SL Paper 3

Distinguish between fundamental niches and realized niches.

Markscheme

fundamental niche is the potential mode of existence whereas realized niche is the actual mode of existence;

adaption/competition/predation/powers of distribution are important in determining the realized niche;

Examiners report

There were some very good answers to this question. Most candidates were able to distinguish between realized and fundamental niches.

a. State **one** condition that favours denitrification. [1]

b. Explain the consequences of releasing raw sewage and nitrate fertilizer into rivers. [4]

Markscheme

a. denitrification is favoured by anaerobic conditions in soil;

   poor drainage/waterlogged soils;

   slightly alkaline;

   suitable temperature;

   the presence of denitrifying bacteria/*Pseudomonas (denitrificans)*;

b. pH changes;

   raw sewage often contains pathogens that cause disease;

   increase in nutrients/nitrates (from fertilizer) leads to eutrophication;

   decomposition of organic matter releases ammonia into water;

   ammonia is converted into nitrate;

   nitrate causes algal bloom;

   bacteria that feed on sewage cause high BOD/lack of (dissolved) oxygen;

   lack of oxygen may kill fish/other aquatic life;

   as algae release oxygen into water via photosynthesis, water recovers downstream;

Examiners report

a. In F3 (a) most candidates were able to achieve marks but few fully explained their answers as required in the command term.

b. N/A

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a. Primary plant succession has been observed in sand dunes adjacent to the northern end of Lake Michigan, one of the Great Lakes in North America. The youngest sand dunes have beach grass (*Ammophila breviligulata*) and prairie bunch grass (*Schizachyrium scoparium*). The oldest dunes have coniferous trees (*Pinus strobus* and *Pinus resinosa*). [3]

   Predict the differences in the soil characteristics between the youngest and oldest sand dunes.

b. Outline how the type of stable ecosystem that will develop in an area can be predicted based on climate. [3]

Markscheme

a. «In the older sand dunes you would expect» (*Accept inverse answers related to younger sand dunes*)

   More complex deeper soil

   Buildup of organic matter

   Better water retention

   Higher nutrient content

   Support larger diversity of soil organisms

   Soil is less likely to be blown away
   OR
   Soil is more stable

   A different pH

b. Climate is defined by temperature and rainfall

   Absence of rainfall/water/humidity leads to desert

   Moderate amount of rainfall leads to grassland

   High levels of rainfall leads to forest

   Temperature determines type of grassland/forest

Examiners report

a. Most candidates could give the differences in the soil but many attributed the older dune characteristics to the younger dunes.

b. Mixed responses but most could outline how ecosystems can be predicted based on climate.

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a. Explain how living organisms can affect the abiotic environment during primary succession. [3]

b. State **one** example of biological control of an invasive species. [1]

Invasive species: .....

Biological control: .....

c. Define *biomagnification.* [1]

Markscheme

a. remains/debris/litter from growth/death of plants can increase soil depth;

remains/debris/litter from growth/death of plants can increase soil mineral content;

remains/debris/litter from growth/death of plants can alter soil pH;

remains/debris/litter from growth/death of plants can improve soil water retention and reduce drainage;

growth of (larger) plants can reduce erosion though binding action of roots;

b. example of invasive species and an example of its biological control

e.g.:

prickly pear cactus is controlled by moth (*Cactoblastis cactorum*)

Accept other suitable example.

c. a process when chemical substances become more concentrated at each trophic level

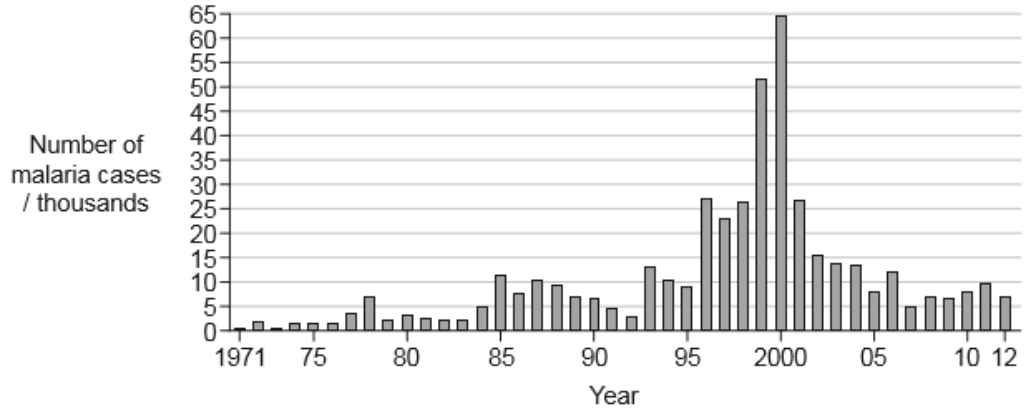
Examiners report

a. Many candidates did not know how plants affected the environment in a primary succession.

b. Many incorrect answers. Some candidates invented examples of biological control. In some cases, the candidate mentioned an invasive species and then a different example of biological control.

c. In (c) Most candidates could define biomagnification.

In 1997 in South Africa, a decision was made to decrease the use of mosquito-killing pesticides due to their negative effect on the environment. Mosquitoes are known to be responsible for the spread of malaria. In 2001 the decision was reversed and the use of pesticides was increased. The graph shows the estimated numbers of people with malaria in each year.



[Source: adapted from www.healthlink.org.za]

a. Outline the trend in the number of people with malaria during the period when the use of pesticides was decreased in South Africa. [1]

b. One pesticide used in killing mosquitoes was DDT. Considering its harmful effects, discuss whether the decision to reintroduce it was justified. [4]

Markscheme

a. the number of people with malaria increased

b. a. choice has to be made between damage to environment or increase in malaria

b. DT may lead to biomagnification/bioaccumulation in food chains
OR
taken up by species in lower trophic levels becoming more concentrated at higher trophic levels

c. causes harm to consumers at end of food chain
OR
example «eg: thin egg shells of falcons»

d. DDT is shown to be effective in reducing malaria

e. possible partial solution to be selective in areas sprayed with DDT

f. may kill insects that are not pests

Examiners report

a. [N/A]
b. [N/A]

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a. Biotic factors involve the other organisms in the environment of an animal species. List **two** biotic factors that could affect the distribution of an animal species. [2]

1. .....

2. .....

b. Research into a river ecosystem produced these approximate values: 25, 300, 6000 and 36 000 kJ m^{-2} yr^{-1}. Using this data, construct a pyramid of energy showing **four named** trophic levels, each with their corresponding energy value. [2]

Markscheme

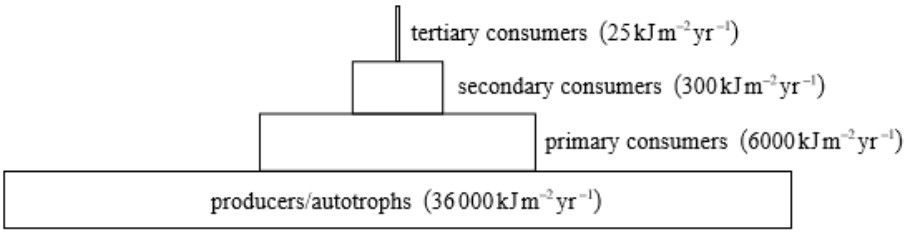
a. predation;

competition;

disease;

food supply;

b.



bars of decreasing size going upwards at least a third of the bar below;
the trophic level on each bar labelled correctly;

Examiners report

a. Almost all correct answers, mainly food supply and competition.

b. For (b) candidates were able to draw and label the energy pyramid. In some cases the bars were not at least one third of the size of the previous bar, therefore scoring no mark for the drawing.

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b. Explain the principles involved in the generation of methane from biomass. [3]

c (i) State the role of *Rhizobium* in the nitrogen cycle. [1]

Markscheme

b. organic matter/manure/waste/agricultural material/seaweed used;

bacteria in digester transform biomass/raw material;

anaerobic conditions / constant temperature / neutral pH in the digester;

bacteria convert organic material to organic acids/alcohol;

other bacteria convert organic acids/alcohols into acetate;

methanogenic bacteria convert acetate to methane

c (i) nitrogen fixation / changes (free) nitrogen to ammonia

Examiners report

b. Most candidates only scored one or two marks in this question as they only explained that bacteria are used to transform organic matter. No further detail of the process was provided.

c (i) (c) (i) and (ii) almost all scored full marks.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

b.i. State what N and n stand for in this formula. [1]

N:

n:

b.ii. Discuss **three** reasons for the conservation of biodiversity in rainforests. [3]

Markscheme

b.i. $\left.\begin{array}{ll} N: & \text{total number of organisms of all species found/in population;} \\ n: & \text{number of organisms of a particular species;} \end{array}\right\}$ *(both needed)*

b.ii *ethical*: life should be respected / cultural importance for (local human indigenous) population / (human indigenous) population's ability to live sustainably within ecosystem might be affected / richness for future generations;

ecological: native species might be replaced by alien species / extinction of one species can lead to the extinction of many others / interdependency of species may be disrupted/negative effects on food chains /soil erosion/floods occur with deforestation / rainforests act as a carbon sink which helps reduce global warming;

economic: medicines or materials not found yet / genes of wild species need to be preserved / ecotourism improves local economy/encourages local conservation / plant sources of pharmaceuticals lost if species extinct / crops may be improved with alleles from wild plants;

aesthetic: loss of beauty of wild / inspiration for artists;

(Words in italics alone are not worth marks)

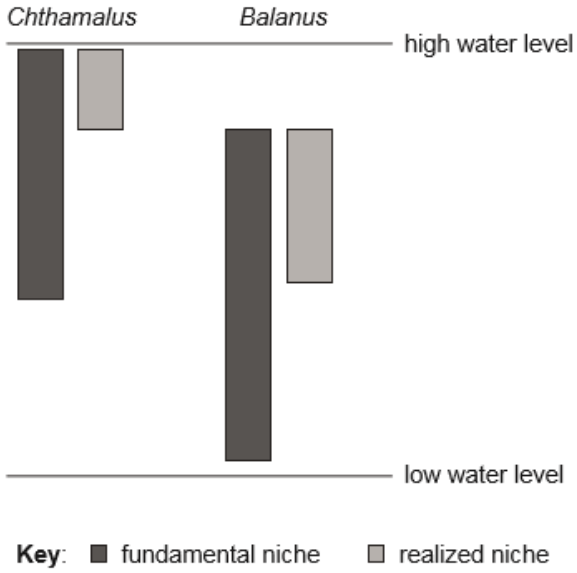
Examiners report

b.i. Candidates had a difficult time stating precisely what N and n stand for in the Simpson Diversity Index.

b.ii.This question on reasons for conserving rainforests has been answered frequently and candidates were often able to get the full 3 marks for giving a reason that was ethical, ecological, economic or aesthetic in nature.

Chthamalus and *Balanus* are two species of barnacles that live attached to rocks between the low and high tide level of the sea.

The distribution of each species is influenced by the presence of their own species and different species.



[Source: adapted from http://bio.classes.ucsc.edu]

a. Distinguish between a fundamental niche and realized niche. [1]

b. Suggest reasons that *Chthamalus* cannot live higher up the shore. [2]

c. Describe how the distribution of *Chthamalus* and *Balanus* is affected when both are present. [3]

Markscheme

a. realized is actual niche, fundamental is potential niche

b. a. must spend some of their time under water / prevent dehydration

b. need water for food/nutrients

c. need water for reproduction

d. more accessible to their predators

e. there are no rocks for them to live on
OR
there is no suitable habitat for them

c. *a. Chthamalus* and *Balanus* / both have a reduced distribution

b. they are in competition for part of the habitat on the rock

c. Balanus occupies some of the habitat of the fundamental niche of *Chthalamus*
OR
where the fundamental niche overlaps *Balanus* prevails/survives

d. the distribution of *Balanus* is unchanged in areas colonized by *Chthalamus*

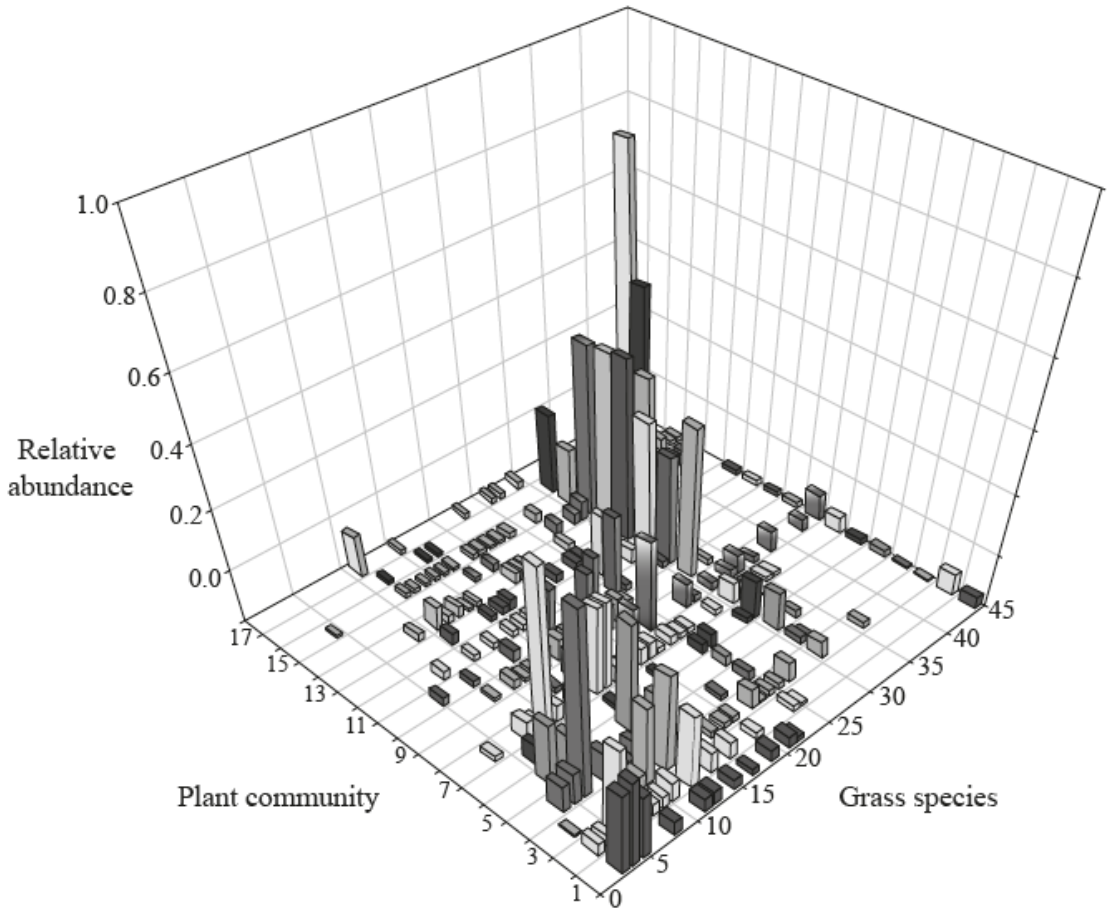
e. Balanus is in competition with other species closer to low water

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The relative abundance of different grass species in the 17 plant communities of the Serengeti ecosystem in Tanzania is presented in the graph below.

The communities are listed along a transect that runs from the dry south-eastern boundary of the park (community 1), north and west across the plains and woodlands to Lake Victoria (community 17).



[Source: Adapted from A. Dobson (2009) 'Food-web structure and ecosystem services: insights from the Serengeti.' *Philosophical Transactions of the Royal Society B*, **364**, pp. 1665–1682, Fig. 3. By permission of the Royal Society.]

Both communities 1 and 17 have a low overall abundance of grasses.

a. State the grass species that is most abundant in plant community 1. [1]

b. Analyse the graph to find whether species 45 has a broad **or** narrow realized niche. [1]

c.i. Suggest a reason for this in community 1. [1]

c.ii. Suggest a reason for this in community 17. [1]

d. Evaluate the conclusion that there are trends in the distribution of plants along the transect of Serengeti grass communities. [3]

Markscheme

a. 4

b. broad (realized niche as present in many communities)

c.i. lack of water

c.ii. shading from trees / lack of light /competition from trees and shrubs

d. communities have different species present;

grass species 1 to 15 more common in communities 1 to 7/dry south east boundary; *(accept values within 3 of the upper and lower values given in the marking point)*

grass species 32 to 45 more common in communities 13 to 17/woodlands; *(accept values within 3 of the upper and lower values given in the marking point)*

pattern linked to variation in rainfall/abiotic factors;

appears to have clusters of distinct plant species with little overlap;

species are found in certain areas only;

Examiners report

a. Almost all correctly identified species 4 as the most common in plant community 1.

b. Most also received the mark for indicating that species 45 had a broad realized niche as it is present in many communities.

c.i. While most gained the mark for (i), few candidates received the mark for (ii). Candidates seemed to overlook the idea of woodlands near Lake Victoria but instead seemed to think the plants were in the lake and have too much water.

c.ii. While most gained the mark for (i), few candidates received the mark for (ii). Candidates seemed to overlook the idea of woodlands near Lake Victoria but instead seemed to think the plants were in the lake and have too much water.

d. This question was very discriminating as in general candidates had a difficult time explaining the trends. Some did note that the pattern seemed to be linked to abiotic factors such as water availability.

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a. Outline **three** factors that affect plant distribution. [3]

b. Outline a method used to correlate the distribution of plant species with an abiotic factor. [2]

Markscheme

a. plant distribution closely linked to levels of abiotic factors in the environment;

given organism can survive only within a certain temperature range to which it is adapted;

water is a limiting factor in most terrestrial ecosystems and plants are classified according to ability to tolerate water shortage;

most plants can only tolerate narrow pH range;

light intensity/quality/wavelength and duration/photoperiod are important for photosynthesis;

most plants cannot tolerate large fluctuations in salinity/high salinity;

mineral nutrients affect plant fertility/soil structure/water retention;

Accept ONE correct reference to herbivore activity

b. transect used when there is a transition in habitats and populations;

description of use of a line or belt transect;

height variation/light intensity/salinity/various abiotic factors can be recorded;

along the transect, along with sampling of plant and/or animal species present;

Examiners report

a. Many candidates did not “outline” the factors, but merely stated them. Consequently, they did not give enough detail to gain marks. There was also some confusion between distribution and dispersal (ie of seeds). Where points had been elaborated, they were often superficial, and references to light were common, rather than the required light intensity or wavelength.

b. Poorly answered on the whole, suggesting that candidates may not have sufficient experience of actual fieldwork on which to base their knowledge.

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a . State **one** example of the accidental release of an alien species that has had a significant impact on an ecosystem. [1]

b. Discuss the impact of alien species on ecosystems. [3]

Markscheme

a . *Answer needs to be specific giving <u>name</u> of organism, where it was released and where it came from. If unsure, check answer with Google, but examples <u>must</u> be accidental releases.*

e.g. zebra mussel (*Dreissena polymorpha*) originally from Russia/Caspian carried in ships’ ballast water and introduced into Great Lakes / rats accidentally introduced to mainland of New Zealand from visiting ships / Africanized honey bees introduced to Brazil (“killer bees”)

b. inter-specific competition/alien species have characteristics that may enable them to out-compete native species;

lack of predators may allow alien species to reproduce more rapidly;

alien species may utilize areas or resources that native species cannot;

predation by invasive species can cause loss of biodiversity;

can lead to species extinction, especially of endangered species;

alien species may introduce new diseases;

use of alien species for biological control can be ineffective or negative;

Examiners report

a . This was a difficult question, and many examples given were not accidental releases of alien species. Where correct examples were given, they were not accompanied by enough detail to gain the mark.

b. The majority of candidates could gain one or two marks in this question, but some answers were generalised and vague. This was a “discuss” question, so candidates should have been able to expand their answers beyond a reference to competition.

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a. Explain the concept of an ecological niche. [2]

b. Distinguish between fundamental niches and realized niches. [2]

Markscheme

a. (ecological niche is) mode of existence/role of an organism within its ecosystem;

(ecological niche includes) its habitat/abiotic factors of the environment;

(ecological niche includes) what the species eats / how the species obtains food;

(ecological niche includes) interactions with other species;

(ecological niche includes) the set of all ranges of limiting factors an organism tolerates / *OWTTE*;

b. fundamental niche is the niche for which a species has adaptations for success/potential mode of existence whereas a realized niche of a species is its actual mode of existence;

the realized niche is often smaller than the fundamental niche (of a species);

competition/predation is reason for the differences (between fundamental and realized niches);

Examiners report

a. The rest of the option did not cause any great trouble. In G2 (a) most candidates were able to explain the concept of an ecological niche.

b. Most candidates were able to distinguish between a fundamental and realized niche.

Explain how alien species can affect community structure in an ecosystem.

Markscheme

Species introduced into habitat/ecosystem

Disrupt food chains

Reduce the number of organism that occupy similar niches

They can overconsume prey species

Reduce availability of prey species for other consumers

They can overconsume a native predator

Leading to loss of control on numbers of prey species

Their impact will reduce the biodiversity

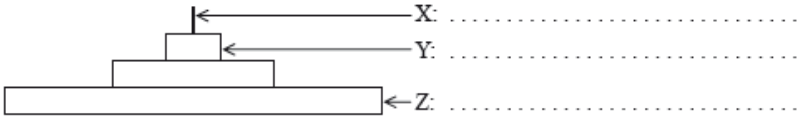
Can lead to extinction of some species

May have no natural predators/control

Examiners report

Nearly all candidates gave good explanations on how alien species affect community structure.

Label the levels of the trophic pyramid of energy shown below.



Markscheme

X: tertiary consumers;

Y: secondary consumers;

Z: producers;

Examiners report

Labelling the pyramid of energy was a very easy 3 marks for the majority of candidates.

Explain reasons for differences in the realized niche and fundamental niche of an organism.

Markscheme

a. an ecological niche is an organism's role/functional place in the environment

b. the fundamental niche is the potential niche and the realized niche is the actual niche

c. includes habitat/feeding/how it survives

d. limiting factors play a part on the actual distribution of species

e. competition prevents species occupying their fundamental niche

f. species show competitive exclusion

OR

two species cannot occupy the same niche in an ecosystem

g. «in competitive exclusion» one species will replace the other species

The answers given in the markscheme may be awarded if the candidate explains a suitable example

For marking point g, do not accept "one species becomes extinct" as a standalone answer unless it is clear they are referring only to the ecosystem under discussion

[Max 4 Marks]

Examiners report

[N/A]

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b.i. State the type of ecological change that will occur following the formation of an island from cooled lava in the Pacific Ocean. [1]

b.ii. Outline the ecological changes that will occur on the island of cooled lava. [4]

Markscheme

b.i. primary succession

b.ii. soil develops as lava/rock weathers/breaks down/erodes;

organic material/soil accumulates from (autotrophic) bacteria/lichens;

(gross productivity/biomass increase as) small plants are replaced by larger plants;

development of plant communities support higher trophic levels;

more soil allows for detritivores;

succession increases species diversity / climax community established;

Examiners report

b.i. Many candidates correctly identified the ecological change occurring as primary succession for 1 mark in (i) but the outline of those ecological changes was very poorly done overall so that few marks were awarded in (ii). Maximum of 2 marks was common.

b.ii. Many candidates correctly identified the ecological change occurring as primary succession for 1 mark in (i) but the outline of those ecological changes was very poorly done overall so that few marks were awarded in (ii). Maximum of 2 marks was common.

Water is one factor that affects the distribution of plant species. Outline **three** other factors that can also affect plant distribution.

Markscheme

temperature affects metabolism/enzyme activity/transpiration rate/germination / each plant species has an optimum temperature range;

light affects rate of photosynthesis/(time of) flowering;

soil pH affects absorption of minerals/enzyme activity / each plant has an optimum pH range / some plants require acid soil / some plants require alkaline;

salinity affects the osmotic potential / most plants function in narrow range of salinity / salts affect the water uptake by the plants;

mineral nutrients required for synthesis of organic molecules;

presence of (suitable) pollinator/dispersal organisms to aid reproduction;

distribution (number and type) of predators/herbivores/diseases/pathogenic organisms which harm plants;

competition from other plants (for resources);

other valid factor with brief outline;

Accept examples for each factor eg nitrates are necessary for protein synthesis.

*Award **[0]** for a list of factors.*

Examiners report

Most candidates were able to get 2 out of 3 marks in (b) for outlining factors that affect plant distribution, although some only listed 3 factors with no other detail given, which did not earn marks.

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a. Define the terms fundamental *niche* and *realized niche*. [2]

Fundamental niche: ....

Realized niche: ....

b. Explain why the carnivores in an ecosystem tend to be fewer in number and have a smaller biomass than the herbivores in the same ecosystem. [2]

c. Explain why carnivores tend to be more affected by biomagnification than organisms lower down the food chain. [3]

Markscheme

a. *Fundamental niche*:

the potential niche / the niche the organism could occupy under ideal conditions / the full mode of existence given the adaptations of the species / *OWTTE*;

Realized niche:
the actual niche / the niche restricted by competition and environmental variables / the niche resulting from the limits placed on the species / *OWTTE*;
Responses must distinguish between the two types to gain credit.

b. energy transfer along the food chain is less than 100 % efficient;

10 % energy transfer between trophic levels;

nutrient transfer is less than 100 % efficient;

each carnivore needs to consume many prey organisms;

tendency for size of organisms to increase as trophic level increases;

c. mercury / DDT / other named example;

biomagnification is the accumulation of chemicals through the food chain;

chemicals that undergo biomagnification are stored/not broken down (in the bodies of the organisms that consume them);

chemicals are passed (unaltered) from one trophic level to the next;

chemicals become more concentrated in the bodies of each (subsequent) trophic level;

organisms higher up the food chain consume larger amounts of the chemical;

Examiners report

a. Few could give accurate definitions of the two niches.

b. This proved to be another weak area, as not many candidates could link the decrease in numbers to the loss of energy between trophic levels in an ecosystem.

c. Most candidates did not seem to understand that the term biomagnification refers to the passing of chemicals along the food chain, or that the chemicals are stored in the bodies of the organisms that consume them. Consequently, there were few good answers to this question.

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a. State a source of vitamin D in a human diet. [1]

b. Discuss exposure to sunlight as a source of vitamin D. [2]

b. Discuss reasons for conservation of biodiversity of a **named** ecosystem. [5]

Markscheme

a. fatty fish *e.g.* mackerel/tuna/sardines/herring *etc.*;

liver;

eggs;

fortified dairy products;

b. sunlight stimulates skin to synthesize vitamin D;

less sun exposure/insufficient vitamin D leads to skeletal deformities/rickets;

UV radiation increases the incidence of skin cancer/melanoma;

vegans/vegetarians are more likely to lack vitamin D so need more exposure to sunlight;

b. *name of ecosystem:*

e.g. (tropical) rainforest;

ethical reason:

every species has a right to life, regardless of whether it is useful/non useful to humans;

potential of undiscovered medicines;

ecological reasons:

better use of the rainforest may occur by respecting the existing balance in concert with the indigenous people;

native species are adapted to local conditions whereas invasive species are less likely to be in balance;

species in the rainforest are interdependent so loss of species threatens the rest of the community;

deforestation of rainforests increases soil erosion/silting of rivers/flooding/CO_2 atmospheric levels;

economic reasons:

ecotourism is a potential source of income;

aesthetic reasons:

loss of beauty of the system;

artists are inspired by the images/flowers/animals of rainforests;

heritage/cultural reasons:

maintenance of the rainforest preserves human cultural diversity;

*Do not award more than **[2 max]** for each category of reasons e.g. not more than **[2]** for ecological reasons.*

Examiners report

a. N/A

b. Surprising how many thought that the sun provided Vitamin D directly and not that the skin is stimulated by sunlight to synthesize it.

b. (b) seemed to be answered very easily and many candidates scored all five marks. Most candidates mentioned the rainforest in their answer.

Explain how temperature and territory affect the distribution of animal species.

Temperature:

Territory:

Markscheme

temperature: **[2 max]**

body size/surface area to volume ratio affects the rate of animal metabolism/ability to conserve heat;

animals that regulate body temperature (homeotherms) can colonize a wider range of environments/habitats;

when animals have less control over their rate of metabolism (poikilotherms) choice of environment/habitat more determined by external temperatures;

fewer species can survive in extreme temperature and special adaptations are needed;

territory: **[2 max]**
some establish and defend an area within a suitable habitat to attract mates/maintain food supply/rear young/avoid predation/competition;
can lead to intra and inter specific competition for space;
a territory may be established by an individual/breeding pairs/groups / may be limited places suitable as territories which affects distribution;
territory may be permanent or temporary / for breeding period / nomadic/migratory animals;

Examiners report

The idea of distribution of animals seemed to present difficulty to many students, and answers tended to be vague and simplistic. Although polar bears were frequently given as an example, few made the connection between external temperature, an animal's metabolic rate and it's ability to survive in different environments.

Many students had the idea of competition between animals for space and food, but again, many responses were inadequate, and often repetitive.

---

a. State the process where pesticides such as DDT become more concentrated at each trophic level. [1]

b. Explain what is meant by the niche concept. [3]

Markscheme

a. biomagnification/bioaccumulation

b. a. every organism in an ecosystem has their own role;

b. (includes) spatial habitat/space inhabited by organism;

c. (includes) feeding activities of organism;

d. (includes) interactions with other species;

e. valid description of an organism’s niche including habitat, feeding activities and interaction with other species;

Examiners report

a. [N/A]

b. Nearly all candidates gave good answers explaining the concept of a niche though some confused it with habitat.

State **one** soil condition that favours denitrification.

Markscheme

a. lack of oxygen / anaerobic conditions;

b. excess water / bog/marsh conditions;

Examiners report

Most gained the mark in a for anaerobic or boggy ground, with some being vague with for example ‘humid’ or ‘damp’.

---

a. List **four** factors that affect the distribution of plant species. [4]

b. Describe **one** effect of plants on an abiotic factor in a pioneer community. [1]

Markscheme

a. pH of soil;

water /humidity;

light;

temperature;

salinity;

mineral nutrients;

competition;

altitude;

pollinating agents;

predators / parasites;

slope;

b. adds humus to soil;

breaks down rock (through roots, chemicals, rhizoids);

holds soil/prevents erosion;

aerates soil;

provides shade;

reduces water content;

Examiners report

a. Most candidates listed the abiotic factors affecting the distribution of plant species and were able to score full marks, making it easy to score 4 marks in this option.

b. N/A

---

a. List **two** abiotic factors that affect the distribution of plant species. [1]

1. .....
2. .....

b. State **one** example of secondary succession. [1]

c. Distinguish between fundamental and realized niches. [2]

d. Discuss the difficulties of classifying organisms into trophic levels. [2]

Markscheme

a. temperature / water / light / soil pH / salinity / mineral nutrients

*Award **[1]** for any **two** abiotic factors.*

b. regrowth following forest fire/fallow land/earthquake / other example of secondary succession

c. fundamental niche is the potential mode of existence and realized niche is the actual mode of existence;

fundamental niche depends on the adaptation of a species;

competition/predation prevents a species from occupying its entire fundamental niche;

realized niche is usually smaller than fundamental niche;

d. organisms may fit into more than one trophic level;

omnivores consume organisms from all levels of the food chain;

there may be seasonal changes in trophic levels depending on food supply;

some organisms alter diet with their life cycle (e.g. some amphibians);

Examiners report

a. Almost all candidates were able to list abiotic factors that affected plant distribution.

b. While there were many possible examples of secondary succession, many indicated colonization of lava after a volcano erupted which is an example of primary succession.

c. Candidates were familiar with fundamental and realized niches and thus gained one mark but few could distinguish clearly between them and gain two marks.

d. Most candidates were able to gain one mark for indicating that organisms may fit into more than one trophic level but few obtained a second mark for discussing such ideas as organisms alter diet with stage in their life cycle or that there are seasonal changes in trophic levels.

Denitrification is part of the nitrogen cycle. Outline the conditions that favour denitrification in the environment.

Markscheme

anaerobic conditions / absence of air/oxygen;

(facultatively) anaerobic bacteria / *Bacillus*/*Thiobacillus*/*Pseudomonas* genera;

soil is waterlogged/bogs/marshes/other valid example;

Examiners report

All parts of this question seemed to prove difficult. In part (b), understanding of the nitrogen cycle was very poor for those who attempted it.

Discuss the impacts of a **named** alien species introduced as a biological control measure.

Markscheme

named alien species e.g. western mosquitofish / small Indian mongoose / rosy wolfsnail;

introduced for removal of pests;

competes with native species;

excessive predation on native species that do not have defences;

impacts industry such as tourism/harvesting of natural resources;

Accept other specific examples of effects.

Examiners report

This was usually not well answered. Many candidates missed the points, as they did not mention an alien species introduced as a biological control measure.

---

a. Discuss the difficulties of classifying organisms into trophic levels. [2]

b. Explain the cause and consequences of biomagnification, using a **named** example. [4]

Markscheme

a. a. consumer may have more than one food source;

b. organisms eaten may be at different trophic levels;

c. may change their trophic level over time;

d. different stages in life cycle might exist in different trophic level (eg frog);

e. example of organism (presenting such a difficulty);

b. a. a process in which chemical substances become more concentrated at each trophic level;

b. valid named example (for example mercury, organophosphorous pesticides, DDT, TBT);

c. these substances cannot be broken down / are broken down slowly by metabolism;

d. are often stored in (adipose) tissues;

e. each organism consumes large quantities of the trophic level below it;

f. so substance accumulates/increases to reach toxic levels;

*If no example is given award **[3 max]**.*

Examiners report

a. This option was attempted by many candidates. The data was more challenging for some than in previous years but candidates on the whole responded well to it.

Few candidates had any difficulty with this question.

b. This option was attempted by many candidates. The data was more challenging for some than in previous years but candidates on the whole responded well to it.

For G3(b) there were many full mark answers. Most candidates were able to give examples of biomagnification and explain the cause and consequences of it.

Discuss the impact of alien species on the environment.

Markscheme

a. (interspecific) competition with native species;

b. does not have natural predators so may survive more;

c. can be a predator difficult to control;

d. reproduce faster/more;

e. may cause the extinction of native species;

f. most are benign/some may be beneficial (*e.g.* honeybee introduced to the Americas from Europe in the 1600s);

Examiners report

Many candidates gave specific examples of alien species rather than discussing the impact of these on the environment. While describing examples however, candidates tended to touch on their impact and get 2 or 3 marks.

Outline the process of nitrogen fixation by a **named** free-living bacterium.

Markscheme

a. atmospheric nitrogen is converted to ammonia;

b. by *Azotobacter*;

Do not accept Rhizobium.

Examiners report

Many weaker candidates referred to Rhizobium.

Explain the consequences of releasing raw sewage and nitrate fertilizer into rivers.

Markscheme

a. raw sewage contains pathogens;

b. can contaminate drinking water / cause disease/death;

c. nitrate fertilizers cause algal blooms/(aquatic) plant development;

d. algae release toxins that can contaminate drinking water;

e. more organic matter results / eutrophication;

f. more oxygen required to decompose organic matter / increase in BOD;

g. (leading to) death of aquatic animals/organisms;

h. recovery follows since algae/plants release more oxygen;

Examiners report

Few candidates answered this option.

In (b) most candidates only scored one or two marks in this question as few could explain the consequences of releasing raw sewage and nitrate fertilizer into rivers.

---

a . Outline **one** example of biological control of a **named** invasive species. [2]

b. Explain the cause and consequences of biomagnification [4]

Markscheme

a . a. named example of invasive species;

b. named example of biological control;

possible examples:

invasive species	*control*
rats	Indian mongoose
aphid	Ladybird (beetle)
rabbits	Myxoma virus

b. a. substances/pesticides/heavy metals accumulate up the food chain / at each trophic level;

b. substances cannot be metabolized/excreted;

c. these substances become concentrated in (fatty) tissues/internal organs;

d. magnified in organisms in upper part of chain as they eat more/larger organisms;

e. increase in concentration may become toxic in higher trophic levels;

f. example of a consequence of biomagnification e.g (DDT causes) thinning of egg shells (in birds);

Examiners report

a . There were some good examples given of biological control of invasive species but also many vague and non-relevant examples.

b. Explaining biomagnification discriminated well with all but the very weakest candidates scoring at least one mark and only the stronger candidates scoring full marks.

---

a. Outline **one** example of herbivory. [2]

b. State the units used in a pyramid of energy. [1]

c. Explain the small biomass of organisms in higher trophic levels. [2]

Markscheme

a. named example of herbivore;

named example of plant;

e.g. aphid

rose

b. kJ m^{-2} yr^{-1} / kilojoules per meter squared per year / example of energy per unit area per time unit *(must be metric units)*

c. much loss of energy / 10/20 % retained / 80/90 % loss of energy;

respiration;

egestion;

less valuable as a food source than primary producers;

Examiners report

a. Most candidates could state an example of a herbivore and the plant it fed on.

b. This was often not answered well.

c. Some candidates mentioned the energy loss from one trophic level to the next. Few explained what caused this loss.

State the name of a statistical method used to quantify changes in biodiversity.

Markscheme

Simpson diversity index

Examiners report

N/A

---

a(i). Outline the function of the appetite control centre in the brain. [3]

a(ii). Outline the implications for the health of a person who has a BMI of 16 kg m^{-2}. [1]

b. Describe a primary succession in a **named** type of habitat. [3]

Markscheme

a(i). a. causes sensation of being full/having eaten too much (when receives messages);

b. stimulated by hormones (insulin, CCK) produced by pancreas/small intestine after eating;

c. stretch receptors in stomach after eating;

d. hormones (leptin) produced by adipose tissue in response to fat storage;

e. send message to appetite control centre in brain;

a(ii). BMI of 16 (kg m^{-2}) is underweight so there is a health risk;

underweight so may be taking in insufficient nutrients;

b. a. named type of habitat; *(e.g. land left after lava flow/glacier retreat / sand dune)*

b. primary succession occurs on bare/lifeless substrate;

c. organisms move into an area and change its nature/pioneers colonize;

d. pioneers are simple autotrophs; *(e.g. lichens grow first)*

e. break down substrate; *(e.g. to form organic soil)*

f. leads to an eventual climax ecosystem; *(e.g. forest)*

g. stages in the succession follow a set sequence;

*Award **[2 max]** if no named type of habitat given or if example is of secondary succession such as after a forest fire*.

Examiners report

a(i). Many candidates were able to get 2 out of the 3 available marks for stating that the appetite control centre causes a sensation of being full and then stating one message sent to the centre after eating. Stretch receptors were often incorrectly stated as being in the small intestine or pancreas and few added that leptin was produced in response to fat storage by adipose tissue.

a(ii). This question asked candidates to outline the implication of the given BMI. Therefore more was expected than simply stating that the person would be underweight.

b. The descriptions of primary succession were not clear or detailed enough. Few used the words pioneer or climax community. Many incorrectly referred to the first plants as mosses rather than lichens. Despite this, the generous mark scheme allowed many to gain 2 marks.

---

a. Explain the principal of competitive exclusion. [2]

b (ii). Using a **named** example, explain a consequence of biomagnification. [2]

Markscheme

a. no two species can occupy the same niche/role in an ecosystem;

too much competition occurs until one is eliminated / one out-competes the other;

competition is for habitat/nutrition/relationships/space/limited resources;

b (ii) name of chemical and top consumer affected; (*both needed*)

consequence;

eg:

DDT, affecting bird of prey;

fragile egg shells which did not hatch affecting population size;

Examiners report

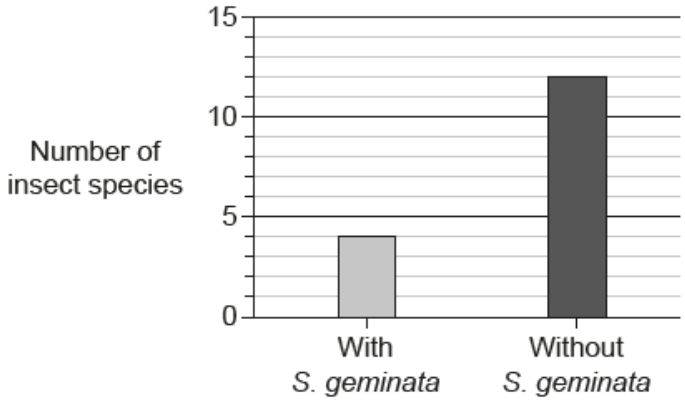
a. Although most candidates had a general idea of the competitive exclusion principle for (a), few could answer this question concisely and clearly.

Most candidates however obtained 1 mark and many gained 2.

b (ii) There were very few accurate, real examples of biomagnification given in (ii).

The fire ant (*Solenopsis geminata*) is an effective colonizer and has become invasive in a number of ecosystems. Sometimes, efforts to eliminate this species have had an unexpected impact on community structure. It is argued that *S. geminata* can play a beneficial role in corn production. The graph shows how the presence of *S. geminata*

can impact insect diversity in areas where crops of corn are grown.



[Source: adapted from Risch and Carroll (1982) *Ecology*, 63, John Wiley & Sons Inc, pages 1979–1983.]

a. State the impact of *S. geminata* on insect species diversity. [1]

b. Discuss whether *S. geminata* might play a positive role in corn production. [3]

c. Researchers have argued that *S. geminata* is a keystone species in the corn agricultural system. Outline what is meant by a keystone species. [2]

Markscheme

a. reduction in number of species/richness/diversity

b. a. biological control of/reduction in corn pests

b. reduction in the use of pesticides

c. damage on beneficial species *OWTTE*

d. reduction in insect diversity can have broad ecosystem negative impact
OR
example of negative effect

e. long-term effects unknown

c. *definition*

a. keystone species is one in which presence has a disproportionate impact on the ecosystem

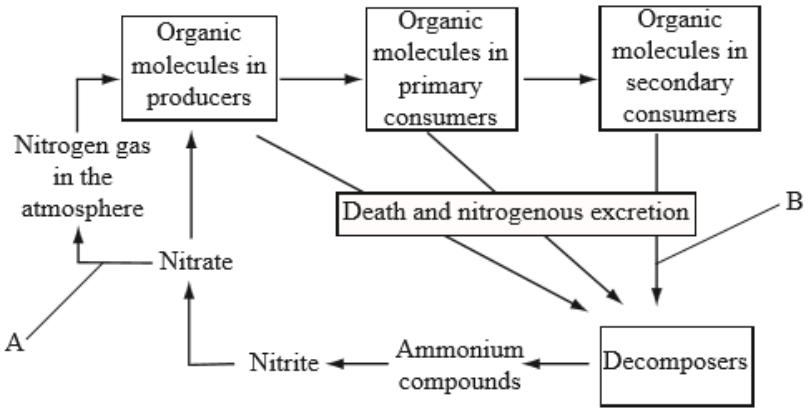
impact

b. removal often leads to significant changes
OR
valid example

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Below is a diagram of the nitrogen cycle.



a. Indicate the processes occurring at A and B. [1]

A: .....

B: .....

b (i) Draw an arrow to indicate where in the cycle *Azotobacter* plays a role. [1]

b (ii). State the role of *Nitrobacter* in this cycle. [1]

c. Outline the consequences of releasing nitrate fertilizer into rivers. [2]

Markscheme

a. *Both required for **[1]**.*

A: denitrification

B: putrification/decay/decomposition

b (i). arrow pointing from nitrogen in atmosphere to ammonium compounds

b (ii). nitrification / converts nitrite to nitrate

c. adding nitrates causes increase in growth of phytoplankton/algal blooms;

decomposition (of increased biomass/dead plants/animals) uses up more oxygen;

can result in death of other aquatic organisms due to lack of oxygen;

plant/algal biomass increases causing turbidity of water;

Examiners report

a. Understanding of the nitrogen cycle is not good, and few candidates answered these questions correctly.

b (i). Understanding of the nitrogen cycle is not good, and few candidates answered these questions correctly.

b (ii). Understanding of the nitrogen cycle is not good, and few candidates answered these questions correctly.

c. The majority were able to discuss changes in the level of algae and the lack of oxygen, so most achieved one or two marks.

---

a. Explain the causes and consequences of biomagnification of a named chemical. [3]

b. Explain the concept of niche. [2]

Markscheme

a. a. named example of chemical (for example: mercury, DDT, PCBs, TBT, PAHs,heavy metals, selenium);

b. long lived / do not biodegrade / stored in body tissues / fat soluble;

c. present in small concentration in the environment;

d. chemical becomes more concentrated in the bodies of organisms at each successive trophic level;

e. reach toxic levels in top consumer/organisms near the end of the food chain / example of top consumer affected;

*Award **[2 max]** if no named example of chemical.*

b. a. includes all aspects of way of life of a species/role of the species in the ecosystem;

b. includes relationships within the community;

c. feeding relationships;

d. interaction with environment/spatial habitat;

Examiners report

a. If candidates knew an example of biomagnification they were able to gain the three marks, but even so, many do not understand how and why a chemical becomes more concentrated in each successive trophic level.

b. The best answers to explaining a niche appeared to be rote-learned, otherwise candidates had difficulty using their own words.

Explain how living organisms can change the abiotic environment during primary succession.

Markscheme

a. lichens secrete chemicals/acid which break down inorganic material/rock;

b. lichens/plants/litter change pH of the soil (which prevents/assists some species to establish);

c. organisms increase the mineral/organic/humus content of the soil when they decompose;

d. (organic matter and humus) can increase water retention;

e. plant (roots) can bind soil preventing erosion / break down soil particles;

Examiners report

Most candidates had some idea about succession but some referred to secondary succession and many answers came without explanations.

---

a. Explain the niche concept. [3]

c. Outline **one** reason for the extinction of a **named** animal species [1]

Markscheme

a. a. niche is an organism's ecological role/mode of existence;

b. niche is how organism uses abiotic and biotic resources;

c. depends on where organism lives/habitat;

d. depends on organism's nutrition/feeding activities;

e. depends on interactions (competition/herbivory/predation/mutualism) with other organisms;

c. name of species and what caused it to become extinct (*both needed*)

The named species must be extinct and not endangered.

eg:

passenger pigeon (became extinct when) hunted as a source of food

Note: dinosaur is not a named species.

Examiners report

a. Most of the better candidates could explain the niche concept. Weaker candidates who attempted this part complicated matters by trying to write at length on fundamental and realised niches.

c. Part c caused several comments from teachers as they were quite correct that it could be construed as a HL question. The markscheme was constructed to incorporate the SL coverage (AS G.3.5), while still allowing for a HL answer (from AS G.4.2) resulting in many students achieving the mark. However a significant number did not mention a named species as instructed, so immediately lost the mark.

Explain the use of indicator species to assess the condition of the environment.

Markscheme

a. indicator species are organisms that indicate health of ecosystem/level of pollution

b. they exist in higher relative numbers under certain environmental conditions

OR

if certain environmental conditions are not found, indicator species die/reproduce

c. are very sensitive/highly tolerant species

d. provides quantitative information on the quality of the environment around it

e. named example of indicator species and susceptibility
Must state a named species. eg: Lichens used to detect air quality.

f. indicator species are used to calculate biotic index

Examiners report

[N/A]

---

a. State the role of *Rhizobium*, *Nitrobacter* and *Azotobacter* in the nitrogen cycle. [3]

Rhizobium: .....
Nitrobacter: .....
Azotobacter: .....

b. Explain the production of methane from biomass. [4]

Markscheme

a. *a. Rhizobium:* nitrogen fixation;

b. Nitrobacter: oxidizes/changes nitrites to nitrates;

c. Azotobacter: nitrification / bind atmospheric nitrogen / nitrogen fixation;

b. a. anaerobic digestion of biodegradable material;

b. fermentation (of carbohydrates) by bacteria;

c. methanogens produce methane;

d. methane/biogas used as energy;

e. waste products used as fertilizer;

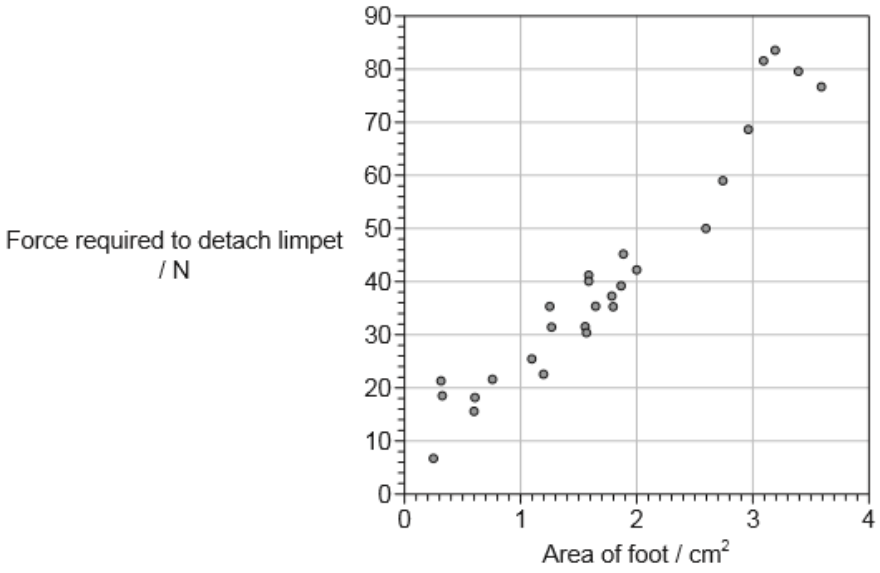
f. CO_2 produced (as a by-product);

Examiners report

a. N/A

b. Some students gave comprehensive explanations of the production of methane from biomass. Most students scored at least one point.

Limpets (*Helcion pectunculus*) are marine molluscs that live in rock crevices (cracks and holes) in South Africa. In order to see whether the crevices protected the limpets from wave action, the force required to detach limpets in their natural habitat was measured. Once detached from the rocks, the area of the foot of each limpet was also measured.



[Source: David R. Gray and Alan N. Hodgson. THE IMPORTANCE OF A CREVICE ENVIRONMENT TO THE LIMPET HELCION PECTUNCULUS (PATELLIDAE). *J. Mollus. Stud.* (2004) **70** (1): 67–72 doi:10.1093/mollus/70.1.67]

a (i) State the force required to detach a limpet with an area of foot of 2 cm^2 . [1]

a (ii) State the smallest area of foot necessary to resist a force of 50 N. [1]

.....cm^2

b. Outline the relationship between area of foot and the force required to detach the limpet. [1]

c. Smaller limpets can only be found at the back of crevices. Discuss the reasons for this. [3]

d. Limpets tend to live towards the high tide zone. State the method used to determine the distribution of limpets between the low and high tide lines. [1]

Markscheme

a (i) 42 (N) *(allow answers in the range of 41 (N) to 43 (N))*

a (ii) 2.6 (cm^2) *(allow answers in the range of 2.5 (cm^2) to 2.7 (cm^2))*

b. Positive correlation / as area of foot increases so does force required.

c. a. back of crevice less subjected to action of waves;

b. (hypothesis supported as) small area of foot requires less force;

c. amount of predators/food could be affecting the distribution;

d. larger limpets may not fit in the back of the crevice;

e. less competition with larger limpets at the back of the crevice;

d. transect line / quadrat with transect line

Do not accept quadrat alone.

Examiners report

a (i) Option G data was a scatter graph showing the relationship between the area of the foot and the force required to detach limpets. The data was on the whole well answered.

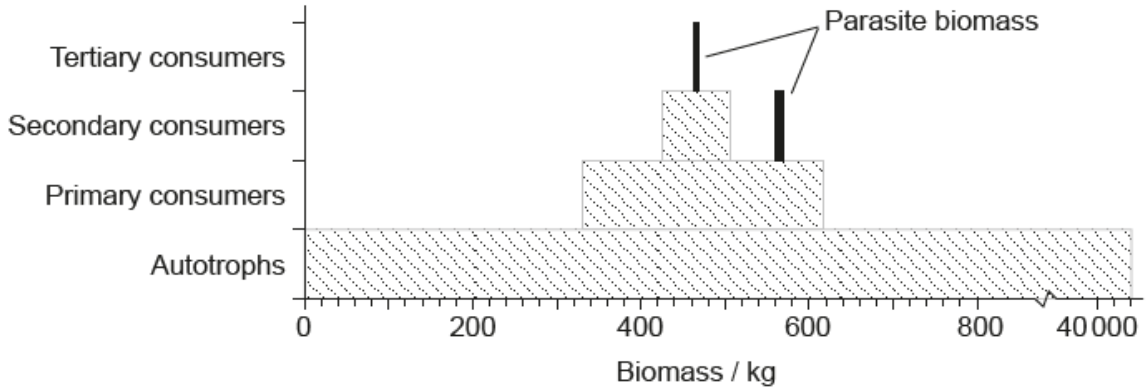
a (ii) Option G data was a scatter graph showing the relationship between the area of the foot and the force required to detach limpets. The data was on the whole well answered.

b. Option G data was a scatter graph showing the relationship between the area of the foot and the force required to detach limpets. The data was on the whole well answered.

c. Option G data was a scatter graph showing the relationship between the area of the foot and the force required to detach limpets. The data was on the whole well answered.

d. Option G data was a scatter graph showing the relationship between the area of the foot and the force required to detach limpets. The data was on the whole well answered.

The pyramid of biomass obtained from a pine forest stream includes the parasite biomass. Parasites are fungi, worms and other organisms that live on a host.



[Source: Michael Sukhdeo (2012) 'Where are the parasites in food webs?' *Parasites & Vectors*, 5, page 239. DOI: 10.1186/1756-3305-5-239]

a. Estimate the approximate amount of biomass represented by parasites in this ecosystem. [1]

b. Compare and contrast the biomass in the different trophic levels. [2]

c. Outline the reason that parasite biomass occurs in both tertiary consumers and secondary consumers. [1]

Markscheme

a. any value between 15 kg and 22 kg

b. a. biomass decreases going up the trophic levels ✓

b. autotrophs have greatest biomass «around 40 040 kg»

OR

tertiary consumers have the least biomass ✓

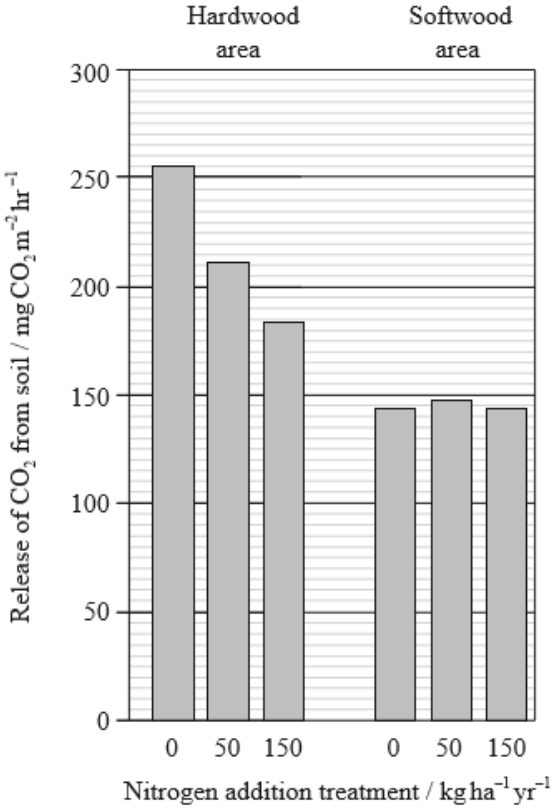
c. greatest loss of biomass is from autotrophs to primary consumers

c. parasites feed on secondary and primary consumers

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

In a long-term experiment in Harvard Forest, Massachusetts in northeastern USA, nitrogen was added to the soil in two different areas of the forest containing either hardwood or softwood trees and the effects on release of CO_2 from the soil were measured.



[Source: adapted from I J Fernandez, Plant, Soil, and Environmental Sciences, www.climatechange.umaine.edu]

a. Estimate the difference between the lowest and highest rates of release of CO_2 from the soil in the hardwood area, giving the units. [1]

b. Suggest **one** process occurring in tree roots that could cause the release of CO_2 from the soil. [1]

c (i) Describe the relationship between rates of nitrogen addition and release of CO_2 from soil in the hardwood area. [2]

c (ii) Suggest a reason for this relationship. [1]

d. Compare the effects of the nitrogen addition treatments on the hardwood and softwood areas of the Harvard Forest. [2]

Markscheme

a. (255–184/183 =) 71/72 mg CO2 m^{-2} hr^{-1} (*units required*)

b. respiration (in tree root cells/mycorrhizal fungi/bacteria/other microorganisms)

c (i) as nitrogen addition increases, release of CO_2 decreases;

greater decrease from zero to 50 kg ha^{-1} yr^{-1} than from 50–150 kg ha^{-1} yr^{-1} / from zero to 50 kg ha^{-1} yr^{-1} decrease is 43 mg CO_2 m^{-2} hr^{-1}, from 50–150 kg ha^{-1} yr^{-1} decrease is 28 mg CO_2 m^{-2} hr^{-1};

c (ii) increased nitrogen addition leads to less root/fungal/bacterial growth/alters pH/osmotic potential of soil so affecting/decreasing respiration of organisms resulting in less CO_2 production

d. as nitrogen addition treatment increases, release of CO_2 from soil decreases in the hardwood area whereas there is no significant change in the softwood area;

release of CO_2 from soil is higher in hardwood area than in softwood area at all nitrogen addition treatments;

at nitrogen addition treatment of 50 kg ha^{-1} yr^{-1} hardwood shows (large) decrease in CO_2 release from zero treatment whereas softwood shows (slight) increase / other valid numerical comparison;

Examiners report

a. This was mainly answered correctly with the correct units being given.

b. Most candidates stated the process of respiration.

c (i) Many gained a mark for saying that release of carbon dioxide decreased as nitrogen addition increased, but few quoted any data from the graph to support their statement, so did not gain a second mark.

c (ii) There were few correct answers here, but stronger candidates did suggest that there was decreased respiration of organisms resulting in less carbon dioxide production.

d. Many answers did not compare the two areas in the forest, and those that gained one mark did not utilise the data accurately to gain a second mark.

The introduction of alien species and the release of environmental pollutants are examples of human activities that have an impact on the environment.

Alien species may arrive in an ecosystem due to accidental or deliberate release. State the impact of **one named** example of deliberate release.

Markscheme

example *e.g.* Cane Toads/*Bufo marinus*;

effect *e.g.* predation of native invertebrates;

Other possible examples:

Example	***Effect***
Salvinia (Floating fern/Giant Salvinia/Kariba weed) or Water Hyacinths	*blocked waterways excessive decomposition depletes oxygen and fish stocks*
Nile Perch	*destroyed native fish species (in Lake Victoria)*
Yellowjackets (German wasps – North America)	*nests in buildings and threat of stings due to aggressive behaviour*
Rabbits (in Australia)	*loss of native plant species erosion due to excessive herbivory*

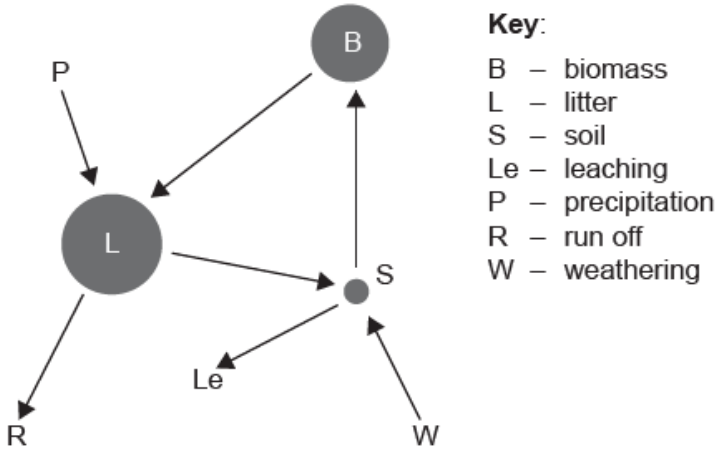
*Accept other suitable examples. Accept common name **or** systematic name.*

Google to check others.

Examiners report

The problem of alien species has been in the paper in the past, normally asking about accidental releases. This time the question was about deliberate releases, and so many answers were not stating the correct type of example. Also the impact of the release was required in order to gain the two marks.

The Gersmehl diagram below shows the movement and storage of nutrients in a taiga ecosystem.



[Source: Adapted from: http://www.slideshare.net/ecumene/ecosystems-3-nutrient-cycle-presentation]

Predict the possible effect of global warming on the nutrient flow in a taiga ecosystem.

Markscheme

a. increased biomass «with higher temperatures»

b. «so» increased uptake of nutrients from soil «into the biomass»

c. increased decomposition of litter «due to growth of decomposers»

d. «so» increased nutrient composition of soil «L→ S»

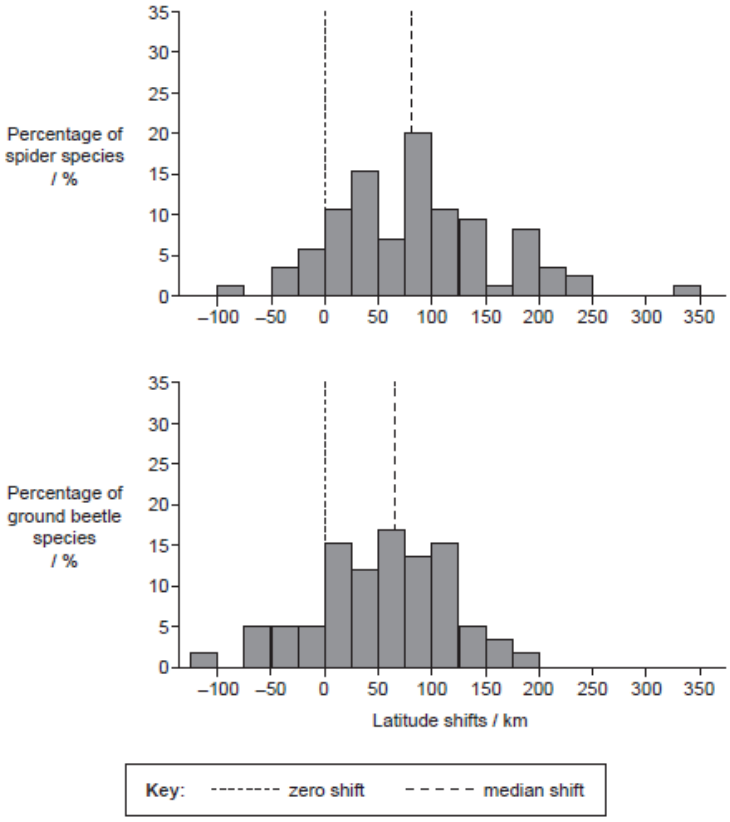
e. increased weathering of rocks «increasing minerals in soil»

f. weather changes cause increased runoff from litter/leaching from soil

Examiners report

[N/A]

The distributions of many terrestrial organisms are currently shifting in latitude in response to changing climate. The graph shows the latitudinal shifts of the northern range boundaries of species within two taxonomic groups that were observed over 25 years in Britain. Positive latitudinal shifts indicate that a species now inhabits areas further to the north than it did before and negative shifts indicate that the northern edge of the range has moved south.



[Source: adapted from I Chen, *et al.*, (2011), *Science*, **333** (6045), pages 1024–1026]

a. State which taxonomic group shows the greatest median shift. [1]

b. Calculate the percentage of ground beetles that are below the zero shift. [1]

c. Compare the changes in the range of ground beetles with the changes in the range of spiders. [2]

d. Spiders and ground beetles are both predators. Discuss possible effects on other species resulting from the latitudinal shift of the predators. [2]

Markscheme

a. spider

b. 16.75(%)

Accept answer in the range of 16.5 (%) to 17(%).

c. a. both taxonomic groups showed movement to the north;

b. slightly more spiders moved north;

c. spiders shows the furthest northern shift;

d. range of ground beetles extends further south (than spiders);

e. the spiders' biggest movement is 75 to 100 km to the north and the ground beetles' biggest movement is 50 to 75 km to the north;

f. overall spiders have a broader range;

d. a. competition for resources/food/space/other resource;

b. change in predation/number of other species;

c. change/decrease/increase in biodiversity;

d. food webs may change;

Examiners report

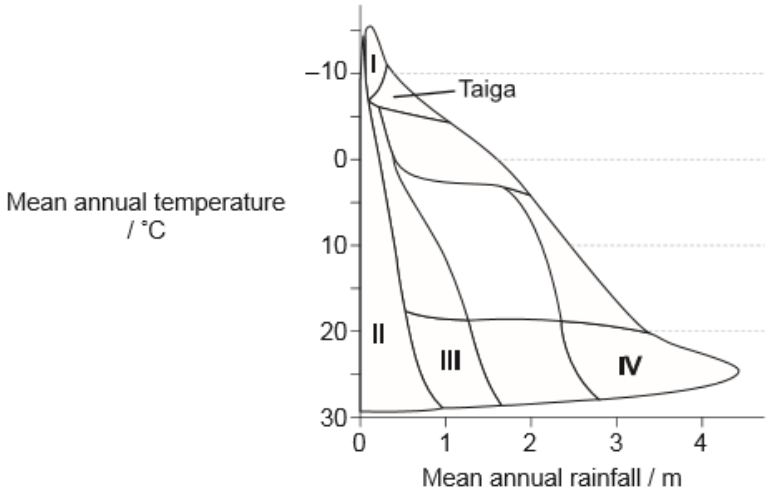
a. A popular option choice with most candidates scoring well on the interpretation of the data.

b. A popular option choice with most candidates scoring well on the interpretation of the data.

c. A popular option choice with most candidates scoring well on the interpretation of the data.

d. A popular option choice with most candidates scoring well on the interpretation of the data.

The climograph shows the distribution of biomes according to the temperature and rainfall of land areas on Earth.



[Source: © International Baccalaureate Organization 2016]

a. Identify the ecosystem with the appropriate numeral from the climograph. [2]

Ecosystem	Numeral
Tropical rainforest	
Desert	
Tundra	

b. Referring to the climograph, explain reasons that the nutrient store in the litter layer of the taiga is greater than in the tropical rainforest. [3]

Markscheme

a.

ecosystem	numeral
tropical rainforest	IV
desert	II
tundra	I

*Award **[2]** if all three are correct, **[1 max]** if one or two are correct and **[0]** if none correct.*

b. a. litter is dead plant material on the ground

b. conditions in tropical rainforests are ideal to decompose plant material
OR
conditions in taiga do not favour decomposition of litter

c. decomposition returns nutrients to soil
OR
nutrients in taiga remain in the litter and not in the soil

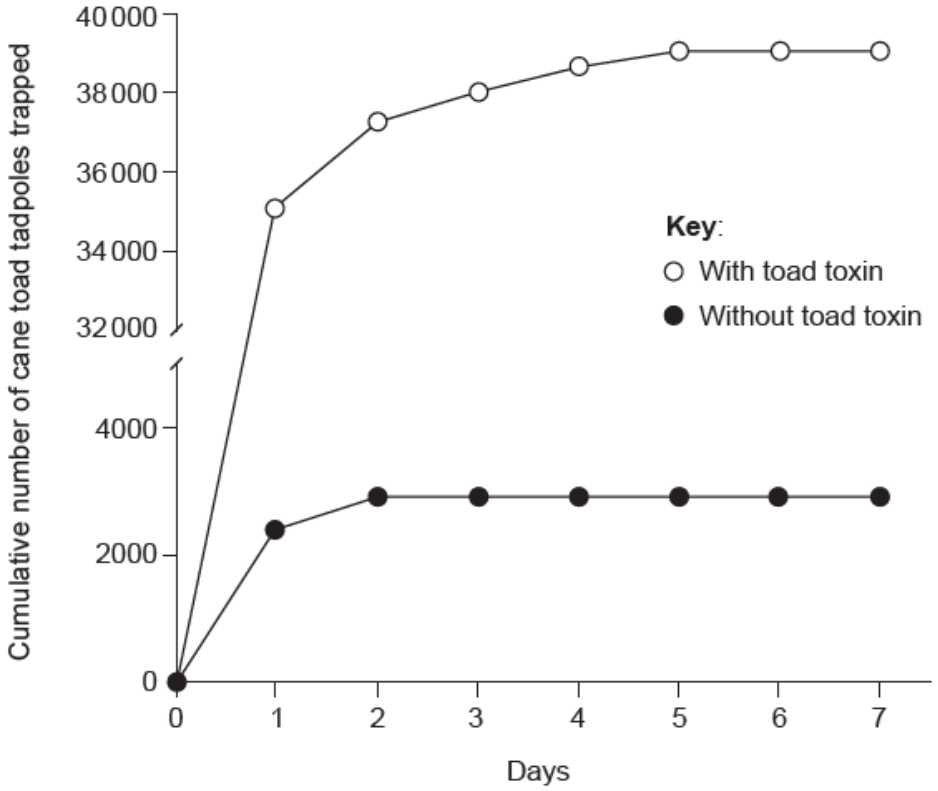
d. tropical rainforests have more saprotrophs/decomposers
OR
taiga have fewer saprotrophs/decomposers

Numbers alone do not constitute an explanation.

Examiners report

a. [N/A]
b. [N/A]

After their introduction cane toads (*Rhinella marina*) have become a serious pest in many parts of Australia. In an attempt to control them scientists set traps to which they added toxins produced by native species of toad to capture cane toad tadpoles. The toad toxin attracts the cane toad tadpoles without killing them.



[Source: Michael R. Crossland, Takashi Haramura, Angela A. Salim, Robert J. Capon and Richard Shine (2012) 'Exploiting intraspecific competitive mechanisms to control invasive cane toads (Rhinella marina).' *Proceedings of the Royal Society B: Biological Sciences*, 279(1742): 3436–3442. DOI: 10.1098/rspb.2012.0821.]

a. Outline **one** consequence of introducing an alien species into an ecosystem. [2]

b. State the origin of cane toads. [1]

c. Evaluate the use of traps containing toxin as a means of cane toad control. [3]

Markscheme

a. a. uncontrolled increase of numbers «in alien species»

OR

become invasive

OR

have no «natural» predators

b. outcompetes native species / reduces biodiversity
OR
carries disease
OR
preys on local species decreasing population size
OR
disrupts food chains/webs

b. Central/South/Latin America

c. a. the baited traps catch a lot more tadpoles than the unbaited traps / traps with bait are more effective than those without

b. baited traps are almost 20 times more effective

c. traps without toxin reach capacity sooner than those with toxin

d. there may be environmental/health/safety problems with the toad toxin used

e. there is no information on how toads are controlled since the toxin does not kill the tadpoles

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Freshwater invertebrates were sampled by students at three sites along a river in central France. The animals were identified and counted. The diversity of each site can be compared using Simpson's reciprocal index.

	Number of animals in the sample		
Species	**Site A**	**Site B**	**Site C**
Baetis rhodani	0	30	7
Ecdyonurus dispar	1	0	9
Ephemerella ignita	4	0	0
Limnephilus lunatus	0	0	2
Brachycentrus subnubilus	2	1	0
Polycentropus flavomaculatus	0	1	0
Rhyacophila obliterata	1	0	0
Gammarus pulex	0	1	0
Asellus aquaticus	8	0	0
Simulium equinum	17	0	0
Dexia	0	5	0
Chironomus annularis	0	0	1
Hirudinea	0	4	2
Simpson's reciprocal index	**3.09**	**1.91**	

Simpson's reciprocal index is given by the following formula:

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

a. Calculate the diversity of site C. Working should be shown. [2]

b. Site A has a higher Simpson's reciprocal index than Site B showing that its diversity is higher. [2]

Explain the reason that ecologists consider Site A to have a higher diversity than Site B, despite both sites having six different species present.

c. Discuss the advantages and disadvantages of in *situ* conservation methods. [4]

Markscheme

a. a. $\frac{21 \times 20}{42+72+2+2}$

b. = 3.56 «allow 3.55»

b. a. the species in Site A are more evenly represented than site B

b. site B has a large number of one species «but very few in the other 5»

c. Simpson's reciprocal index is a measure of species evenness as well as species richness

c. *Advantages*:

a. conservation in the natural habitat / ecosystem

b. the species will have all the resources that it is adapted to

c. the species will continue to evolve in their environment / can maintain genetic diversity

d. the species have more space so a bigger breeding populations can be kept

e. it is cheaper to keep an organism in its natural habitat

f. established food webs/ species interactions can be maintained

Disadvantages:

g. it is difficult to control illegal exploitation «*eg* poaching»/harder to monitor populations

h. the area may need restoring / may be required for other purposes

i. alien species are difficult to control

j. species close to extinction are harder to conserve

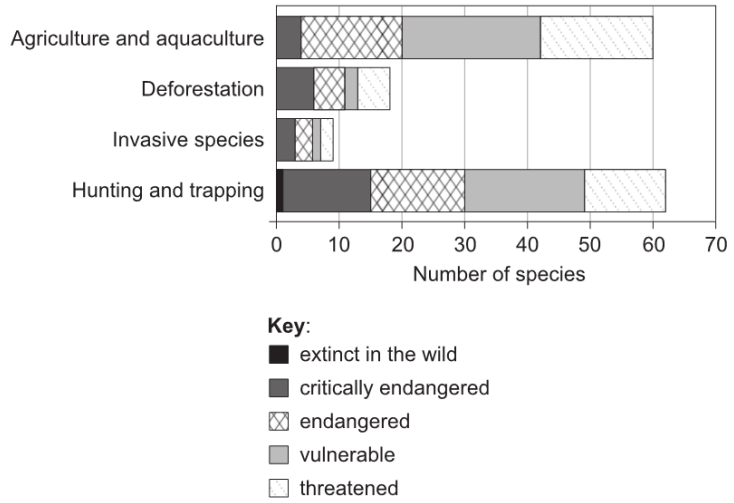
k. management/protection may represent a significant cost

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

Data from the International Union for Conservation of Nature (IUCN) indicates that the population numbers of many mammal species are decreasing.

The chart shows reasons for the decrease and the number of species in each category of danger.



[Source: Michael Hoffmann et al. 2011. The changing fates of the world's mammals. Philosophical Transactions of the Royal Society B, Volume 366, issue 1578. DOI: 10.1098/rstb.2011.0116. By permission of the Royal Society.]

a. Calculate how many species are classified as endangered due to hunting and trapping. [1]

b. State **one** reason mammals can continue to survive even if they are extinct in the wild. [1]

c. Outline how deforestation can affect the richness of biodiversity in an ecosystem. [1]

d. Explain the impact of plastic waste on Laysan albatrosses (*Phoebastria immutabilis*). [2]

Markscheme

a. 14/15/16

Do not accept intermediate values eg: 14.5

b. zoos/nature reserves/captive breeding/*ex situ* conservation/farming/husbandry/pets

c. deforestation reduces richness by destroying habitat/loss of food/shelter/nesting sites

d. a. adults/young ingest plastic «which is indigestible»

b. plastic damages/fills stomach «can lead to starvation and death»

c. plastic blocks intestine so food cannot be digested «can lead to starvation and death»

d. adults/young can become entangled in plastic and so they drown/choke/suffocate

Allow other verifiable effect of plastic

"Can kill the birds" is too vague and worth ***[0]***

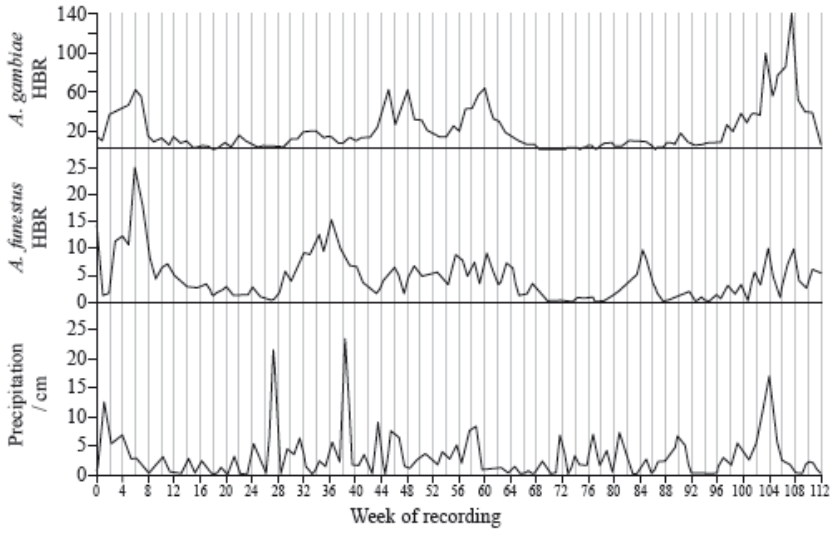
[Max 2 Marks]

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]
d. [N/A]

Many factors affect the distribution of animal species including weather patterns. The mosquito *Anopheles* is a carrier of malaria, a disease that kills one to two million people annually. The eggs of the mosquito are laid in water and they hatch out as larvae before turning into adult mosquitoes. A study was undertaken to look at the influence of weather patterns on the incidence of bites on children. Being bitten increases the risk of catching malaria.

The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

State the week number when the highest human biting rate (HBR) is found for *A. gambiae*.

Markscheme

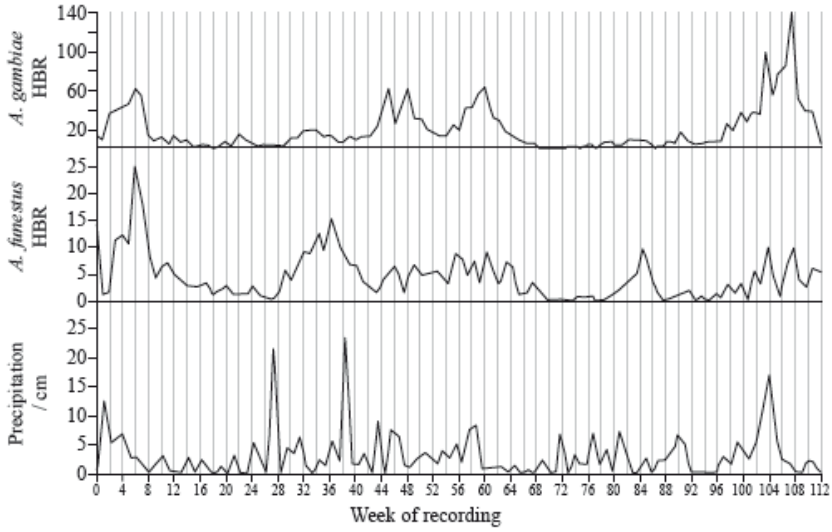
(highest HBR for *Anopheles gambiae/A. gambiae* week) 107/108

Examiners report

The majority of candidates correctly stated that week 107 had the highest human biting rate (HBR).

Many factors affect the distribution of animal species including weather patterns. The mosquito *Anopheles* is a carrier of malaria, a disease that kills one to two million people annually. The eggs of the mosquito are laid in water and they hatch out as larvae before turning into adult mosquitoes. A study was undertaken to look at the influence of weather patterns on the incidence of bites on children. Being bitten increases the risk of catching malaria.

The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

b. Calculate the difference in peak HBR for *A. gambiae* and *A. funestus* for week 6. [1]

d. Suggest how predictions of global climate changes, such as predictions of precipitation patterns, could be used to help control malaria. [1]

e. Suggest another factor which might affect the ecological distribution of mosquitoes. [1]

Markscheme

b. 35 *(accept answers in the range of 34 to 37)*

d. a. spraying insecticides just before rainy seasons;

b. draining swamps before (and after) rain;

c. providing (endangered) population with repellents/mosquito nets before rainy season;

e. temperature / breeding site / food supply / predators / other reasonable answer

Do not accept global warming.

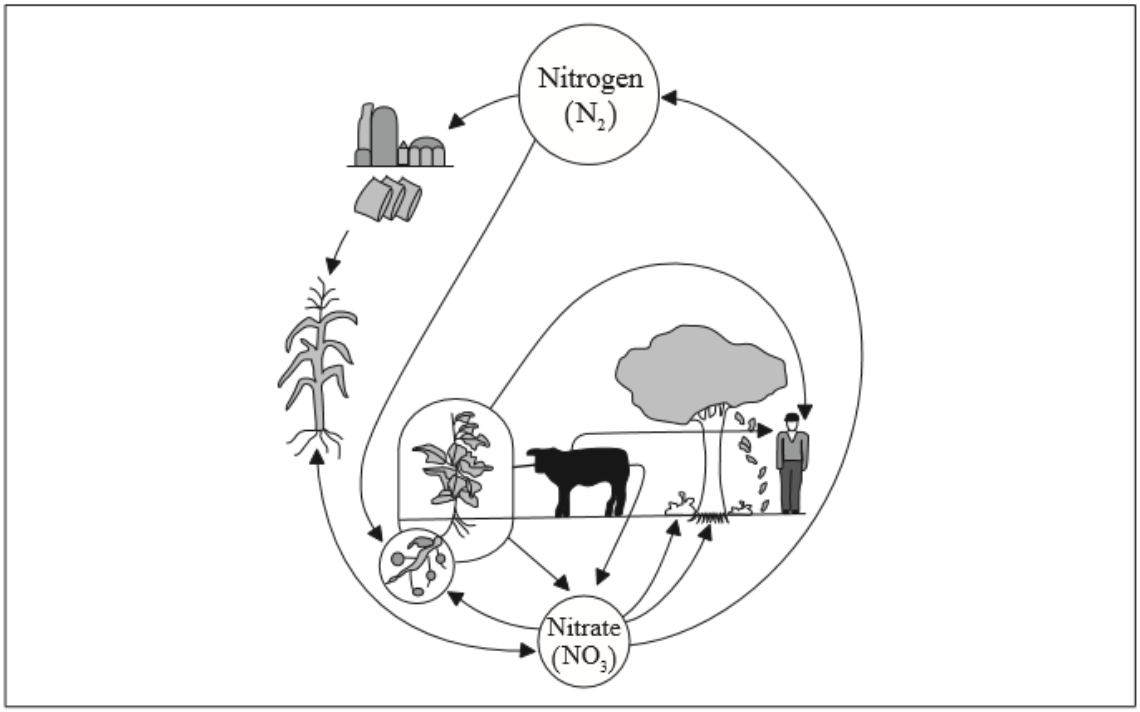
Examiners report

b. The majority were able to correctly do the calculation.

d. There were many vague answers to this section which did little more than repeat the question without giving a specific reply. A specific action was required such as use of mosquito nets or spraying insecticides rather than stating that "protection is needed".

e. Most were able to give a factor that could affect mosquito distribution.

The diagram below shows the nitrogen cycle.



[Source: adapted from http://bldg6.arsusda.gov/images/Ncycle.jpg]

Using the letter X, label where the process of denitrification occurs in the nitrogen cycle.

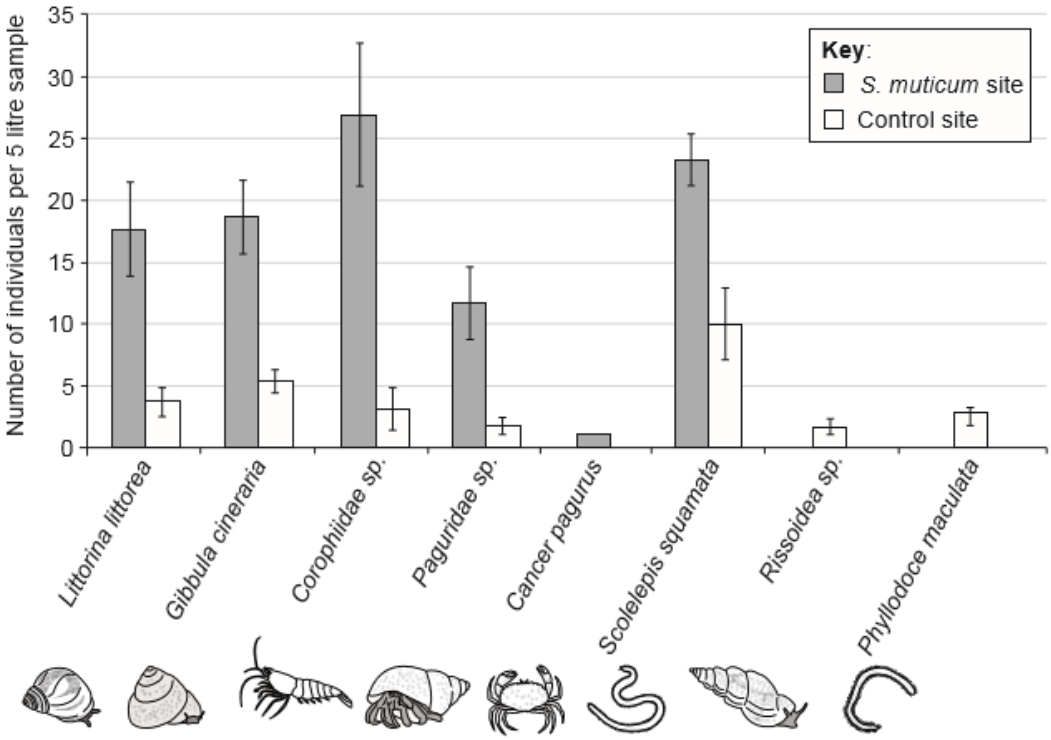
Markscheme

letter X labelled anywhere on the arrow between Nitrate (NO_3) and Nitrogen (N_2)

Examiners report

Many candidates were correctly able to indicate that denitrification was indicated by the arrow between nitrate and nitrogen on the diagram.

The brown alga *Sargassum muticum* is a successful invasive species around the world. It grows attached to rocks in the intertidal zone and has large fronds that float in the water. It has recently become established in intertidal communities on the west coast of Scotland. The impact of this invasive species was investigated by measuring the composition of the animal community in the intertidal zone in an affected area. The data were compared to a control site with no invasive *S. muticum* which was located close by.



[Source: D. Harries, S. Harrow *et al.* (2007) *Journal of the Marine Biological Association*, **87**, pages 1057–1067, Figure 2. "The establishment of the invasive alga *Sargassum muticum* on the west coast of Scotland: a preliminary assessment of community effects", reproduced with permission.]

a. Identify the most abundant animal type at [1]

the *S. muticum* site:
the control site:

b. Describe the impact of invasive *S. muticum* on the shoreline animal community. [3]

c. Discuss possible reasons for the differences in the animal communities seen at the two sites. [3]

Markscheme

a. *S.muticum site: Corophiidae sp.*

control site: S. squamata
*Both needed for **[1]**.*

b. a. fewer different types of organism / smaller diversity at *S. muticum* site;

b. mean abundance at *S. muticum* site is higher for those organisms present;

c. *Rissoidea sp*. and *P. maculata* found at control site but not at *S. muticum* site;

d. *C. pagurus* only found at *S. muticum* site;

Comparisons are required but the control site does not need to be mentioned in each response.

c. a. *S. muticum* provide habitat/shelter/protection from predators for some species;

b. *S. muticum* change the environment to suit some species/example of a change;

c. some organisms more successful because less (inter-specific) competition;

d. more food may be available (for herbivores);

e. some herbivores may rely on native algae that have been displaced;

f. (other) conditions at the control site may not be identical to the test site;

Examiners report

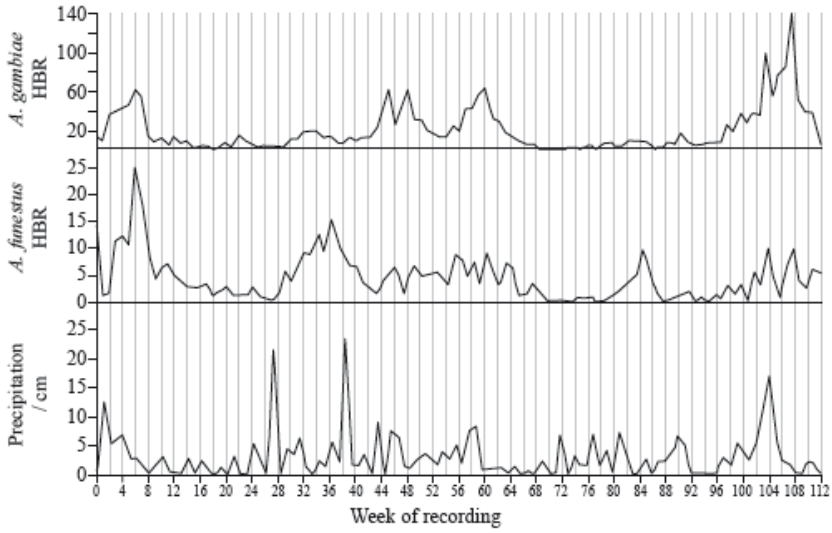
a. 19(a) was answered correctly.

b. Most candidates scored at least 2 marks for part (b), with some responses being too vague, for example not making it clear that *Rissoidea sp* and *P. maculata* were not present at all at the *S. muticum* site.

c. There was some confusion in part (c), where evidently the introduction to the data had not been properly read, as some candidates appeared to think that *S. muticum* was an animal.

Many factors affect the distribution of animal species including weather patterns. The mosquito *Anopheles* is a carrier of malaria, a disease that kills one to two million people annually. The eggs of the mosquito are laid in water and they hatch out as larvae before turning into adult mosquitoes. A study was undertaken to look at the influence of weather patterns on the incidence of bites on children. Being bitten increases the risk of catching malaria.

The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

Evaluate the effect of increased precipitation on HBR for both species.

Markscheme

a. both species show relationship between elevated precipitation and higher HBR (*e.g.* between week 0 and week 8 / week 100 and week 108);

b. there is a lag between the period of precipitation and the increase in HBR;

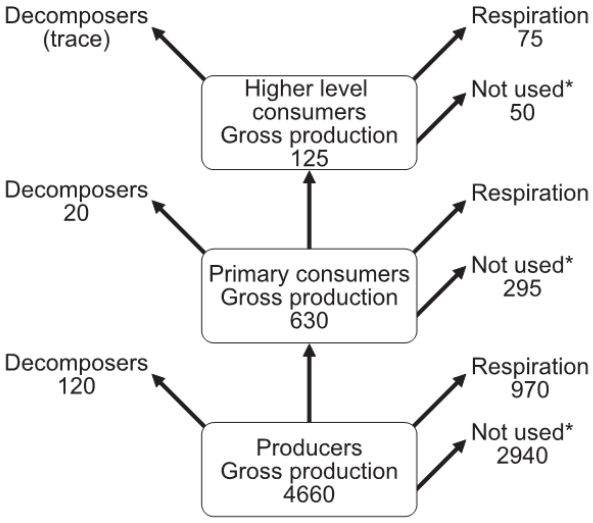
c. sometimes elevated precipitation does not lead to peaks of HBR (*e.g.* week 27);

d. precipitation has a greater effect on *Anopheles gambiae/A. gambiae*;

Examiners report

Almost all candidates gained 1 mark for stating that both species show a relationship between elevated precipitation and higher HBR and many received a second mark, often for commenting on the lag between precipitation and increase HBR. Some were able to identify other effects as well.

The diagram shows both production and losses of energy in three trophic levels of a freshwater lake over the period of one year. All values are expressed in kJ m^{-2} y^{-1}.



* not used: this refers to organic material sinking to the lake bottom, becoming unavailable to other trophic levels

a. Calculate the energy loss due to respiration in primary consumers in kJ m^{-2} y^{-1}. [1]

b. Outline why a year is more suitable than a month for the measurement of energy flow. [1]

c. Explain how pesticides may undergo biomagnification in the lake. [2]

Markscheme

a. 190

b. accounts for different productivity at different times of year/seasonal variations

OR

more data collected

OR

to increase reliability

OR

trends over time more easily detected

c. a. the increase in concentration of the pesticide at higher trophic levels

b. taken in by organisms low in the food chain

c. cannot be excreted so remains in tissues

OR

accumulates as more organisms from lower levels are eaten

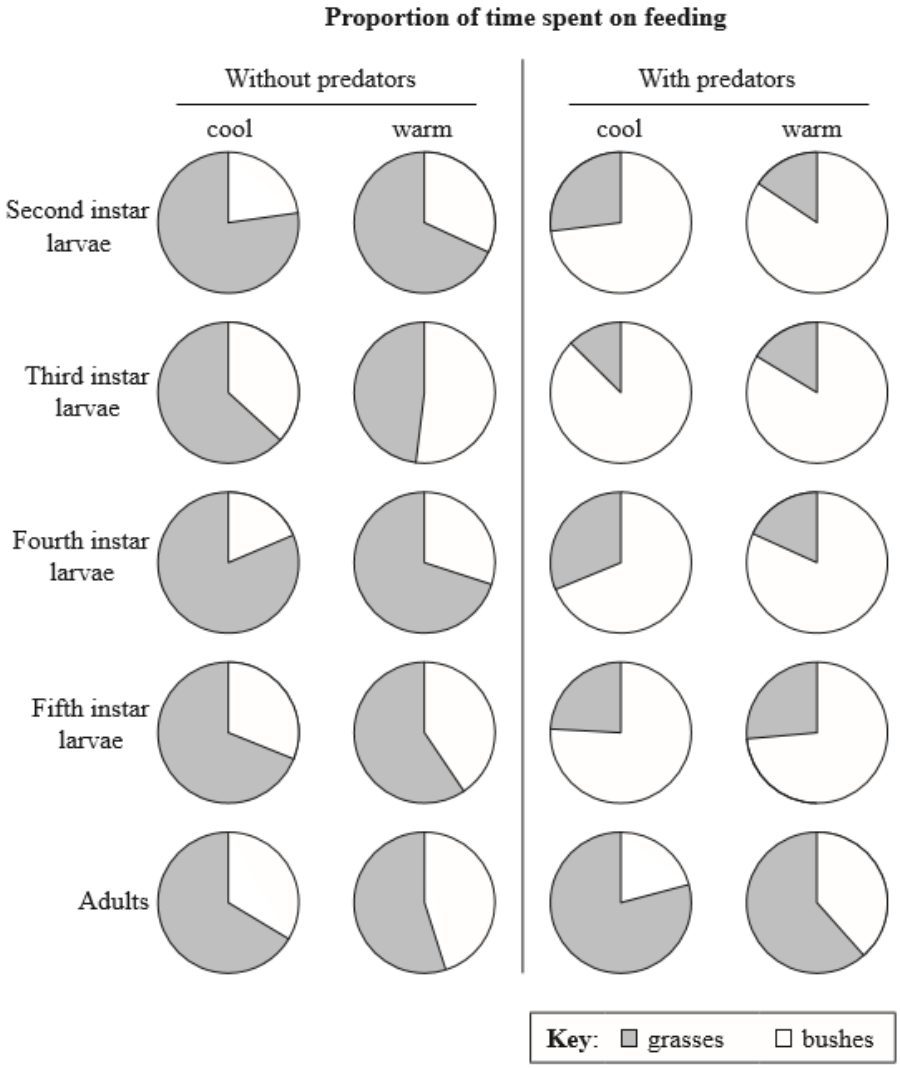
d. pesticides do not degrade/degrade very slowly

[Max 2 Marks]

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

A grassland food web was studied to understand how climate warming affects the interaction of different animal and plant species. Grasshoppers (*Melanoplus femurrubrum*) feed on grasses growing amongst taller bushes. Spiders (*Pisaurina mira*) feed on the grasshoppers. For 75 days, the feeding behaviour of the grasshoppers was observed with and without predators, in temperatures that were cool or warm. During the study period, the grasshoppers progressed through stages of larval development (instars) to adulthood.



[Source: B. T. Barton (2010) *Ecology*, 91(10), pages 2811–2818. Used by permission of the Ecological Society of America.]

a. Identify the primary food for all grasshoppers without predators. [1]

b (i) Deduce, using the data, how the feeding behaviour of instar larvae changes if without predators, conditions change from cool to warm. [1]

b (ii) Deduce, using the data, how the feeding behaviour of instar larvae changes if in warm conditions, predators are introduced. [1]

c. Compare adult feeding to instar larval feeding. [2]

d. Suggest why adult feeding differs from instar larval feeding when predators are present. [1]

Markscheme

a. grasses

b (i) feeding time on grasses (slightly) reduces / feeding time on bushes increases

b (ii) feeding time on grasses (greatly) reduces / feeding time on bushes increases

c. feeding is similar without predators;

more feeding on grass by adults with predators;

d. a. instars are more protected from predators/camouflaged when feeding in bushes;

b. adults can escape predator attacks more easily/camouflaged when feeding in grasses;

c. adults are bigger and less easily captured;

Accept other reasonable responses.

Examiners report

a. There were some comments on the G2 forms that said that these graphs were confusing. In fact the vast majority of candidates gained all three marks on parts a and b.

b (i) There were some comments on the G2 forms that said that these graphs were confusing. In fact the vast majority of candidates gained all three marks on parts a and b.

b (ii) There were some comments on the G2 forms that said that these graphs were confusing. In fact the vast majority of candidates gained all three marks on parts a and b.

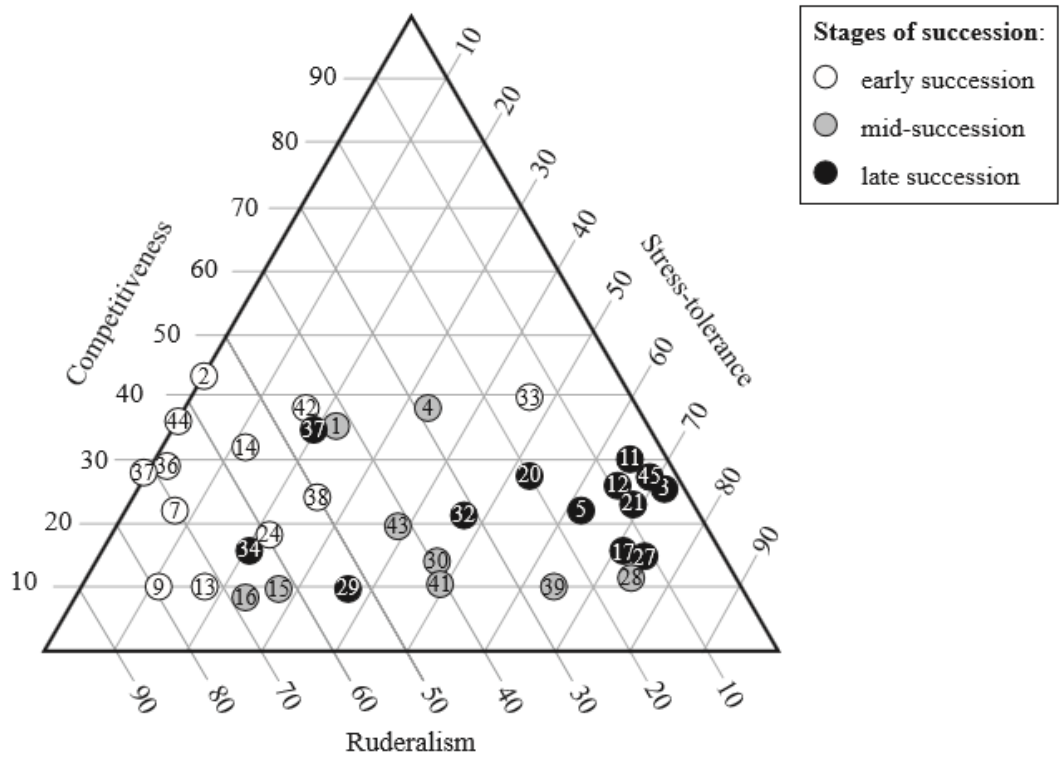
c. In c there were often very wordy answers that did not get to the point, not being proper comparisons. Only the better candidates were able to narrow it down to the fact that the feeding in adults and instars is similar without predators, but there is more feeding on grass by adults with predators.

d. Many could correctly suggest a reason why the feeding differs.

Scientists studied the characteristics of plant species growing in front of the progressively receding Rutor glacier in Italy. As the ice recedes plants are able to colonize the exposed ground. In a study of primary succession, scientists sampled plants from three areas exposed during different time periods. The data is shown in the following triangle graph.

Each species is represented by a number and positioned according to its degree of competitiveness (the ability to exclude other species), stress-tolerance (the ability to use nutrients efficiently) and ruderalism (the ability to develop rapidly to avoid disturbance).

Stages of succession were classified according to the time the ground had been exposed: early succession (species occurring in ground exposed for less than 68 years), mid-succession (species found in ground exposed between 69 and 181 years) and late-succession (species found in ground exposed for more than 181 years).



[Source: M. Caccianiga et al. (2006) "The functional basis of a primary succession resolved by CSR classification", *OIKOS*, 112, pages 10–20.]

a (i) State the most ruderal species. [1]

a (ii) Species number 4 has a ruderalism value of 29. State the stress-tolerance value and competitiveness value of this species. [1]

Stress-tolerance value: .....

Competitiveness value: .....

b. Analyse the change of species over time. [3]

Markscheme

a (i) early succession species/examples of species /(numerical species numbers)/9

a (ii) stress-tolerance value: 34 (*Accept answers between 33 and 35*)

competitiveness value: 38 (*Accept answers between 37 and 39*)

b. a. high ruderalism and (slightly higher) competitiveness in early succession;

b. (as time goes / succession stages advance) stress-tolerance increases;

c. competitiveness decreases;

d. ruderalism decreases/is more variable;

e. competitiveness least important factor / stress-tolerance most important factor;

f. exceptions for all categories;

Examiners report

a (i) This option was attempted by many candidates. The data was more challenging for some than in previous years but candidates on the whole responded well to it.

(a) (i) almost all answers were correct

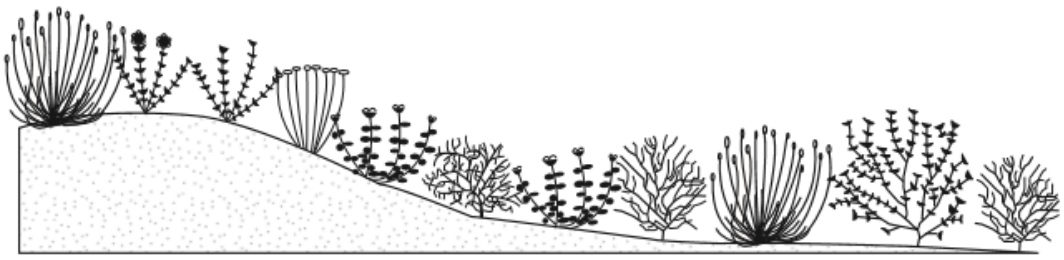
a (ii) This option was attempted by many candidates. The data was more challenging for some than in previous years but candidates on the whole responded well to it.

(i) almost all answers were correct, though (ii) proved more difficult.

b. This option was attempted by many candidates. The data was more challenging for some than in previous years but candidates on the whole responded well to it.

For (b) candidates were able to list, but few were able to analyse as required by the question stem.

The diagram below shows changing vegetation along a slope in a terrestrial ecosystem.



[Source: © International Baccalaureate Organization 2015]

a. Describe how a transect can be used to investigate the distribution of plant species in this ecosystem. [2]

b. The vegetation shown here has developed as a result of primary succession. Outline the changes that take place in the abiotic environment during primary succession. [2]

c. Outline the abiotic factors that affect the distribution of plant species in an ecosystem. [2]

Markscheme

a. a. random positioning of the transect;

b. transect is a line stretched over an area of study;

c. samples taken/species present recorded at regular intervals along the transect;

d. used to investigate effect of an abiotic variable/named example;

b. a. rocks begin to break down;

b. minerals begin to accumulate;

c. soil begins to develop;

d. water retention increases;

e. erosion of soil is reduced (by rhizoids and roots);

c. *The question asks for an outline but most candidates have given a list of factors without a reason. Therefore award **[1]** for every two factors listed or **[1]** for each qualified factor.*

water (distribution) for turgor/biochemical reactions/photosynthesis;
mineral / inorganic content / salinity of soil/water;
temperature (max, min, range, seasonal changes) / altitude;
light (intensity, duration, wavelength) for photosynthesis;
pH (range, average, changes) of soil/water;
wind (direction, strength);

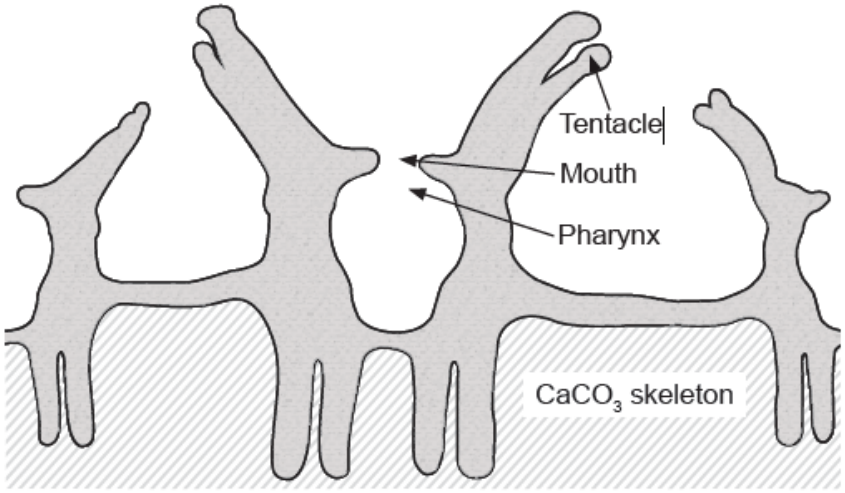
Examiners report

a. As in previous years, many candidates did not know what a transect is or its purpose and some were evidently confused with estimating a population size.

b. In (b) many answers described the vegetative changes in succession rather than the abiotic.

c. The mark scheme in (c) was generous in allowing lists of factors and/or elaborations, otherwise many would not have scored here.

Reef-building corals are an association between two organisms: coral polyps and *Zooxanthellae*.



[Source: © International Baccalaureate Organization 2017]

a. State the relationship between *Zooxanthellae* and coral reef species. [1]

b. Describe the exchange of materials between the coral's polyps and *Zooxanthellae*. [2]

c. State **one** limiting factor on *Zooxanthellae* which affects coral reef formation. [1]

Markscheme

a. mutualism

b. a. polyp is a source of carbon dioxide for the *Zooxanthellae*

OR

polyp is a source of ammonia/nitrogen for the *Zooxanthellae*

b. *Zooxanthellae* provide oxygen to the polyp
OR
Zooxanthellae provide sugars/glucose/glycerol/lipids/amino acids to the polyp

c. light / temperature / salinity / carbon dioxide / pH

Examiners report

a. [N/A]
b. [N/A]
c. [N/A]

The number of plants in two fields of approximately the same size was counted.

Type of plant	Field 1	Field 2
Daisy (*Bellis perennis*)	307	18
Dandelion (*Taraxacum officinale*)	332	48
Buttercup (*Ranunculus repens*)	361	934
Total	1000	1000

a. Compare and contrast the richness and the evenness of the two fields. [2]

b. A calculation of Simpson's reciprocal index was undertaken on each field with the following results. [2]

Field 1	3.0
Field 2	1.1

Evaluate these results.

b. A calculation of Simpson's reciprocal index was undertaken on each field with the following results. [2]

Field 1	3.0
Field 2	1.1

Evaluate these results.

Markscheme

a. a. same richness as they have the same number of species/total of individuals

b. field 1 has more evenness as more even distribution of numbers among the species. *Allow vice versa.*

b. a. the higher the number the more diverse/biodiverse is the field

OR

b. field 1 shows greater diversity/biodiversity (as it has a higher value)

b. a. the higher the number the more diverse/biodiverse is the field

OR

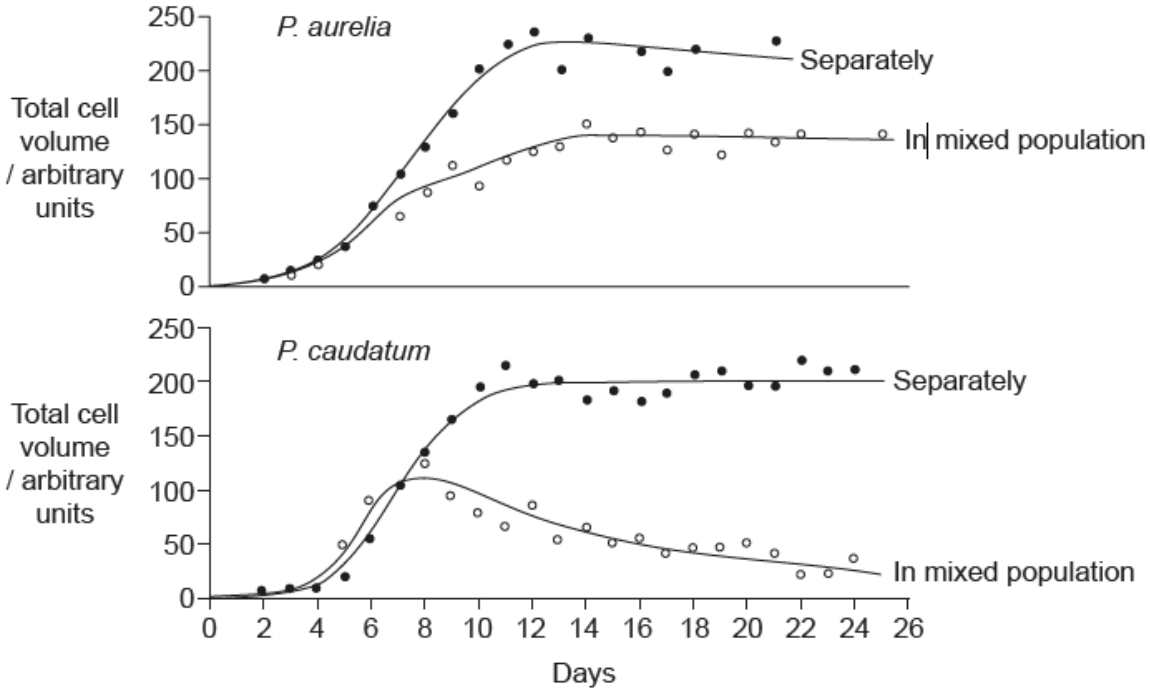
$D = \frac{N(N-1)}{\sum n(n-1)}$

b. field 1 shows greater diversity/biodiversity (as it has a higher value)

Examiners report

a. [N/A]
b. [N/A]
b. [N/A]

Paramecium aurelia and *Paramecium caudatum* are single cell organisms. They were grown separately and together. The population growth curves are shown.



[Source: G. F. Gause (1934) *The Struggle for Existence*, published by The Williams & Wilkins Company]

Explain the results shown in this experiment.

Markscheme

a. when they are alone they both show a greater population than when together

b. two species cannot survive indefinitely in the same habitat if their niches are identical

OR

competitive exclusion

c. *Paramecia* compete for food/space

d. *P. caudatum* starts to disappear/decrease after day 6–8 days «whereas *P. aurelia* reaches a plateau» *Vice versa*
OR
the population of *P.caudatum* decreases much more than the population of *P.aurelia*

e. *P. aurelia* is better suited/fitted than *P. caudatum*

Examiners report

[N/A]

The images show three predator–prey relationships.

Sparrowhawk
(*Accipiter nisus*)
preys on song birds

[Source: https://en.wikipedia.org/wiki/Eurasian_sparrowhawk#/media/File:Accnis_edit.jpg]

Buzzard
(*Buteo buteo*)
preys on small rodents

[Source: https://upload.wikimedia.org/wikipedia/commons/c/cd/Buteo_buteo_-Netherlands-8.jpg]

Swift fox
(*Vulpes velox*)
preys on small rodents

[Source: https://en.wikipedia.org/wiki/Swift_fox#/media/File:Swift_Fox.jpg]

Biomagnification of two groups of organic pollutants was investigated in three predator–prey relationships. BDEs and PCBs are broadly used in industry. The biomagnification factor is a ratio of the amount of pollutant in predator tissue compared to the amount of pollutant in prey tissue.

	Mean biomagnification factor		
	sparrowhawk–song bird	buzzard–rodent	fox–rodent
Pollutant	mean	mean	mean
BDE 47	10	12	<1
BDE 100	25	17	<1
BDE 99	20	14	<1
BDE 153	21	22	<1
BDE 183	29	12	<1
PCB 153	19	45	2
PCB 138/163	21	49	2
PCB 180	20	36	5

[Source: Reprinted from *Journal of Environmental Sciences*, 23 (1), Ziaofei Qin *et al*, "Polybrominated diphenyl ethers in chicken tissues and eggs from an electronic waste recycling area in southeast China", pp. 133–138, © 2011, with permission from Elsevier.]

a. Outline how biomagnification occurs. [2]

b. (i) Identify the predator with the **least** biomagnification of pollutants. [2]

(ii) Suggest a reason for the species identified in (b)(i) having the **lowest** biomagnification factor.

c. Deduce **two** conclusions about PCBs that are supported by the data. [2]

Markscheme

a. Toxin at lowest concentrations in organisms at lowest trophic level

Toxin concentration builds/is magnified in organisms at each successively higher trophic level

Toxins often fat-soluble
OR
can accumulate in body tissues

Toxin/chemical is not metabolized/excreted

b. (i) Fox

(ii) Unlike the other two predators, it is a mammal
OR
has other sources of food
OR
different biochemistry/metabolism

c. PCBs biomagnify in all three predator–prey relationships

PCBs biomagnify most in rodent–buzzard/least in rodent–fox relationship

Greatest range of PCB biomagnification occurs in rodent–buzzard

Biomagnification in birds is higher than in mammals

Examiners report

a. N/A

b. (ii) Candidates struggled to find reasons the fox had lower PCB levels and restated that they had lower levels.

c. Only the better candidates could deduce conclusions about PCB's.

The sea snail Nucella ostrina and the sea star Pisaster ochraceus are predators of the mussel Mytilus trossulus. The mussels live on rocks at the edge of the sea and feed on phytoplankton and zooplankton. The zooplankton feed on the phytoplankton.

Nucella ostrina

[Source: Photograph ©Kelly Fretwell, www.centralcoastbiodiversity.org]

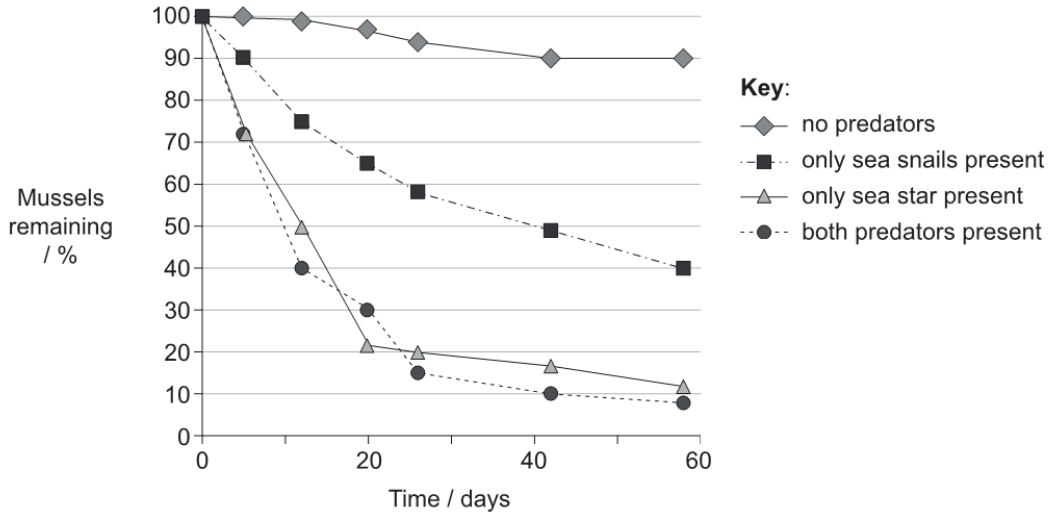
Pisaster ochraceus

[Source: D. Gordon E. Robertson. https://en.wikipedia.org/wiki/Pisaster_ochraceus#/media/File:Ochre_sea_star.jpg]

Mytilus trossulus

[Source: NNehring/iStock]

Groups of 50 mussels were transplanted to an experimental area and protected from predation until the start of the experiment. Researchers then investigated the effect of the predators on the population of the mussels over a period of 60 days.



[Source: Republished with permission of John Wiley and Sons, from Navarrete, S. A. and Menge, B. A. (1996), Keystone Predation and Interaction Strength: Interactive Effects of Predators on Their Main Prey. Ecological Monographs, 66: 409–429. doi:10.2307/2963488; permission conveyed through Copyright Clearance Center, Inc.]

a. Compare and contrast the effects of the predators on the population of the mussels. [2]

b. The sea star also eats the sea snails. Construct a food web to show the feeding relationships between these five organisms in the ecosystem. [2]

Markscheme

a. a. both cause the frequency of the mussel to decrease

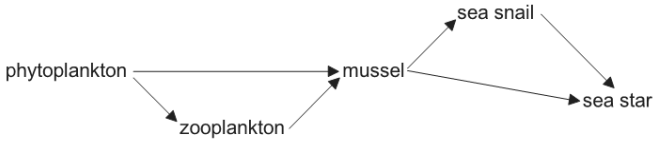
b. sea star affects the mussel population more than the sea snail

c. when both are together the effect of the sea snail is low

Accept binomial names

Allow numerical answers if expressed as comparisons and the candidates are not simply stating numbers

[Max 2 Marks]

b. 

*Award **[2]** for a correct food web*

*Award **[1]** for phytoplankton, zooplankton and mussel with correct arrows*

*Award **[1]** for mussel, sea snail and sea star with correct arrows*

*Award **[0]** if arrows are in wrong direction*

Accept binomial or scientific names

Examiners report

a. [N/A]
b. [N/A]