M19/4/ENVSO/SP2/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Environmental systems and societies

Standard level

Paper 2

17 pages

Subject details: Environmental systems and societies SLP2 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions in Section A **[25]** and **TWO** questions in Section B **[40]**.
- The maximum total = **[65]**.

1. Environmental systems and societies uses marking points and markbands to determine the achievement of candidates

When using marking points (<u>All of this paper except</u> Section B, part (c) questions):

i. A markscheme often has more marking points than the total allows. This is intentional

ii. Each marking point has a separate line and the end is shown by means of a semi-colon (;)

iii. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **<u>precise point</u>** where it becomes clear that the candidate deserves the mark. **<u>One tick to be shown for each mark awarded</u>**

iv. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

When using markbands (<u>Only</u> for Section B, part (c) questions):

i. Read the response and determine which band the response fits into

ii. Then re-read the response to determine where the response fits within the band

iii. Annotate the response to indicate your reasoning behind the awarding of the mark
Do not use ticks at this point

iv. Decide on a mark for the response

v. At the end of the response place the required number of ticks to enable RM Assessor to input the correct number of marks for the response.

2. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

3. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

4. Words that are <u>underlined</u> are essential for the mark.

5. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).

6. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

7. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

8. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

Section A

1. (a) Outline **two** reasons why the species within pioneer communities in **Figure 1** are more likely to be *r*-strategists than *K*-strategists. **[2 max]**

r-strategists produce greater numbers/many offspring/fast population growth;
r-strategists distribute themselves more widely/colonize more quickly;
r-strategists mature quickly/reproduce earlier/establish themselves faster;
r-strategists better adapted to harsh/low-nutrient conditions/less specialised niches;

Do not accept just ANY valid characteristic of r-strategists (eg short life-span) ...only those directly relevant to a pioneer community as above.

(b) Outline **two** reasons why the climax community in **Figure 1** is more stable than the intermediate community. **[2 max]**

greater number of species/habitat/ecological niches/genetic diversity in climax community;
gross productivity/stored biomass is higher in climax community;
more complex/diverse energy pathways/food webs;
more established nutrient cycling;
more favourable abiotic conditions/soil properties;
more established negative feedback mechanisms;

(c) Distinguish between zonation and succession. **[1]**

succession is the process of changes in community/ecosystem over time, whereas zonation is the process of changes over an environmental gradient/space;

(d) Outline **two** ways in which the food web is likely to change as a result of succession. **[2]**

increasing numbers of trophic levels / longer food chains;
will be composed of new/different species;
more branching / greater complexity / more species at each trophic level;
greater gross productivity/energy transferred at each trophic level;
more biomass stored at each trophic level;
increased prominence of decomposer community;

(e) Outline **two** ways in which the soil quality in the pioneer stages of the succession model shown in **Figure 1** will differ from that in the climax ecosystem. **[2 max]**

In pioneer communities...
there will be lower organic content/leaf litter (due to combustion from the fire);
there may be a higher concentration of available minerals (released from ashes);
there may be fewer soil organisms (following deaths from fire);
it will be more prone to erosion/evaporation losses (through lack of vegetation cover/roots by fire);
less established nutrient recycling / reduced decomposer community;

Accept converse of these statements for climax community.
***Note:** The model shows SECONDARY succession (after fire), so not all generic features of a pioneer community in PRIMARY succession would be valid. eg in primary succession soil nutrients may be higher in climax community, but in secondary succession reverse is more likely (although processes of nutrient cycling/decomposition may still be more advanced established in climax community as in primary succession).*

2. (a) With reference to **Figure 2**, state the country that has the highest level of recycling/composting. **[1]**

Austria;

(b) Outline **two** possible reasons for greater use of landfills in the United States compared with the European countries shown in **Figure 2**. **[2]**

more available land in USA / less available land in Europe;
high cost/privatisation of recycling in USA / more subsidies for recycling in Europe;
limited domestic technology for recycling established / dependence on export of recyclables in USA;
in Europe, a stronger environmental education/commitment/more ecocentric EVS;
EU laws/regulations may penalise landfill use/promote alternative disposal;

(c) Outline **two** strategies for reducing the environmental impact of landfill sites. **[2 max]**

reducing waste/employing alternative disposal methods;
collection of methane / management to prevent spontaneous ignition;
extraction/treatment of leachates;
use of impermeable liner/clay/materials / locating above impermeable rock;
locating away from surface and groundwater sources/residential areas/vulnerable or valuable ecosystems;
visual screening to reduce impact of eyesore/aesthetic degradation OWTTE;
effective cover/containment system to prevent plastics/lightweight materials blowing into environment;
limiting transport distance/emissions from collecting vehicles;
densely compacting solid waste before dumping;

(d) Identify **two** problems associated with **one** of the waste disposal choices of Germany. **[2 max]**

ALTERNATIVE 1: Waste to energy (through incineration/biogas):
emissions from combustion/anaerobic digestion can be toxic/release GHGs/add to air pollution;
still require disposal of solid waste/ash;
requires technology/infrastructure which could be expensive/not cost-effective;
public opposition due to noise/smell/aesthetics/perceived health threats/impact on property prices;
may reduce public incentive to reduce waste;

ALTERNATIVE 2: Recycling/composting:
recycling can be energy intensive;
recycling requires technology which could be expensive;
emissions from recycling process/unaerated composting could release GHGs etc;
limited range of products can be effectively recycled/composted (inappropriate materials/poor sorting/condition);
requires political will/civil management/public collaboration;
recycling can degrade materials;
composting may lead to bacterial/fungal infections / leachates/run-off contaminating soil/water;
may be public opposition to smell of composting;
may reduce public incentive to reduce waste;

*Award **[1 max]** if chosen method is not identified. If **both** choices (i.e. "waste to energy" AND "recycling/composting" are addressed only credit the higher scoring one).*

3. (a) With reference to **Figure 3**, calculate the difference between the highest concentration and lowest concentration of tropospheric ozone. **[1]**

(peak of 175 – lowest point of 73 =) 102 (ppb);

Accept 72 – 75 as lowest point, ie 100–103 (ppb).

Units and working are NOT required for the 1 mark.

(b) State **two** factors necessary for the chemical formation of ozone in the troposphere. **[2]**

sunlight/UV light;
NOx/oxygen (atoms/ free radicals/molecules)/hydrocarbons/VOCs;

Note: *Only credit necessary reactants for ozone formation as shown above. Do not credit sources of these active pollutants (eg fossil fuel use, organic solvents, pesticides etc).*

(c) Outline why a high concentration of ozone in the troposphere is a direct problem for humans, while in the stratosphere it is a benefit to humans. **[2]**

in the troposphere it causes respiratory illnesses / eye/nose/throat irritations / heart failure;

in the stratosphere it prevents entry of UV that is harmful to humans/can cause mutations/skin cancer/tissue damage/cataracts/crop damage; **[1 max]**

Note: *Do not credit responses that simply suggest global warming/climate change as an impact of tropospheric ozone without referring to some direct impact of those phenomena on humans.*

Note: *Accept "ozone in stratosphere protects humans from UV" WTTE … (use of "protects humans" implies UV is harmful to humans).*

d) Suggest possible reasons for the overall trends of tropospheric ozone levels in **Figure 3**. **[4 max]**

in first few years, increase due to:
- increase in population / car ownership/use / fossil fuel use;
- increased industrialisation / oil industry;
- lack of political awareness/funding to address the issue;

from around 1991 onwards, a decline may be due to:
- improvements in technology, *eg* energy efficiency/hybrid cars/catalytic converters/scrubbers;
- stricter monitoring/regulations on air quality control for industries / car-owners;
- switch to cleaner-burning/alternative energy sources;
- green initiatives/education campaigns/lobbying of politicians to promote, *eg* public transport/green roofs/car-pooling/registration plate limits *etc*;

*Award **[3 max]** if only discussing decline or only discussing increase or failing to specifically identify either decline or increase.*

Section B

Part (c) questions in Section B are all to be assessed using the markbands on page 19 with the guidance given below for each question.

4. (a) With reference to processes occurring within the atmospheric system:

(i) Identify **two** transformations of matter. **[2 max]**

condensation; evaporation; freezing; melting;

$O_3 \rightarrow O_2 + O$; $Cl + O_3 \rightarrow ClO + O_2$; $SO_3 + H_2O \rightarrow H_2SO_4$; $NOx + H_2O \rightarrow HNO_3$;

Accept other reasonable responses.

Accept any valid chemical changes identified by formulae or words (eg decomposition of ozone).

(ii) Identify **two** transfers of energy. **[2 max]**

radiation of sunlight/solar energy/heat/light toward earth;
radiation of heat/IR away from earth;
reflection of light/heat toward space from earth/clouds;
scattering of light/heat from particulate matter;
movement of (sensible) heat pole-wards by wind currents/tricellular winds/Hadley Cell/hurricanes/tropical cyclones;
movement of latent heat in water vapour by winds;

(b) Explain how regional differences in the hydrological cycle influence the formation of different biomes. **[7 max]**

in certain tropical regions there is high transpiration/precipitation;
…allowing for high productivity/tropical rainforests;
in other tropical regions evaporation exceeds precipitation;
…so, water is limiting for growth leading to vegetation of desert biomes;
in polar regions large proportion of water is frozen/stored as ice/glaciers;
…so unavailable to plants resulting in limited vegetation of tundra;
in mid-latitudes there is moderate transpiration/precipitation;
…allowing for moderate plant growth of temperate grasslands/forests;
in regions where water inputs exceed outputs/surface topography promotes rise of water table;
...water accumulates above the soil to form an aquatic system/wetland;
mountainous regions cause variations in precipitation on leeward/windward sides;
...may cause forest growth on windward side/drier desert-like communities on leeward;

Credit can be given for responses that identify features of hydrological cycle characteristic of a given region OR how such a characteristic gives rise to a given biome.

*Award **[3 max]** if the characteristics are not directly linked to given biomes.*

(c) Climate can both influence, and be influenced by, terrestrial food production systems.

To what extent can terrestrial food production strategies contribute to a sustainable equilibrium in this relationship? **[9]**

*The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria given in each of the markbands (although "ESS terminology" has been conflated with "Understanding concepts"). This guide simply provides some **possible** inclusions and should not be seen as requisite or comprehensive. It outlines the kind of elements to look for when deciding on the appropriate markband and the specific mark within that band.*

Answers may include:

- **understanding concepts and terminology** of equilibria, sustainability, natural capital/income, climatic factors (temp/precipitation/seasonality), greenhouse gases, climate change, biome shifts, water conservation, irrigation, desertification, vegetarian vs meat-rich diets, mitigation, adaptation, commercial vs artisanal, intensive vs extensive, food miles, selective breeding/genetic engineering, *etc;*
- **breadth in addressing and linking** influences of climate on food production *eg* water scarcity, shifting biomes, mean temperatures / precipitation, desertification, wind / rain / erosion, *etc* and influences of food production on climate *eg* methane production, deforestation, use of fossil fuels, global transport, *etc* and ways in which production strategies may adapt to, or mitigate climate change;
- **examples** of food production strategies that ***adapt*** to climate change *eg* water conservation, drip irrigation, terracing, drought/temperature resistant crops, aquaponics, greenhouses, *etc* and strategies that ***mitigate*** climate change *eg* switching from meat-rich diets, localising food production, employing artisanal/low-energy farming strategies, *etc;*
- **balanced analysis** of the extent to which production strategies from a range of contexts may contribute to, or mitigate against, an equilibrium between food production and the climate *etc;*
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "although there are many production strategies that mitigate or adapt to climate change, the relationship has already shifted so far away from a sustainable equilibrium, and with growing populations, it seems unlikely that their contribution will be sufficient to avoid a tipping point in the future";

Please see markbands on page 17.

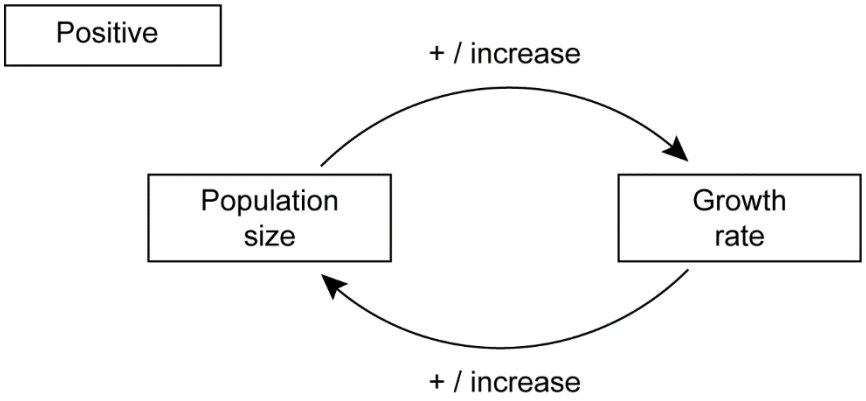
5. (a) Identify **four** impacts on an ecosystem that may result from the introduction of an invasive species of herbivore. **[4 max]**

reduction in plant species (through feeding);
…(causing) reduction in overall productivity;
reduction/loss of native herbivore species (through competition);
…(causing) reduction/loss of carnivore species/higher trophic levels;
…(causing) reduction in species diversity;
shift of equilibrium/toward tipping point;
introduction of new diseases/pathogens/parasites (carried by invasive species);
in some circumstances may benefit ecosystem by *eg* increasing food for higher trophic levels/increasing diversity;

(b) Explain how both positive and negative feedback mechanisms may play a role in producing a typical S population growth curve for a species. **[7 max]**

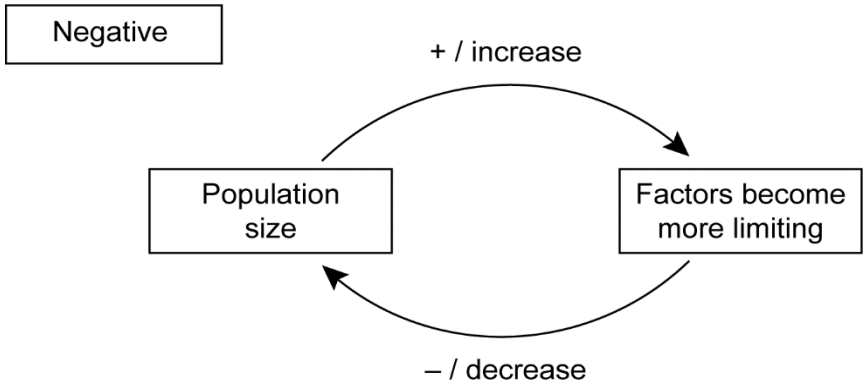
positive feedback will occur at start of S curve where numbers are small;

*Award **[3 max]** for following marking points as statements OR shown in a diagram. See example below:*
as populations increase/reproduce they increase the number of reproducing individuals;
…which will further increase the growth rate;
ie positive feedback …a change promoting further change in same direction;



negative feedback occurs as graph approaches maximum/carrying capacity/plateau;

*Award **[3 max]** for following marking points as statements **OR** shown in a diagram. See example below:*
Limiting / density dependent factors / predation/food/water availability/disease;
…will become increasingly limiting, reducing growth rate;
…stabilizing population at around carrying capacity
ie negative feedback …a change leading to reduction of further change;



*Award **[3 max]** if responses do not clearly identify +ve and -ve feedback.*

(c) Technocentrists may support the belief that technological development has always been able to overcome limits to human population growth.
To what extent do the patterns of growth and development in human populations, as demonstrated in the Demographic Transition Model, support this claim? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of demographic transition model, birth/death/growth rates, FR, DT, NIR, pre-industrial/expanding/stationary/declining stages of transition, age pyramids, phases of exponential growth curves, limits to growth, carrying capacity, agricultural/industrial revolutions, pro/anti-natal policies, urbanisation, economic development, lifestyle choices, Malthus/Boserup theories, technocentric/cornucopian views, medical advancements *etc;*
- **breadth in addressing and linking** earlier stages of demographic transition/ population growth with technological developments in *eg* agriculture, industry, medicine, social welfare, family planning, globalisation, addressing a range of limits to growth *eg* food, shelter, disease, wealth, energy, in MEDCs, LEDCs, and linking later stages with limits of lifestyle choices, economic independence, population policies, historical events, international collaboration, *etc;*
- **examples** of populations in expanding stages overcoming limits to growth through technology *eg* fertilisers, pesticides, agricultural mechanisation, fossil fuels, antibiotics/antiseptics/sanitation, immunisation, contraception, urban technology, alternative energies *etc* and populations in stationary/declining stages being limited by family costs, anti-natal policies, gender equality, urban/industrial lifestyles *etc;*

- **balanced analysis** of the extent to which technological developments have overcome or failed to overcome limits to growth in a diversity in human populations in various stages of demographic transition, *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** eg “it is true that technological developments have played a large role in overcoming limits to population growth in the earlier stages of demographic transition; however, there is a finite limit to the Earth’s carrying capacity, and many populations are now stabilising due to self-imposed economic and political constraints”;

Please see markbands on page 17.

6. (a) Identify **four** strategies for limiting the impact of burning fossil fuels without reducing their use. **[4 max]**

use of scrubbers on factories/power plants;
use of catalytic converters on vehicles;
regulating quality of exhaust gases;
using low sulphur coal resources;
restoring ecosystems damaged by pollutants / *eg* liming of acidified lakes;
sequestration/CCS;
afforestation/reforestation/reducing deforestation;
masks reducing inhalation of toxic gases/emissions;
building of sea defences;
vaccination/anti-malarial programmes;

Credit any responses identifying other valid strategies that don't involve reducing fossil fuel use. Do not credit "increasing efficiency of vehicles/machinery using fossil fuels" ...these will only limit impact by reducing consumption, which is explicitly excluded by question.

(b) Suggest a range of practical procedures that could be carried out to measure the abiotic and biotic impacts of an oil spill in an aquatic ecosystem. **[7 max]**

identify a transect / sampling scheme to compare conditions over time/distance;
carry out multiple samples at each site to ensure reliability;
measure oil content/concentration using chemical tests;
measure light penetration using Secchi disc;
(use appropriate probes/meters/logging devices) to measure temperature/oxygen concentration/pH/salinity;
measure change in O_2 concentration of samples kept in dark as a measure of BOD;
sample invertebrate populations using kick samples/Eckman grab/water samples;
Lincoln Index/mark-release-recapture may be used to quantify fish/larger invertebrates;
identify species present and abundance of each;
use this to calculate a biotic index evaluating sensitivity/tolerance of species present;
use similar data to calculate diversity with a diversity index;
count total numbers of birds/fish *etc* clearly impacted/killed by oil;

Credit any other procedures of equivalent detail and validity to those given above.
No additional credit for evaluating procedures/discussing impacts.
If response simply indicates measuring a named abiotic factor they can be credited for MP5 but can only gain one mark in total for any number of such factors. To gain further credit for other abiotic factors they should indicate some detail of the procedure beyond simple use of a probe/meter/logging device.

*Award **[4 max]** for responses that address only biotic or only abiotic impacts.*

(c) Even though there is growing global support for ecocentric values, the global consumption of fossil fuels continues to rise each year.

With reference to energy choices in named countries, discuss possible reasons for this situation occurring. **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of environmental value systems, ecocentrism, origins/influences on EVS, alternative energies, renewable/non-renewable, fossil-fuel technologies/infrastructure, impacts of global warming/climate change, sustainability, self-restraint, self-sufficiency, energy availability/affordability/reliability, energy security, *etc;*
- **breadth in addressing and linking** energy choices *eg* fossil fuels, renewables, nuclear *etc* and influences upon these choices through cultural, political, economic, technological, environmental, geographical factors *etc* Also factors influencing growth of ecocentrism *eg* education, cultural backgrounds, globalised media, climate change/energy-related disasters *etc;*
- **examples** of factors promoting fossil fuel energy choices *eg* availability of coal in Russia, fracking in USA, falling price of coal worldwide, *etc* and technological factors *eg* low technology in LEDCs, existing infrastructure in MEDCs *etc* and economic factors *eg* China's dependency on industry, LEDCs seeking rapid economic growth *etc* and energy security issues *eg* Middle East oil, oil in USA, all kinds of fossil fuel in Russia, coal in China *etc.* Also, examples of influences promoting ecocentrism *eg* global social media, climate change disasters, NGOs *eg* Greenpeace, education on sustainability *eg* IB ESS, international movements *eg* UN Sustainable Development Goals *etc;*
- **balanced analysis** distinguishing and weighing against one another potential reasons for the simultaneous growth in both fossil fuel consumption and ecocentrism.
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "while the widespread impacts of fossil fuel use and globalised media have promoted a growing support for ecocentric values in the wider populace, it is the governments that ultimately make decisions and their priorities often lie with the economics and politics that favour the continued use of these fuels";

Please see markbands on page 17.

7. (a) Identify **four** factors that make the estimation of carrying capacity more problematic for human populations than for most other species. **[4 max]**

Humans:
- use such a wide range of resources that could be limiting;
- have a greater ingenuity to increase efficiency of resource use/substitute resources for one another;
- local populations can import resources from elsewhere;
- show great variation in lifestyles/demand from place to place;
- depend on technological development demanding different resources over time;
- …making it difficult to identify any one limiting factor/resource for carrying capacity;
- produce a diverse range of wastes damaging their habitat/reduce carrying capacity;

(b) Explain why the ecological footprint of two populations consuming the same quantity of food and energy may be different. **[7 max]**

a population may consume the same as another but produce more (for export or just wasted) which will increase its EF/require more land;
food production systems may be different in terms of efficiency / sustainability;
…some may be more intensive / use advanced technology / fertilisers;
…or rely less heavily on meat products / more heavily on vegetarian products;
…or be located in a climate more favourable to food production;
…and therefore, produce same quantity of food with less land/lower EF;
energy production may rely more heavily on renewable sources/solar energy/hydroelectricity/wind power;
…or be located in regions with higher rates of primary productivity/photosynthesis;
…employ more effective mitigation strategies;
…so, absorb carbon wastes with less local land/lower EF;
activities other than food and energy provision may influence ecological footprint (*eg* urbanization/water pollution);
one population may lack treatment facilities / regulations for wastewater leading to greater EF;
one population may live in multistory buildings / smaller houses using less land so lower EF;

Note: *Question addresses difference in footprints between populations not per capita footprints.*

*Award **[4 max]** for responses that address only food or only energy production OR for responses that make no reference to actual difference in EF or land required.*

(c) Discuss the potential for designing a protected forest area that allows for the harvesting of natural resources while at the same time conserving its biodiversity. **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of sustainable harvesting/yield, natural capital/income, renewable vs non-renewable resources, reserves/protected areas, habitat vs species conservation, ecological pyramids, edge effects, design principles of conservation areas, ecotourism, local/national/international organisations, community support, *etc*;
- **breadth in addressing and linking** effective conservation with *eg* size, shape, location of protected areas, central "no-go" zone/wilderness, use of corridors, roles of international organisations, local ownership, *etc.* Also with sustainable harvesting *eg* managing sustainable yield, reducing collateral impacts of infrastructure, raising funds and incentive for conservation, subsistence of local populations, commercial value of harvestable goods, *etc;*
- examples of supporting biodiversity through large area/food base, circular shape to reduce edge effects, links to other areas via corridors to increase genetic mixing, maintaining certain/central area with no human activity, promoting local support by providing employment/resources/income, gaining global support through international bodies UNEP, Greenpeace etc;
- **balanced analysis** of ways in which, and the extent to which, in a variety of geographical/social contexts, a protected area can or cannot support harvesting while at same time conserving biodiversity;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "one of the greatest contributions to successful conservation is a local "ownership" of the project and therefore, provided the harvesting is limited to certain areas and sustainably managed, there could be considerable potential for such a design to provide very successful conservation";

Please see markbands on page 17.

Section B, part (c) markbands

Marks	Level descriptor
0	The response does not reach a standard described by the descriptors below and is not relevant to the question.
1–3	The response contains: • minimal evidence of knowledge and understanding of ESS issues or concepts • fragmented knowledge statements poorly linked to the context of the question • some appropriate use of ESS terminology • no examples where required, or examples with insufficient explanation/relevance • superficial analysis that amounts to no more than a list of facts/ideas • judgments/conclusions that are vague or not supported by evidence/argument.
4–6	The response contains: • some evidence of sound knowledge and understanding of ESS issues and concepts • knowledge statements effectively linked to the context of the question • largely appropriate use of ESS terminology • some use of relevant examples where required, but with limited explanation • clear analysis that shows a degree of balance • some clear judgments/conclusions, supported by limited evidence/arguments.
7–9	The response contains: • substantial evidence of sound knowledge and understanding of ESS issues and concepts • a wide breadth of knowledge statements effectively linked with each other, and to the context of the question • consistently appropriate and precise use of ESS terminology • effective use of pertinent, well-explained examples, where required, showing some originality • thorough, well-balanced, insightful analysis • explicit judgments/conclusions that are well-supported by evidence/arguments and that include some critical reflection.