funding and proper research increases the chance of success for conservation efforts.

The DVCA contains more than 120 mammal species including 10 species of primate. The DVCA and surrounding forest is an important reservation for orang-utan. These forests are particularly rich in other large mammals including the Asian elephant, Malayan sun bear, clouded leopard, bearded pig, and several species of deer. The area also provides one of the last refuges in Sabah for the critically endangered Sumatran rhino. Over 340 species of bird have been recorded at Danum, including the argus pheasant, Bulwer's pheasant, and seven species of pitta bird. Higher plants include more than 1300 species in 562 genera of 139 families, representing 15 per cent of the species recorded for Sabah.

A Sumatran rhino

The location of a conservation area in a country is a significant factor in the success of the conservation effort. Use of surrounding land and distance from urban centres are important factors for consideration in conservation area design.

Species-based conservation strategies

Alternative approaches to the development of protected areas are species-based conservation strategies that include:

- **CITES**
- **captive breeding and reintroduction programmes, and zoos**
- **selection of charismatic species to help protect others in an area (flagship species)**
- **selection of keystone species to protect the integrity of the food web.**

The Convention on International Trade in Endangered Species (CITES)

CITES was established in 1973 and celebrated its 40th anniversary in 2013. It is an international agreement aimed at regulating trade in endangered species of both plants

and animals. This trade is worth billions of dollars every year and involves hundreds of millions of plant and animal specimens. Trade in animal and plant specimens (whole organisms, alive or dead, or their parts and derivatives), as well as factors such as habitat loss, can seriously reduce their wild populations and bring some species close to extinction. CITES' aim is to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild. CITES gives varying degrees of protection to 35 000 species of animals and plants. Species under threat from extinction are protected under 'Appendix I' of CITES. Commercial trade in wild-caught specimens of these species is illegal (permitted only in exceptional licensed circumstances). Many wildlife species in trade are not endangered: these are listed under 'Appendix II'. CITES aims to ensure that trade of Appendix II species remains sustainable and does not endanger wild populations, so as to safeguard these species for the future. Countries who sign up are agreeing to monitor trade in threatened species and their products that are exported and imported. Illegal imports and exports can result in seizures, fines and imprisonment, which discourages illegal trade.

How CITES works

Membership of CITES is voluntary. Each member country agrees to adopt legislation to implement CITES at the national level. All import, export, re-export, or

Case study

The effect of reclassifying African elephants from Appendix I to Appendix II

An African elephant

One of the biggest threats to elephant populations is the ivory trade, as the animals are poached for their ivory tusks. Other threats to wild elephants include habitat destruction and conflicts with local people. African elephants were listed on Appendix I of CITES in 1990. Appendix I prohibits the trade of wild-caught specimens completely (so as to protect plants and animals under considerable threat of extinction), whereas under Appendix II specimens can be exported but with trade restricted by a tightly controlled permitting process (i.e. classification is extended to species that are not necessarily threatened but could easily become so). As elephant populations grew in Zimbabwe, Botswana, and Namibia, in 1997 the classification of African elephants in these countries was changed to Appendix II (i.e. they were down-listed). The down-listing of African elephants in these countries resulted in a single shipment of stockpiled ivory, estimated to be ca. 50 000 kg, to Japan in 1999. African elephants were down-listed to Appendix II in South Africa in 2000. Delisting may have led to increased ivory poaching and a decline in many wild elephant populations African elephants provide an example of the effect of reclassification on wild populations.

introduction of specimens or parts and derivatives of any species covered by CITES, has to be authorized through a licensing system and permits must be obtained. The scheme has its limitations: it is voluntary and countries can 'enter reservations' on specific species when they join or when Appendices are amended, and penalties may not necessarily match the seriousness of the crime or be sufficient deterrent to wildlife smugglers (particularly given the large amounts of money that can be earned by poachers). In addition, unlike other international agreements such as the Montreal Protocol, CITES lacks its own financial mechanism for implementation at the national level and member states must contribute their own resources. However, taken overall, CITES has been responsible for ensuring that the international trade in wild animals and plants remains sustainable (Appendix II species), and for protecting species at risk of extinction (Appendix I).

CITES in numbers:

- 180: the number of countries ('contracted parties') signed up to the agreement
- 5500: the number of listed animals
- 29 500: the number of listed plants
- 35 000: the number of listed species.

Captive breeding and reintroduction programmes, and zoos

Zoos have become increasingly focused on conservation and many now lead the way in the preservation of species threatened with extinction. In prioritizing species for conservation, zoos have to answer many crucial questions.

How to select what to conserve?

- What is the level of threat? It is better to conserve endangered animals than ones that are not endangered.
- What to focus on? Different zoos have different expertise and areas of influence; they focus on their particular strengths.
- Can the zoo afford to financially support the project in the long term?
- Should species that are threatened for natural reasons (natural ecology) be conserved, such as those threatened by natural predation?
- What is the economic status of the country concerned? Zoos are more likely to support *in situ* conservation in LEDCs than MEDCs (which can help themselves).

In situ or *ex situ* conservation?

- How big is the animal? Smaller ones are easier to keep in zoos.
- Species facing habitat loss need to be conserved *ex situ* (e.g. Livingstone fruit bat – where 90 per cent of the habitat was lost due to cyclone damage).
- Animals threatened by diseases need to be kept *ex situ* (e.g. amphibian species are currently under threat globally from a fungus which is wiping them out in the wild, and so are being kept in quarantine in zoos).
- Decisions on which projects to undertake, will be influenced by staff expertise and whether or not the zoo vet has the knowledge to look after the species.
- If local people are willing to help, *in situ* conservation may be appropriate. If there are local political problems, *ex situ* may be preferred.
- Zoos often use species that are attractive to the public (e.g. lemurs and meerkats) to bring in visitors to provide funds for conservation. *Ex situ* conservation is therefore often used, even if the species is not especially threatened.

Is intervention helping?

Research to see if intervention is helping can be carried out by studying whether or not numbers are improving in the wild. Local expertise can assess whether the conservation effort is effective (e.g. in February 2015, a giant panda census was carried out in China, indicating that populations had grown by 268 to a total of 1864 since the last survey in 2003).

How are zoo populations managed?

When keeping animals in zoos, the welfare of the species must be taken into account. Behavioural studies can indicate whether or not animals are under stress. These studies may look at male and female social interactions, and how the animal uses their enclosures. The zoo would also consider whether the five freedoms are being met. The five freedoms were established in 1965 and were important in establishing modern zoo standards.

1. Freedom from thirst, hunger, and malnutrition through ready access to fresh water and a diet to maintain full health and vigour.
2. Freedom from thermal and physical discomfort by providing an appropriate shelter and a comfortable resting area.
3. Freedom from pain, injury, and disease by prevention or rapid diagnosis and treatment.
4. Freedom to express normal behaviour by providing sufficient space, proper facilities, and company of the animal's own kind.
5. Freedom from fear and distress by ensuring conditions and treatment avoid mental suffering.

How are breeding programmes managed?

For effective conservation and re-establishment of species in the wild, breeding programmes can be used. To be effective, details of the species' natural breeding behaviour must be known.

- Is it acceptable to choose the mate? Do you allow mate choice?
- The zoo may want to look at genes and the genetic compatibility of mates so as to avoid inbreeding. Leaving it to chance may lead to an animal choosing an unsuitable partner.
- Stud books can be used to establish genetic compatibility.
- Is artificial insemination a possibility? This will get round the problem of shipping in a mate.
- Birth control may be needed as the zoo may not want to have animals breeding (if zoo capacity is full).
- Keeper intervention may be needed – females sometimes reject young.
- Latest knowledge of reproductive biology and genetics is needed. Research is used (e.g. DNA testing by establishing parentage within a population).

Correct enclosure design and enrichment schemes mean that a species is more likely to breed.

Strengths and weaknesses of zoos

Among the strengths of zoos is their role in educating the public about the need for conservation. They also provide a way for people to empathize with wildlife. Although captivity is not the best solution, it acts as a good substitute and zoos can use breeding programmes to increase the population sizes of endangered animals while ensuring

genetic diversity (i.e. by genetic monitoring). Well-managed zoos provide a proper diet and enough space while keeping species in a controlled environment which protects individual organisms. They offer a temporary safe haven while efforts are made to preserve habitats, so that species can be reintroduced later.

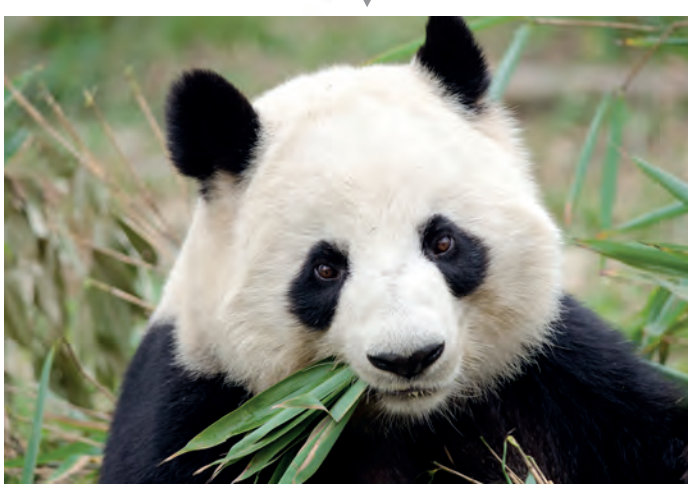
Weaknesses of zoos include the following. Some animals may have problems of re-adapting to wild, and captive animals released into the wild may become easy prey for predators. Not all species breed easily in captivity (e.g. it has proved extremely difficult to breed giant pandas). People may get used to seeing species in zoos and assume it is normal. Habitats in zoos are very different from natural habitats, especially for animals that have complex interactions with their environment such as orang-utans. There are ethical issues around caged animals, and some people object to animals being kept in captivity for profit. The best solution for endangered animals lies in the protection of their habitats.

The golden lion tamarin is one of the great success stories of zoo conservation. This small primate has been saved from extinction through captive breeding programmes.

Coordination of efforts between zoos helps in the effective conservation of species. The European Association for Zoos and Aquaria (EAZA) works out where specific zoos can help in specific areas. They have a number of Regional Collection Plans (RCPs). One of the RCPs is for the Callitrichid group of monkeys. The golden lion tamarin is a member of this group and has been brought back from the brink of extinction.

Flagship species

Flagship species are 'charismatic' species selected to appeal to the public and thereby help to protect other species in an area (e.g. the giant panda, meerkats, gorillas). By focusing on high-profile, iconic species there is a greater chance that conservation issues will catch the public attention, both nationally and internationally, and raise the necessary money for conservation initiatives. The advantages of this approach are twofold: money can be raised for the conservation of other species that may be equally endangered but are less appealing, and by preserving the habitat of the high-profile animal, other organisms in the habitat are also be preserved. Disadvantages of the approach include the favouring of



Giant panda eating bamboo, Chengdu, China

charismatic species (including those that may not be endangered in the wild) at the expense of less publically attractive species (even though they may be more critically endangered). Another disadvantage is that while species are preserved in zoos, their native habitat may be destroyed (as has happened with the giant panda).

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How do we justify the species we choose to protect? Is there a focus on animals we find attractive (the ones with fur and feathers) and is there a natural bias within the system? Do tigers have a greater right to exist than endangered and endemic species of rat?

An agouti feeding on a Brazil nut in a forest

Keystone species

Keystone species are species that are vital for the continuing function of the ecosystem: without them the ecosystem may collapse. For example, the agouti of tropical South and Central America, which feeds on the nuts of the Brazil nut tree.

The Brazil nut tree (*Bertholletia excelsa*) is a hardwood species that is found from eastern Peru, eastern Colombia and eastern Bolivia through Venezuela and northern Brazil. They are the tallest trees in the Amazon (they grow up to 50 m). The agouti is a large forest rodent, and the only animal with teeth strong enough to open the Brazil nut tree's tough seed pods. The agouti buries many of the seeds around the forest floor so it has access to food when the Brazil nuts are less abundant. Some of these seeds germinate and grow into adult plants. Without the agouti, the Brazil nut tree would not be able to distribute its seeds and the species would eventually die out. Without the Brazil nut tree, other animals and plants that depend on it would be affected; for example, harpy eagles use the trees for nesting sites. Brazil nuts are one of the most valuable non-timber products found in the Amazon: they are a protein-rich food source, and their extracted oils are a popular ingredient in many cosmetic products. The sale of Brazil nuts provides an important source of income for many local communities.

A keystone is the central stone at the top of an arch. It supports the whole arch and ultimately the building it is part of.

There are various approaches to the conservation of biodiversity. How can we know when we should act on what we know?

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Given the complexity of ecosystems, keystone species may be difficult to identify. In addition, many keystone species may be species that are as yet unidentified. By conserving whole ecosystems (i.e. establishing protected areas), rather than attempting to conserve individual species, the complex interrelationships that exist there will be preserved, including the keystone species.

Comparing different approaches to conservation

Table 3.3 summarizes advantages and disadvantages of some of the *in situ* and *ex situ* conservation strategies explored in this chapter.

	Advantage	Disadvantage
protected areas	• can conserve whole ecosystems • allows research and education • preserves many habitats and species • prevents hunting and other disturbance from humans • visiting an intact ecosystem enables it to be studied to increase understanding of its functions • preservation of diversity more likely with a holistic approach as diversity can be species/habitat/genetic • many species have not been discovered yet but are protected	• requires sufficient funding and protection to ensure area is not disturbed • difficult to establish in first place due to political issues/economic interests • areas can become islands and therefore may lose biodiversity due to size, shape, edge effects, etc. • may be subject to outside forces that are difficult to control
CITES	• can protect many species • signed by many countries • treaty works across borders • CITES is legally binding on the parties and so they must implement the convention	• difficult to enforce • implementation varies from country to country • it does not take the place of national legislation and countries must make their own laws to ensure that CITES is applied at the national level
zoos	• allows controlled breeding and maintenance of genetic diversity • allows research • allows for education • effective protection for individuals and species • education/empathy	• have historically preferred popular animals not necessarily those most at risk • problem of reintroducing zoo animals to wild • *ex situ* conservation and so do not preserve native habitat of animals

Table 3.3 Evaluating habitat conservation (protected areas) and species-based conservation (CITES and zoos)

The main strengths of species-based conservation are that it attracts attention and therefore funding for conservation, and successfully preserves vulnerable species in zoos, botanic gardens, and seed-banks (i.e. preserve genetic diversity for future restocking of habitats). The main limitation of this approach is that if the ecosystem is not treated as a holistic unit, and habitats are not directly preserved, it will be difficult to ultimately preserve species.

The main strength of protected areas is that they protect the whole ecosystem and the complex interrelationships that exist there, so long-term survival of species is more likely. They also allow research to take place on intact ecosystems, greatly adding to our understanding of the factors that support biodiversity. Ecotourism raises awareness and profits are recycled back into biodiversity programmes. However, they do require considerable funding and protection to ensure the areas are not disturbed. Limitations may come from the fact they may become islands and may therefore lose biodiversity through their size, increased edge effects, or reduced gene flow between populations.

A mixed approach

Combining both *in situ* (e.g. protected areas) and *ex situ* (e.g. zoos and captive breeding) methods can be the best solution for species conservation in many instances. A good example of this is giant panda conservation. You have already seen how these animals can act as flagship species (page 203), and they were listed Appendix I by CITES in March 1984. Other species-based approaches include breeding programmes in zoos. Chengdu Zoo began breeding giant pandas in 1953, and Beijing Zoo in 1963. From 1963 to the present time, the giant panda has been bred in 53 zoos and nature reserves within China and internationally. Beijing Zoo has an impressive giant panda house, and has established a successful breeding programme.

Giant pandas enjoy a high profile within Chinese culture. Billboard showing pandas at Beijing zoo.

To learn more about the Chengdu Panda Base, go to www.pearsonhotlinks.co.uk, enter the book title or ISBN, and click on weblink 3.7.

Raising giant pandas in captivity has three main difficulties: getting the female to come into heat (become reproductively receptive), conducting artificial insemination (introducing sperm into the female), and raising the cubs. In 1963, Beijing Zoo had the first success in artificially breeding giant pandas, and in 1978 the same zoo was the first to successfully carry out artificial insemination. In 1992, Beijing Zoo succeeded in raising a panda cub that had been artificially bred.

In situ conservation of giant pandas has involved the establishment of protected areas. The first five nature reserves for giant pandas in China were established in 1963, of which four are in Sichuan province. The giant panda nature reserves have expanded from the initial 5 to 56 in 2008.

When asked to evaluate different conservation strategies do not simply say 'raises awareness' unless this statement is directly linked to action which enhances diversity (e.g. education of public leads to increased donations to conservation organizations leading to improved biodiversity protection).

The Chengdu Research Base of Giant Panda Breeding (also known as the Chengdu Panda Base) is involved in both *in situ* and *ex situ* conservation, with an emphasis on wildlife research, captive breeding, conservation education, and educational tourism. As well as breeding pandas, the Chengdu Panda Base covers an area of about 200 ha, with habitat that also contains red pandas and other endangered species.

Exercises

1. Outline arguments about species and habitat preservation.
2. Draw up a table contrasting governmental organizations and NGOs in terms of use of the media, speed of response, diplomatic constraints, and political influence.
3. State the criteria used to design protected areas. Your answer should address size, shape, edge effects, corridors, and proximity to other reserves.
4. What makes a protected area a success? List at least five essential factors that are required.
5. Evaluate the success of a named protected area.
6. Evaluate different approaches to protecting biodiversity, including habitat conservation, species-based conservation, and a mixed approach.

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?
- What value systems can you identify at play in the causes and approaches to resolving the issues addressed in this topic?
- How does your own value system compare with others you have encountered in the context of issues raised in this topic?
- 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?

Points you may want to consider in your discussions:

- How do different conservation measures (e.g. *in situ* and *ex situ*) prevent environmental impacts, limit the extent of the environmental impacts, or restore systems in which environmental impacts have already occurred?
- How would a technocentric view of biodiversity differ from an ecocentric one? How do different EVSs affect approaches to conservation?
- If you are from a MEDC, how would your EVS differ from that of someone from a LEDC, or from someone who relies on the preservation of natural ecosystems for survival?
- Do you think that the conservation measures being taken today will be sufficient to preserve the Earth's biodiversity for the future?

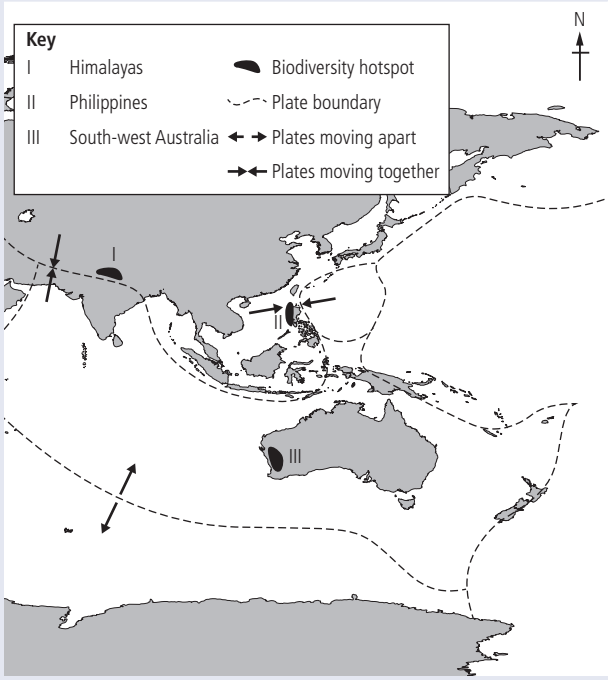
Practice questions

1 **a** Distinguish between *biodiversity*, *species diversity*, *habitat diversity* and *genetic diversity*. [2]

b Explain how species diversity for an area may be calculated. [4]

c Outline the reasons why tropical biomes should be conserved. [5]

2 The map in the figure below shows plate movements and three biodiversity hotspots in Asia and Australasia. Hotspots are regions with especially high biodiversity.



a Explain how the plate movements shown in the figure may have contributed to the biodiversity of the hotspot regions. [4]

b Below is a photograph of a clouded leopard (*Neofelis nebulosa*), one of the Himalayan species that is listed as 'vulnerable' on the Red List.

i Outline four factors that are used to determine the conservation status of an organism on the Red List. [2]

ii With reference to the case history of a named critically endangered species or endangered species, describe the human factors that have led to its conservation status. [2]

3 a The World Wide Fund for Nature (WWF) estimates that there are now more tigers in captivity than in the wild. Evaluate the use of zoos for the preservation of the tiger population. [3]

b Suggest two criteria that should be used to design a protected area for tigers. [2]

4 a Population dynamics can be defined as, 'the study of changes and the reasons for changes in population size'. Discuss why an understanding of the population dynamics of an endangered species is essential to the efforts for its conservation. [8]

b Outline two reasons for the extinction of a named species and suggest how intervention measures can improve the conservation status of a species. [8]

c Justify which criteria you think should be used to judge the success of a conservation area. Evaluate the success of a named protected area using the criteria you have identified. [7]