IB Environmental Systems and Societies

Unit 4 Conservation and Biodiversity

"Destroying the rainforest for economic gain is like burning a Renaissance painting to cook a meal."

E.O. Wilson

	Assessment statement	Teacher's notes
4.1.1	Define the terms biodiversity, genetic diversity, species diversity and habitat diversity.	
4.1.2	Outline the mechanism of natural selection as a possible driving force for speciation.	Speciation occurs as a result of the isolation (geographical or reproductive) of populations. The concept of fitness should be understood. The history of the development of the modern theory of evolution is not expected, nor is a detailed knowledge of genetics (including frequency).
4.1.3	State that isolation can lead to different species being produced that are unable to interbreed to yield fertile offspring.	Isolation of populations, behavioural differences that preclude reproduction and the inability to produce fertile offspring (leading to speciation) should all be examined, with examples.
4.1.4	Explain how plate activity has influenced evolution and biodiversity.	The consequences of plate tectonics on speciation should be understood (that is, the separation of gene pools, formation of physical barriers and land bridges) together with the implications these consequences have for evolution. The role of plate activity in generating new and diverse habitats, thus promoting biodiversity, should also be considered. Detailed understanding of the mechanism of plate tectonics is not required.
4.1.5	Explain the relationships among ecosystem stability, diversity, succession and habitat.	Consider how: • Diversity changes through succession • greater habitat diversity leads to greater species and genetic diversity • a complex ecosystem, with its variety of nutrient stability and energy pathways, provides stability

		• human activities modify succession, for example, logging, grazing, burning • human activities often simplify ecosystems, rendering them unstable, for example North America Wheat farming versus tall grass prairie • an ecosystem's capacity to surivive change may depend on diversity, resilience and inertia.
4.2.1	Identify factors that lead to loss of diversity.	These include: • natural hazard events (for example volcanoes, drought, ice age, meteor impact) • habitat degradation, fragmentation and loss • agricultural practices (for example monoculture, use of pesticides, use of genetically modified species) • introduction and/or escape of non-native species • pollution • hunting, collection and harvesting.
4.2.2	Discuss the perceived vulnerability of tropical rainforests and their relative value in contributing to global biodiversity.	Consider: • vulnerability of other systems • the regeneration rate of tropical rainforests • total area and species diversity • rainforest and "green politics".
4.2.3	Discuss current estimates of numbers of species and past and present rates of species extinction.	Examine the fossil record for evidence of mass extinctions in the past, and compare and contrast the possible causes of these to present-day extinctions. The time frame of these periods of extinction should be considered.
4.2.4	Describe and explain the factors that may make species more or less prone to extinction.	The following factors (among others) will affect the risk of extinction: numbers, degree of specialization, distribution, reproductive potential and behaviour, and trophic level.
4.2.5	Outline the factors used to determine a species' Red List conservation status.	Students should be aware of the factors used to determine a species' conservation status, and that a sliding scale operates. Students should appreciate that a range of factors are used to determine conservation status, such as: • Population size • reduction in population size • number of mature individuals • geographic range and degree of fragmentation • quality of habitat

		• area of occupancy • probability of extinction Definitions of the conservation status categories are not required and the term "criteria" has been avoided due to the complexity of the Red List classification system.
4.2.6	Describe the case histories of three different species: one that has become extinct, another that is critically endangered, and a third species whose conservation status has been improved by intervention.	Students should know the ecological, socio-political and economic pressures that caused or are causing the chosen species' extinction. The species' ecological roles and the possible consequences of their disappearance should be understood.
4.2.7	Describe the case history of a natural area of biological significance that is threatened by human activities.	Students should know the ecological, socio- political and economic pressures that caused or are causing the degradation of the chosen area, and the consequent threat to biodiversity.
4.3.1	State the arguments for preserving species and habitats.	Students should appreciate arguments based on ethical, aesthetic, genetic resource and commercial (including opportunity cost) considerations. They should also appreciate life- support and ecosystem-support functions.
4.3.2	Compare and contrast the role and activities of intergovernmental and non-governmental organisations in preserving and restoring ecosystems and biodiversity.	Consider the United Nations Environment Programme (UNEP) as an intergovernmental organization and the World Wide Fund for Nature (WWF) and Greenpeace as non-governmental organizations. Compare and contrast UNEP and WWF in terms of use of the media, speed of response, diplomatic constraints and political influence. Consider also recent international conventions on biodiversity (for example, conventions signed at the Rio Earth Summit (1992) and subsequent updates).
4.3.3	State and explain the criteria used to design protected areas.	In effect, protected areas may become "islands" within a country and will normally lose some of their diversity. The principles of island biogeography might be applied to the design of reserves. Appropriate criteria should include size, shape, edge effects, corridors and proximity.
4.3.4	Evaluate the success of a named protected area.	The granting of protected status to a species or ecosystem is no guarantee of protection without community support, adequate funding and proper research. Consider a specific local example.

4.3.5	Discuss and evaluate the strengths and weaknesses of the species- based approach to conservation.	Students should consider the relative strengths and weaknesses of: • the Convention on International Trade in Endangered Species (CITES) • captive breeding and reintroduction programmes, and zoos • aesthetic versus ecological value.

4.1.1 Define the terms biodiversity, genetic diversity, species diversity and habitat diversity.

Biodiversity - "refers to the amount of biological or living diversity per unit area."[1]

Genetic diversity - refers to "the range of genetic material present in a gene pool or population of a species...A large gene pool leads to high genetic diversity and a small gene pool to low genetic diversity."[2]

Species diversity - "refers to the variety of species per unit area; it includes both the number of species present and their relative abundance."[3]

Habitat diversity - refers to the "range in different habitats in an ecosystem."[4]

4.1.2 Outline the mechanism of natural selection as a possible driving force for speciation.

Natural Selection is a controversial topic. Not taught in many national curricula, however, as a theory for speciation there is significant evidence for the theory of **Natural Selection** proposed by Charles Darwin in 1859.

A reminder back to Unit 2 and assessment objective 2.1.6... A species is " a group of organisms that interbreed and produce fertile offspring."[5] Therefore the continuation of a species is dependent on the reproductive cycle and fertility of the offspring. Where two different species can biologically reproduce, they do not produce fertile offspring. This creates a new species altogether. The process of forming new species is called **speciation**.

The theory of evolution is that over long periods of geological time species have slowly changed according to their environment and their ecological niche. Competition mechanisms (parasitism, mutualism and predation) have been a significant drivers to speciation. As food and water resources have changed over time, along with habitats and climates the characteristics of certain species who are dependent on resources have evolved or changed. The lack of one food source has then increased demand for another. Biologically, some species may not have been equipped to access a new food source and therefore had to develop new methods to access food or change their diet. Over many years, gradual change in ecological niche has supposedly led to the formation of different species.

More commonly, the theory of natural selection, is known as 'survival of the fittest'. We can see that even today in many species the strongest, fastest animals have the right to reproduce. This is particularly true with animals which live with a hierarchical society e.g. Elephants, Lions, Deer and Wolves. Therefore

[1] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.175.
[2] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.176.
[3] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.176.
[4] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.176.
[5] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.19.

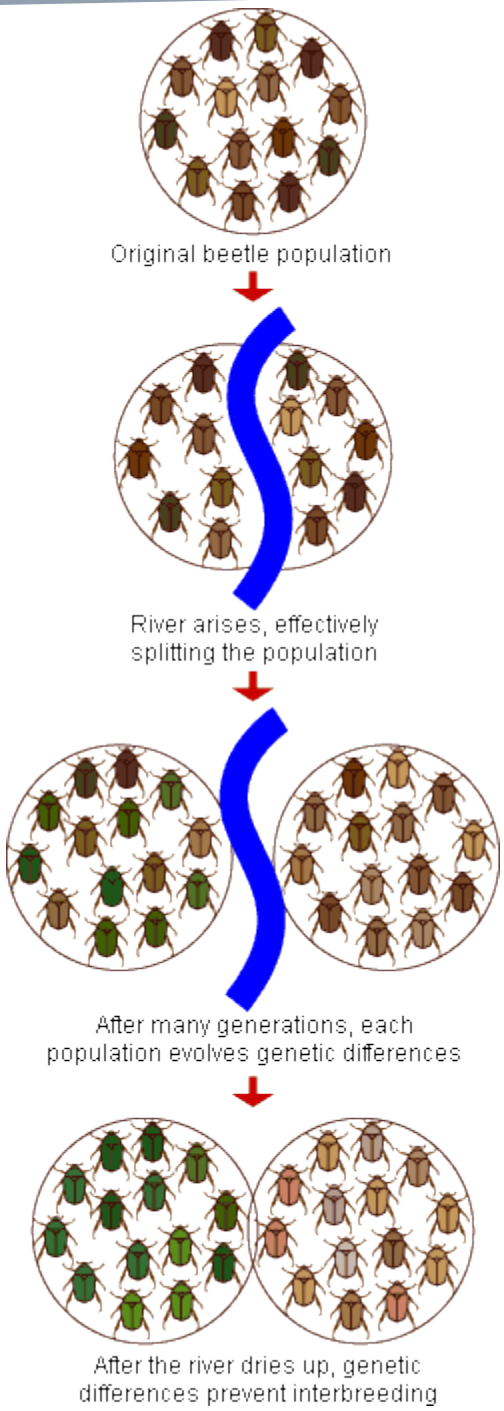


Figure 1 Geographic Isolation

the males species which are strongest and most likely to protect the pack or herd are most likely to reproduce. Subsequently these genes are then passed onto the next generation, meaning that the next generation are as strong as their parents. Over millennia these genes have become stronger and more resistant to change. Weaker species which have been less resistant to change have then become extinct. More on extinction under assessment objective 4.2.4.

4.1.3 State that isolation can lead to different species being produced that are unable to interbreed to yield fertile offspring.

Figure 1 [6] shows a diagram to explain how isolation can lead to different species being produced that are unable to interbreed to yield fertile offspring. A geographic barrier could be a number of physical landforms such as a river, river valley, mountain range.

Where a population of the same species in one habitat is split by a geographic barrier such as a river, or forest track the newly split communities cannot interact, and therefore not reproduce with one another. Over time the seperate communities reproduce within their community and there change their genetics according to their new ecological niche. Since their genetics have changed over many generations, when the geographical barrier is removed or overcome (migration, afforestation) then the two species cannot interbreed with fertile offspring.

4.1.4 Explain how plate activity has influenced evolution and biodiversity.

From IGCSE Geography, all students should be aware of tectonic movement and continental drift. The layer on which life inhabits is the outer most layer of the earth, known as the crust or lithosphere. The lithosphere floats ontop of the astenosphere, which acts as a lubricant between the Earth's Mantle and lithosphere. Due to the movement of magma beneath the Earth's surface some plates on the Earth's crust move apart, some slide in opposite directions and some collide. This movement of the Earth's plates has resulted in the movement of continents over millions of years. Subsequently forming new geographic barriers and land bridges over previous barriers.

[6] 'Speciation: Ernst Mayr', Understanding Evolution. University of California Museum of Paleontology. 2012 ,Web. 27.12.2012 <http://evolution.berkeley.edu/evolibrary/article/history_21>

The movement of continents both in latitude and longitude, distance from open water and mountain ranges and altitude has resulted in the change in climates. We can support this theory with geological evidence in the form of rock types and fossils preserved in the rocks. The change in geographical locations has led to some areas being subjected to many of the worlds extreme climatic conditions and the presence of species which can tolerate such conditions.

Furthermore, the formation of Island arcs allow geographic isolation to occur from the initial stage of succession as a result of the pioneering species. Take Hawaii and the Galapagos Islands as prime examples.

4.1.5 Explain the relationships among ecosystem stability, diversity, succession and habitat.

The different environments and geographic locations give each ecosystem unique conditions for life. The more complex an ecosystem's structure the higher the resistance to disturbance and change. "Three factors determine the ability of ecosystems to recover following disturbance:

- Inertia (persistence) - resistance to being altered
- resilience - ability of a system to recover after a disturbance
- diversity - the number and proportions of species present."[7]

The greater the amount of inertia, resilience and diversity that a ecosystem has the better the chance it has to withstand long term damage. Therefore when a diverse ecosystem is threatened or endangered is likely to return to its stable and steady-state equilibrium. Where an ecosystem has low amount of resistance to alteration, low biodiversity and a poor ability to recover after any disturbance to the ecosystem it is unlikely to return to its natural balance and be subject to continued disturbance or destruction.

Areas which are isolated and newly disturbed are obviously harder to initially colonize since vegetation is most likely to have been killed. There are three ways which new species to an isolated location can arrive, by air, water or transported by migratory species.

These three ways to colonise an isolated area are easiest for mobile species such as animals and fish. However, plants also use the air, water and migratory species to disperse their seeds. Passive transportation occurs as seeds disperse their seeds through the air. Local winds lead and link to larger currents. Using the trade winds, plants can disperse their seeds over long distances. Other plant seed may be stored inside migratory animals (within their faeces) this way seeds can also be transported long distances. This method of dispersal is known as **'jump dispersal'** where the dispersal is relatively rapid considering the vast areas that are covered in order to colonise. In contrast "**Diffusion** - Slower than jump dispersal and involves populations, rather than individuals. It describes the spread of species at the edge of their ranges into new areas."[8] The third type of species dispersion is "Secular Migration - dispersal over geological timescales (thousands to millions of years). This is diffusion taking place so slowly that the

[7] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.186.
[8] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.184.

diffusing undergoes under evolutionary change during the process. It inclused the diversification and spread of flowering plants, and the evolution of South American Llamas and vicunas that are descended from the now extinct North American members of th e camel family that migrated during the Pliocene."[9]

The rate at which these three modes of colonizing occur, impact on the speed at which new ecosystems are formed. When ecological succession takes place, the relationship between the ecosystem and the diversity becomes stronger. Where the conditions for life are harsh and extreme the diversity tends to be low. This is due to the tolerance levels of organisms. Therefore, r-strategists tend to colonise extreme ecosystems and reduce the presence of chemicals which make the conditions for life hard. As a result of the short life span that r-strategists have the dead organisms then create a more fertile environment and subsequently more tolerable to other species. As a consequence, the diversity of an area increases as succession takes place.

Ecosystems which have reached their final stage of succession have the highest diversity. This makes the ecosystem most resilient to disturbance (or plagioclimax). Due to the amount of species present, the food webs also become more complex. "Complex ecosystems such as rainforests have complex food webs which allow animals and plants many ways to respond to disturbance of the ecosystem and thus provide high inertia."[10]

4.2.1 Identify factors that lead to loss of diversity.

[9] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.185.
[10] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.186.

4.2.2 Discuss the perceived vulnerability of tropical rainforests and their relative value in contributing to global biodiversity.

The Tropical Rainforests are unique. Their conditions for life are optimal. This is due to the availability of fresh water (up to 2500mm per annum), moderate-high temperatures as well as the large concentration of the sun's solar energy. However, these ecosystems only occupy 5.9% of the land on Earth.[11]

Despite the excellent conditions for life of Tropical Rainforests (TRFs), the pressure and stress on them is huge. As a complex ecosystem, containing a massive amount of producers and consumers, the services it can offer to societies are many. Thus, human society relies on TRFs to supply timber as a primary and direct product. Consequently leading to deforestation. Other factors which ensure the demise of the TRFs is the demand for land to raise livestock (to produce beef), grow soya, bio-fuel crops, mineral extraction and the constant growth of urban areas continues to reduce the amount of land occupied by TRFs. This excludes the ecological services that TRFs provide. Primarily capturing Carbon and producing valuable Oxygen, filtering water and providing habitat.

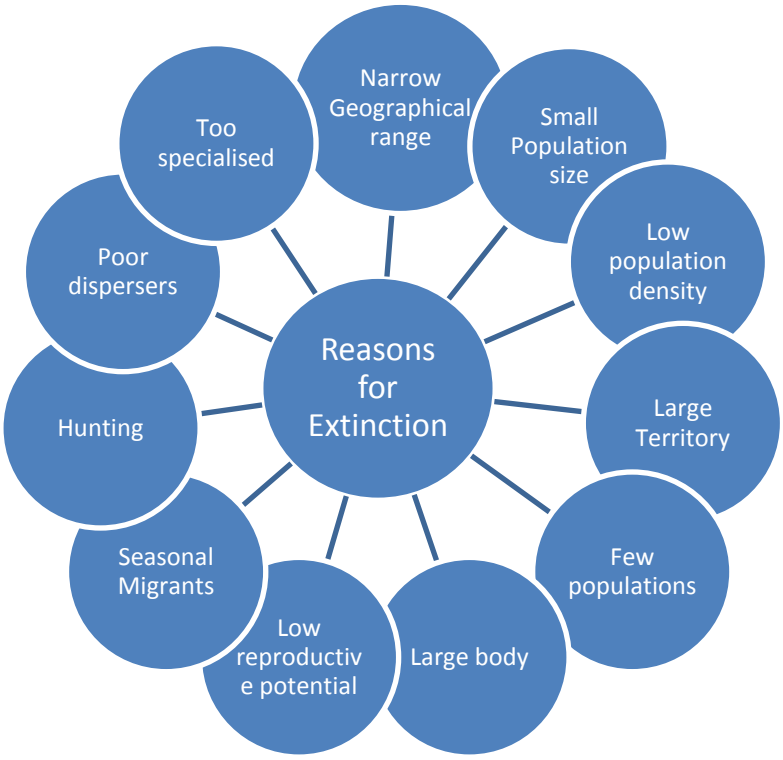
As a result of all this disturbance, the rate of natural replenishment is undoubtedly compromised. Where the amount taken from TRF is greater than is replenished. Soils become more and more infertile, rivers become increasingly full of sediment and therefore these abiotic factors have an impact on the biotic factors. The amount of vegetation that can be supported in infertile soil is much lower, this has a domino effect on species in higher trophic levels.

4.2.3 Discuss current estimates of numbers of species and past and present rates of species extinction.

Any current estimates are hugely inaccurate. Whilst new species are being discovered daily, species are also becoming extinct at an increasingly alarming rate. It is estimated that there could be between 5 million and 10 million species on Earth. However, only 1.8 million are known to man. Our inability to access the deepest ocean trenches, highest peaks and the hottest deserts ensure that we have little understanding of the species on our own planet. Although the amount of areas unexplored are decreasing, the probability of recording everything that lives there it remote. When you consider that scientists have to find the species (could be bacterial for fungus' or nocturnal) then it becomes very difficult. Some of the time, discoveries are only as a result of opportunistic sightings of species. Additionally, scientists must also know whether or not that particular individual is belonging to an identified species already. The difference in appearance between male and female, young and old in a species could potentially cause misidentification and subsequent confusion.

[11] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.188.

4.2.4 Describe and explain the factors that may make species more or less prone to extinction.



4.2.5 Outline the factors used to determine a species' Red List conservation status.

The International Union for the Conservation of Nature (IUCN) is an organisation which regularly records the vulnerability of species and publishes "Red Data Books" on vulnerable species. The IUCN have split the categories into the following divisions (Figure 2):

Figure 2 Categories of Vulnerability[12]

The IUCN categorise species based on a variety of factors. The greater the risk of extinction, more protection is given. This could involve introduction of governmental policy or the creation of natural reserves or Sites of Special Scientific Interest. However, IUCN use the factors highlighted in Assessment objective 4.2.4 to determine the categorisation of the species. This could include:

- "Population size
- reduction in population size
- number of mature individuals
- geographic range and degree of fragmentation

[12] 'International Union for the Conservation of Nature', IUCN. 2014 ,Web. 06.01.2014 <http://www.iucnredlist.org/>

- quality of habitat
- area of occupancy
- probability of extinction."[13]

4.2.6 Describe the case histories of three different species: one that has become extinct, another that is critically endangered, and a third species whose conservation status has been improved by intervention.

This assessment objective directly relates to your own research essay on a species of your choice. Although other examples found in your Core Textbook include Falkland Islands Wolf, Iberian Lynx and he American Bald Eagle. (Pages 196-199)

4.2.7 Describe the case history of a natural area of biological significance that is threatened by human activities.

Similarly, use your textbook to look at The Great Barrier Reef to complete the table below. (Page 199-201)

Ecological Value	Human Threats	Natural Threats
Consequences:		

[13] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.194.

4.3.1 State the arguments for preserving species and habitats.

Both Species and their Habitats provide services for other species and environments. It is essential that nature is given the opportunity to function to its potential and not hindered or disturbed to a level which it cannot recover. Sadly, human society is much to eager to place a financial or economic value on the environment. However, from an ethical, aestetic or genetic perspective it is much harder to place value on such important components of an ecosystem.

Economic Values	Ethical, Aestetic or Genetic Values"
"Products such as tiber and medicines	Ecosystem Productivity The functioning of ecosystems depend on many different interacting biological components. Insects are needed for pollinaion, decomposers and detritivores for soil aeration and fertility, and mammals and birds for seed dispersal. Ecosystems contain plants which remove carbon dioxide from the air, provide oxygen and help to regulate the climate...
Food such as wheat, rice and maise - are all derived from wild plants.	Scientific reasons - The number of species on Earth and their interactions are still poorly understood. When areas of biodiversity are lost before they can be studied, irreversible damage is done to scientific knowledge.
Ecotourism attracts tourists to areas such as The Great Barrier Reef thus providing revenue for the local economy.	Ethical reasons - Each species on Earth has the right to exist. Humans, as the dominant form of life, have a responsibility to protect the widest range of biodiversity as possible.

Page 203 in your text book.

4.3.2 Compare and contrast the role and activities of intergovernmental and non-governmental organisations in preserving and restoring ecosystems and biodiversity.

When looking at how areas or species are protected or restored, two main groups of organisations seek to meet the same target, but with very different approaches. "Non-governmental organisations (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)."[14] In contrast, "Intergovernmental Organisations (GOs) are bodies established through international agreements to protect the environment and bring together governments to work together on an international scale (e.g. United Nations Environment Programme (UNEP), International Union for the Conservation of Nature (IUCN) and the European Environment Agency (EEA)).[15]

	GOs	NGOs
Use of Media	Employed Media Liasions to prepare official statements, international campaigns.	Popular advertisement, leaflets and press packs. Not as targeted in terms of audience.
Speed of response	Fairly slow due to bureaucracy and legalities. All the official steps must be taken within government run organisations	Fast and regular as they are independent from governmental organisations so can skip some of the bureaucratic processes.
Diplomatic constraints	Cannot give opinion without consulting lawyers and other countries because they represent many countries, therefore international agreement must be made before there is any progress.	Generally unaffected by the politics. Although activities are occasionally illegal.
Political influence	Direct access to many governments.	No direct political persuasion, however, pressure can be added to politicians to encourage certain habits or practices.
Enforceability	Internationally binding agreements and laws	Pressure as opposed to legalities.

based on p.205 of Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010).

[14] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.204.
[15] Andrew Davis and Garrett Nagle, 'Environmental Systems and Societies', (Pearson Education Limited, New Jersey, 2010), p.204.

4.3.3 State and explain the criteria used to design protected areas.

- Shape
- Edge Effect
- Area
- Corridors
- Buffer Zone

4.3.4 Evaluate the success of a named protected area.

All areas have potential to be successfully protected. In order to evaluate how successful an area is we must look at the overall management of the threats to an area. Simply, for conservation purposes, economics, education and management are crucial for the success of a protected area.

Economics - protected areas which are not partially funded by the government or supported by the government tend to struggle and have a much lower impact on their environment. Therefore having the interest of the government inevitably increases the chances of the success of the protected area. But why would a government be willing to invest in a protected area. The rarer the species, or more charismatic the species, the bigger the appeal for international cooperation to protect it. This could be in terms of economically...ecotourism or international funding to preserve the environment. In turn this provides jobs for locals and stimulates the local economy. Similarly, protected areas encourage research teams to develop in the local area, thus attracting international attention.

Education - the second key to success. Whilst having good management and economics is crucial, if the local population work against such programmes it makes them much harder to manage, protect and develop. Involving local populations in the projects to protect areas should reduce tension and potential conflicts between farmers and conservationists for example. Additionally, education should reduce the amount of disturbance from locals, but educating tourists also spreads the aims of the protection zone much further afield. Areas which have charismatic species living within them, tend to gain much more publicity. Therefore can exploit the species' charisma to promote the importance of protection. One must ask though why humans, as a species, react differently to different species. There is much more empathy shown towards large mammalian species as opposed to fungi or invertebrates.

Management - with some governmental funding, the probability of their being a committee or a research group to oversee the project is much higher. Consequently, there will be a bank of national experts who will be able to assist locals with a knowledge base. This gives the protected area much more importance and there is an active part played by the government and it's departments to ensure the successes of such protected areas. Similarly, with managerial experiences from a government level, there is likely to be more structure and thus progress within the area. Rather that it developing to sudden changes in the area forcing a park authority to make a decision as opposed to having a choice of options.

In class the Danum Valley Conservation Area in Malaysian Borneo was used to illustrate the ideas above.

4.3.5 Discuss and evaluate the strengths and weaknesses of the species- based approach to conservation.