SL Paper 3

Distinguish between fundamental niches and realized niches.

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

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

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]

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

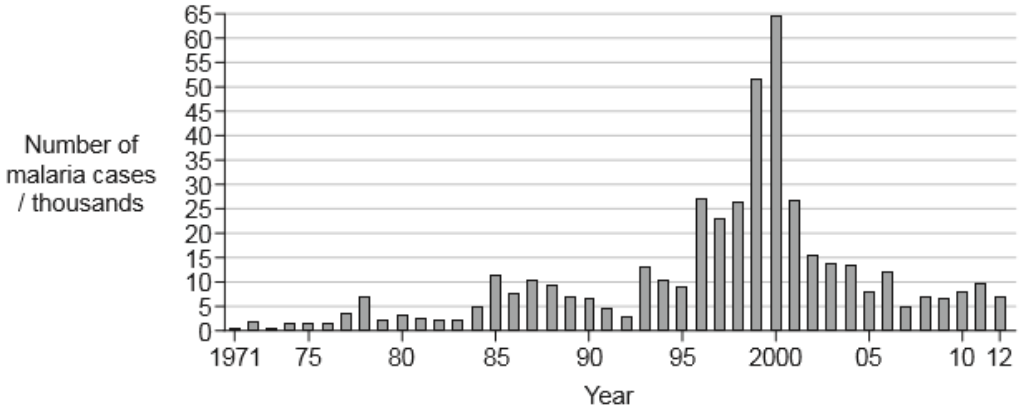
b. State **one** example of biological control of an invasive species. [1]

Invasive species: .....

Biological control: .....

c. Define *biomagnification.* [1]

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]

---

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]

---

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]

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

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

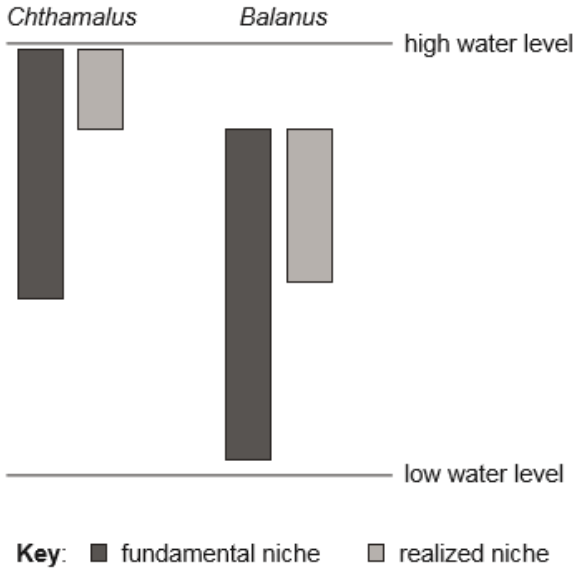
N:

n:

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

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]

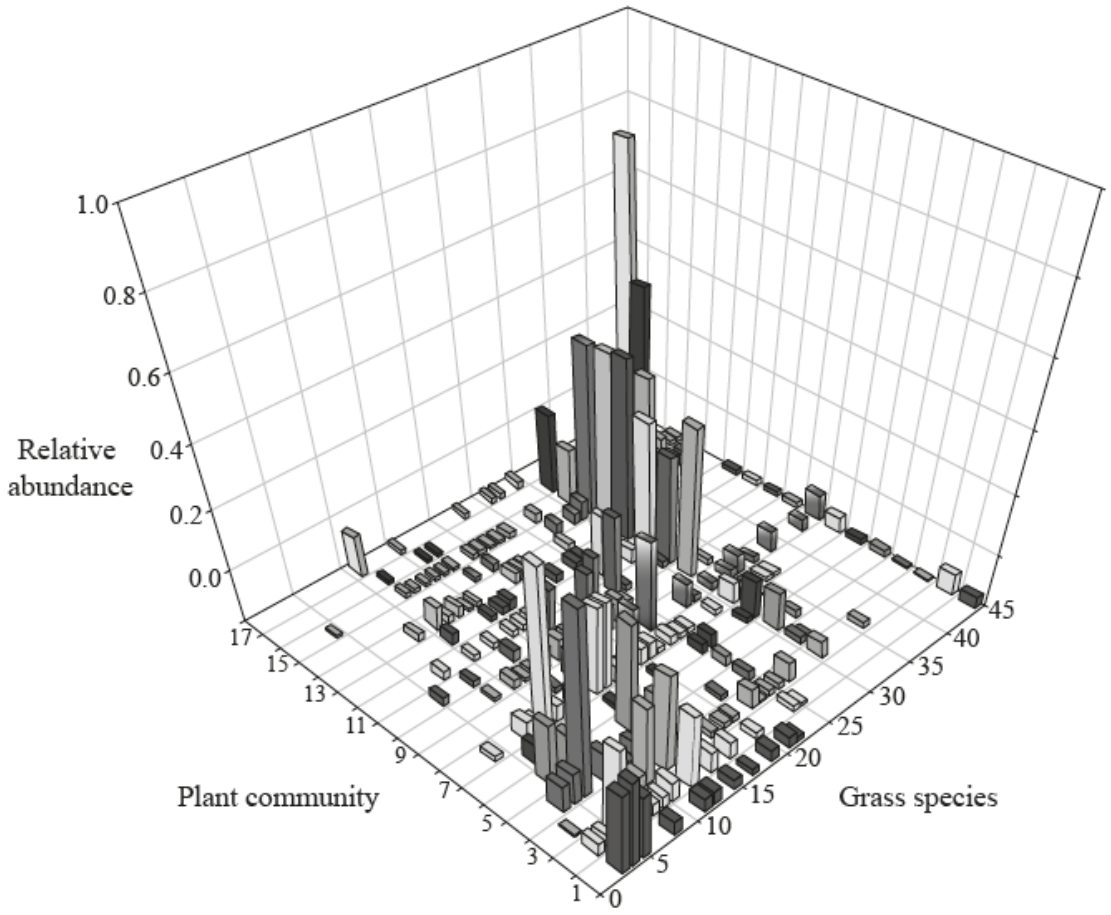
a. Distinguish between a fundamental niche and realized niche. [1]

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]

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]

---

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]

---

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

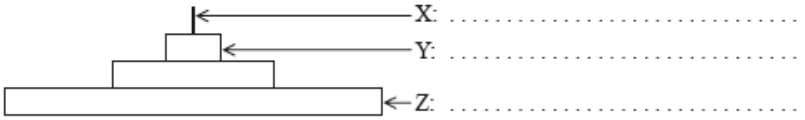
b. Discuss the impact of alien species on ecosystems. [3]

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

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

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

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



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

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]

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

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]

---

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]

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

Temperature:

Territory:

---

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]

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

---

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]

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]

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

Discuss the impacts of a **named** 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]

Discuss the impact of alien species on the environment.

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

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]

---

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]

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

---

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]

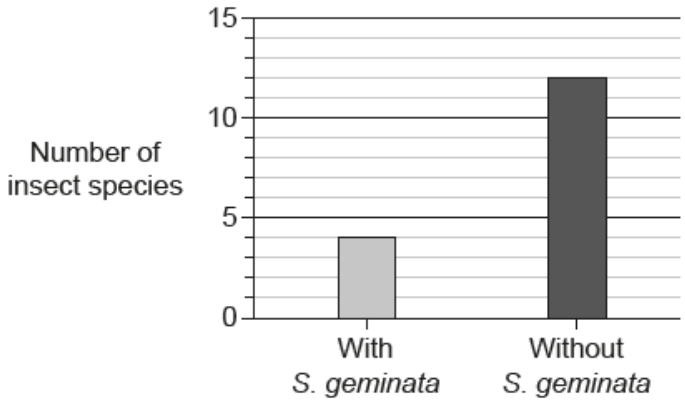
---

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

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

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.



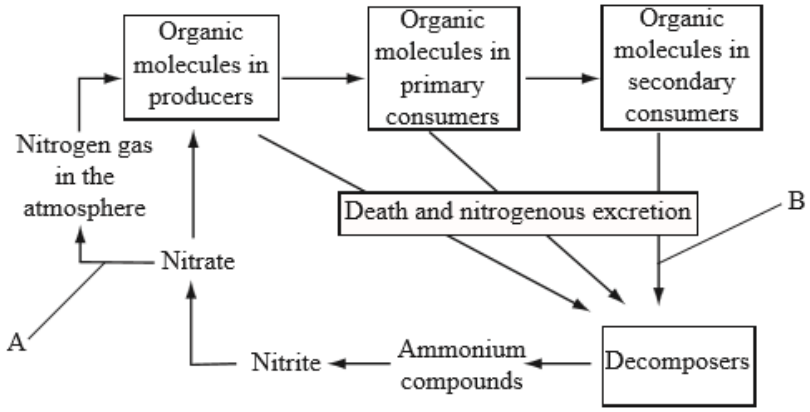
[Source: adapted from Risch and Carroll (1982) *Ecology*, 63, John Wiley & Sons Inc, pages 1979–1983.]

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]

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]

---

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

b. Explain the concept of niche. [2]

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

---

a. Explain the niche concept. [3]

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

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

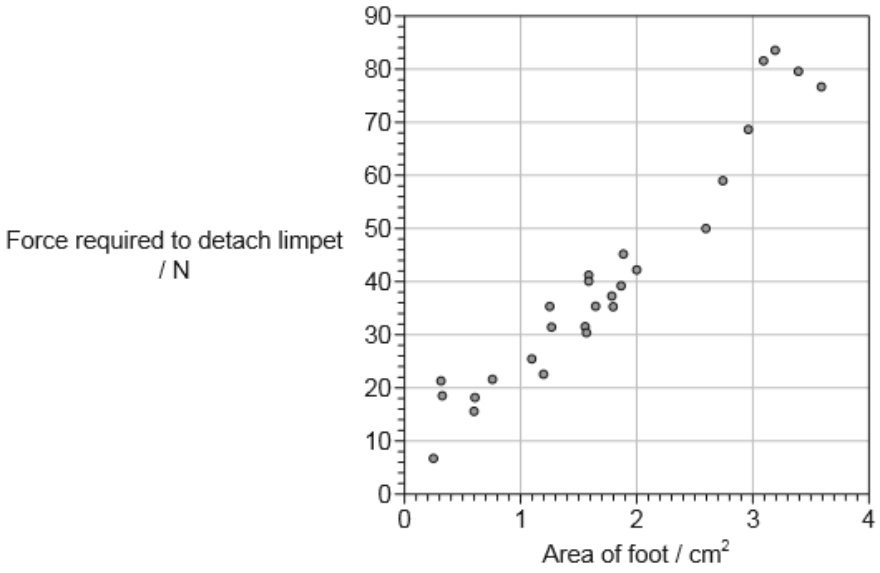
---

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]

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]

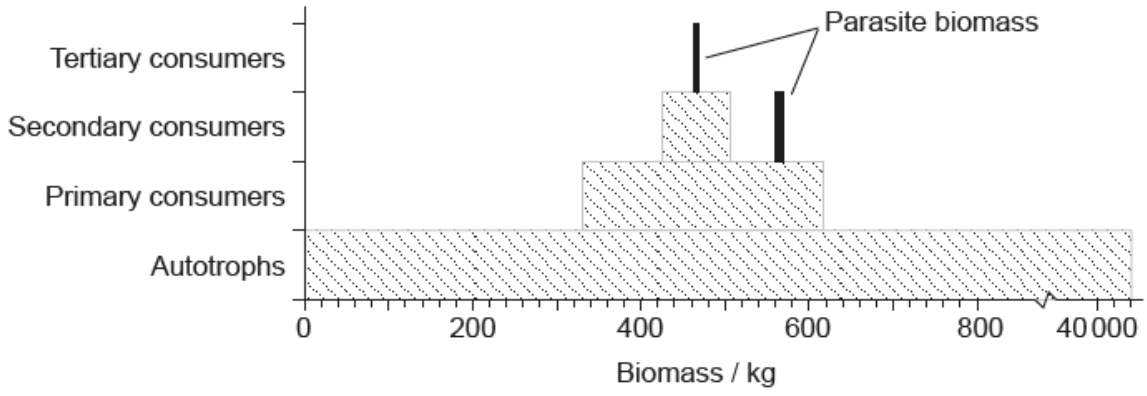
.....cm^2

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]

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.



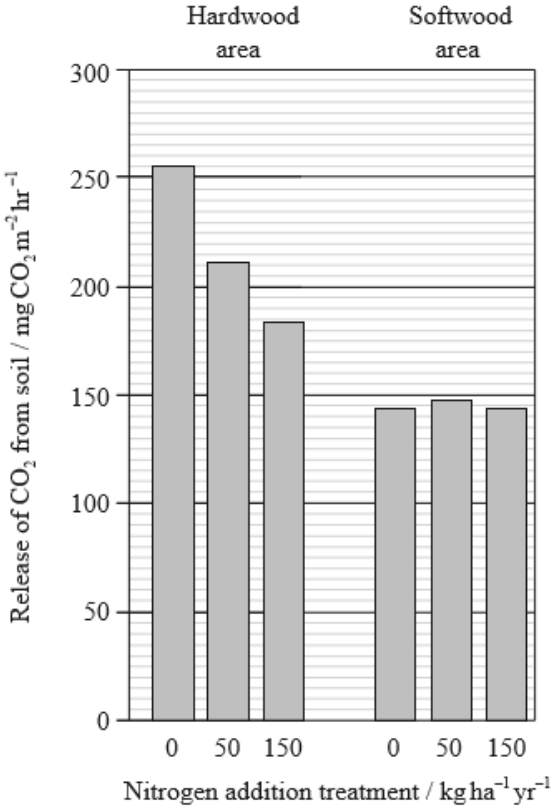
[Source: Michael Sukhdeo (2012) 'Where are the parasites in food webs?' *Parasites & Vectors*, 5, page 239. DOI: 10.1186/1756-3305-5-239]

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]

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]

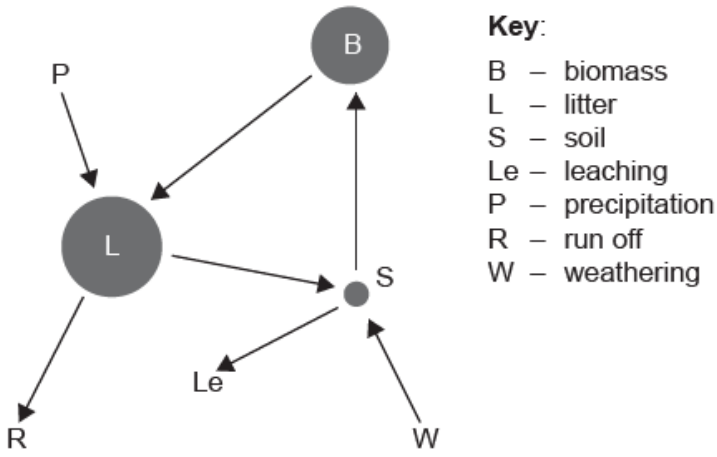
c (ii) Suggest a reason for this relationship. [1]

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

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.

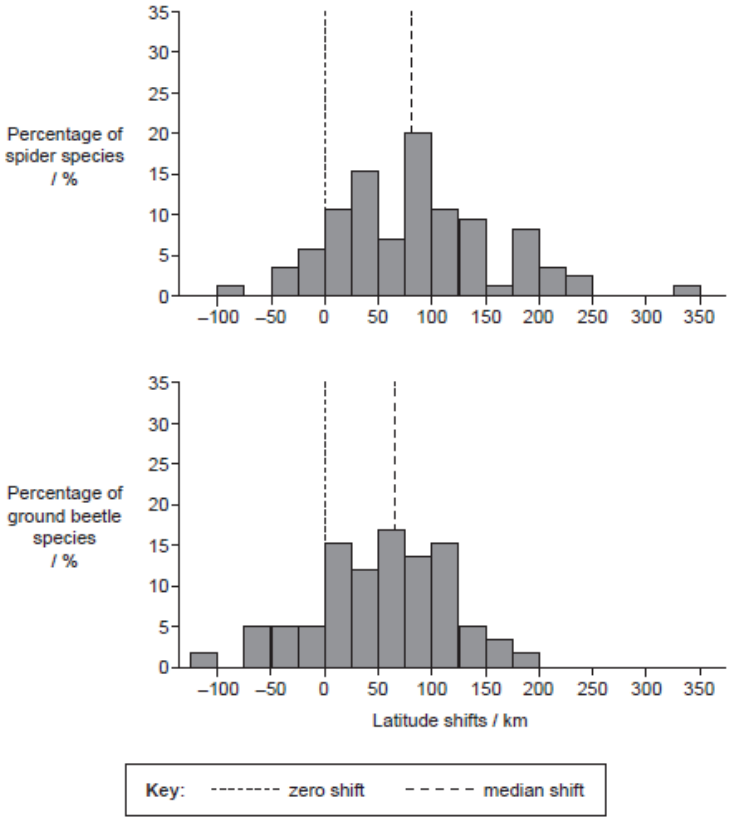
The Gersmehl diagram below shows the movement and storage of nutrients in a taiga ecosystem.



[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.

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]

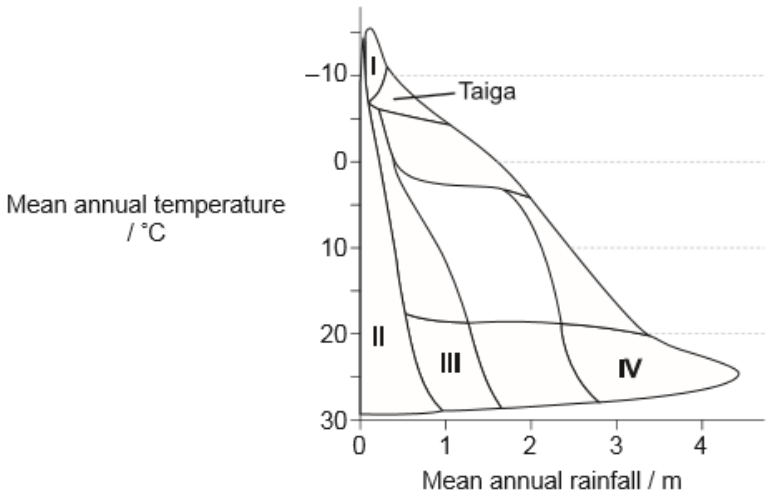
a. State which taxonomic group shows the greatest median shift. [1]

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]

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



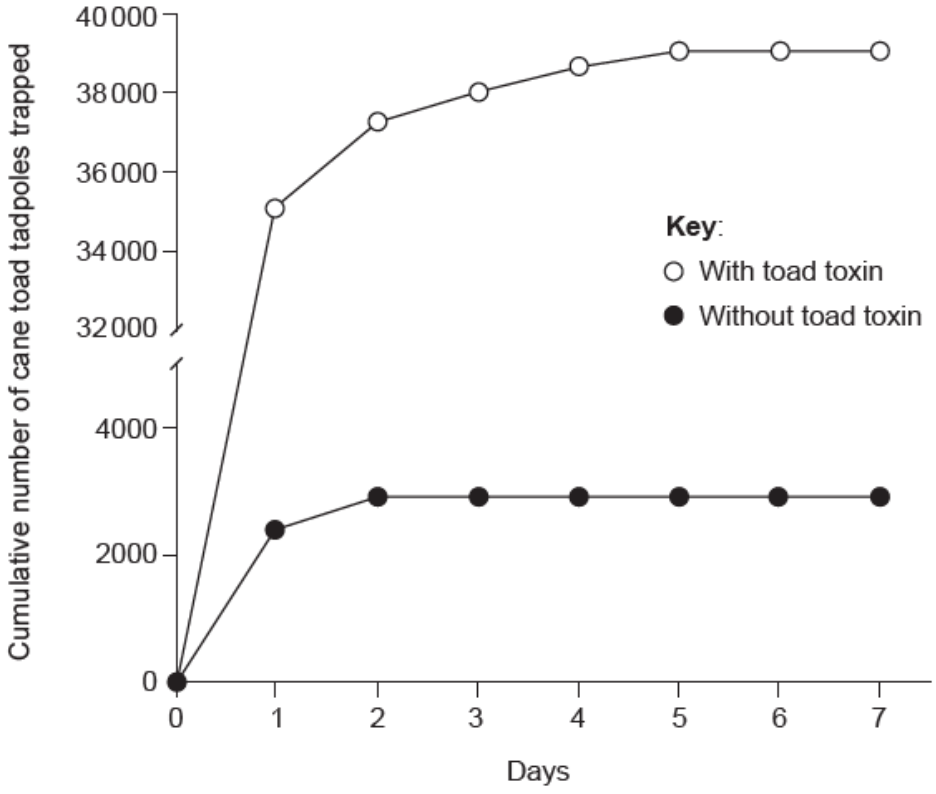
[Source: © International Baccalaureate Organization 2016]

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]

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]

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:

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

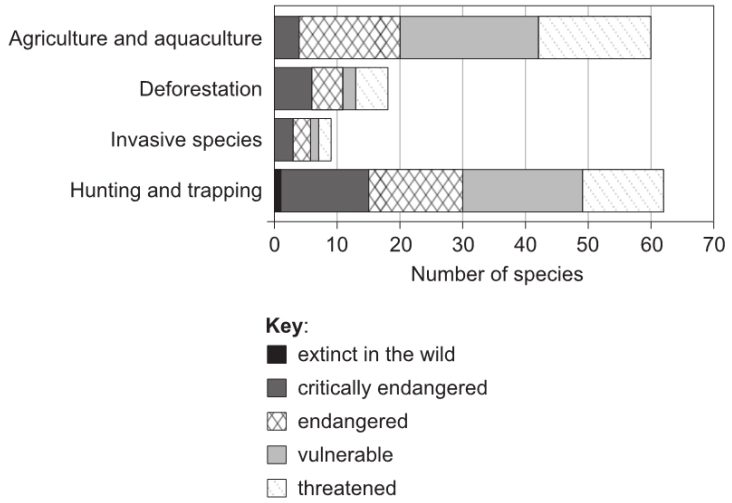
a. Calculate the diversity of site C. Working should be shown. [2]

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]

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]

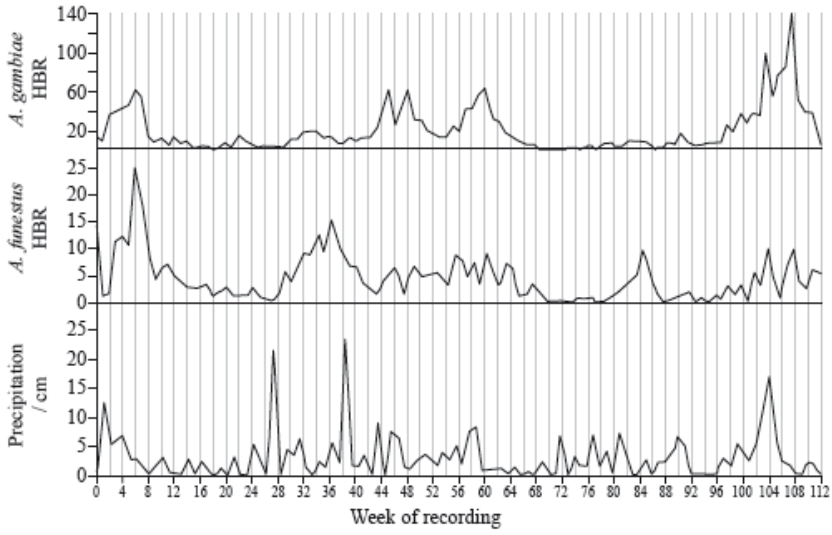
b. State **one** reason mammals can continue to survive even if they are extinct in the wild. [1]

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]

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.

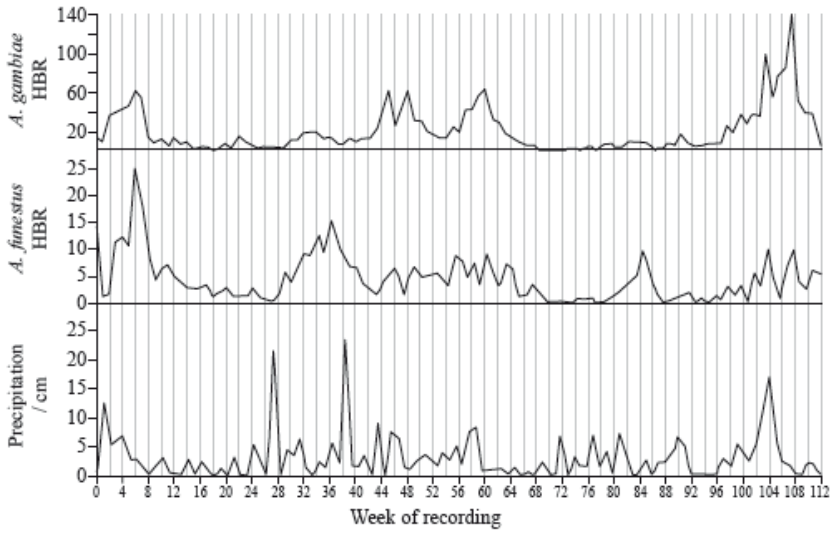


[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

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

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.



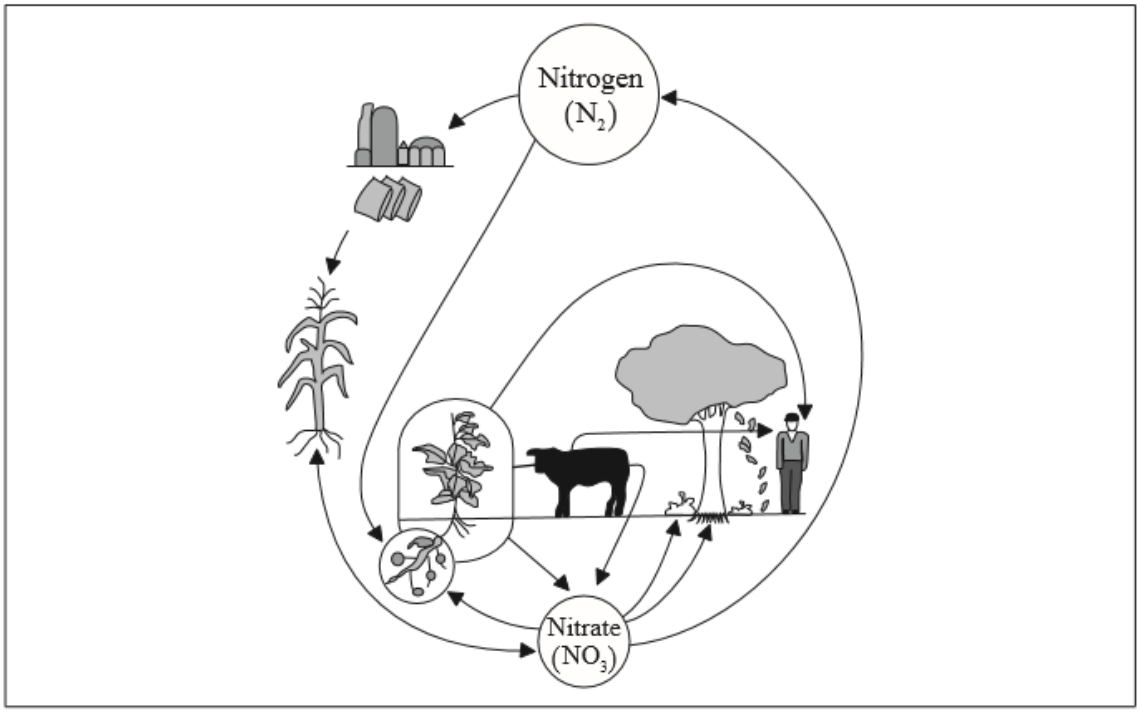
[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

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]

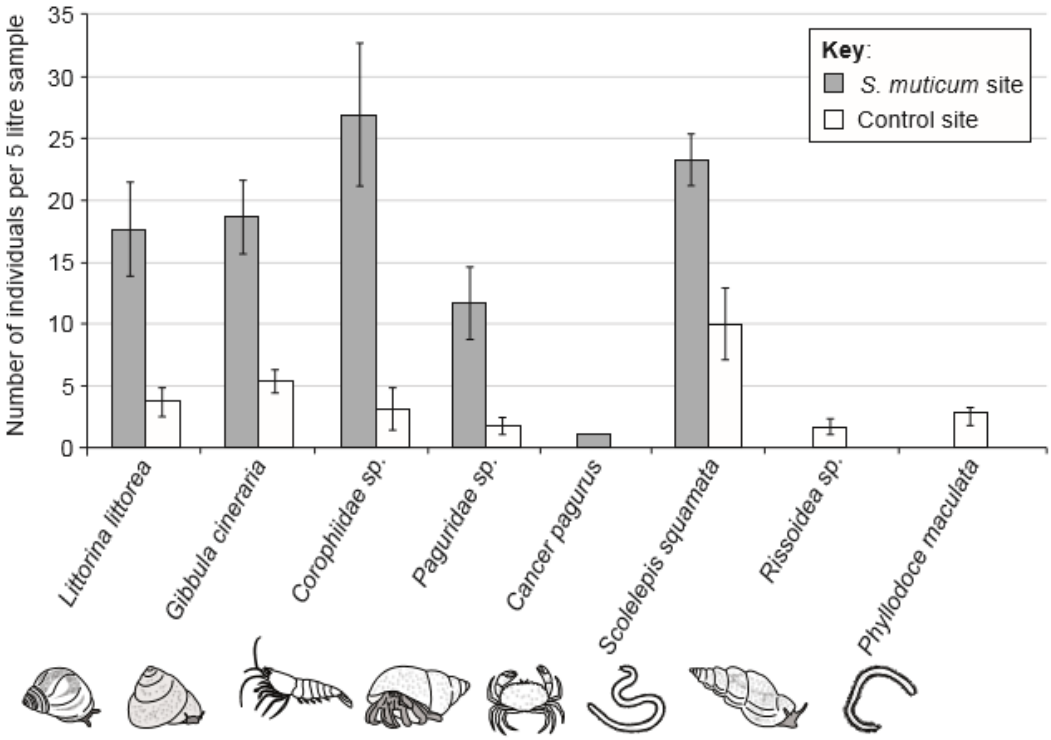
The diagram below shows the nitrogen cycle.



[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.

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]

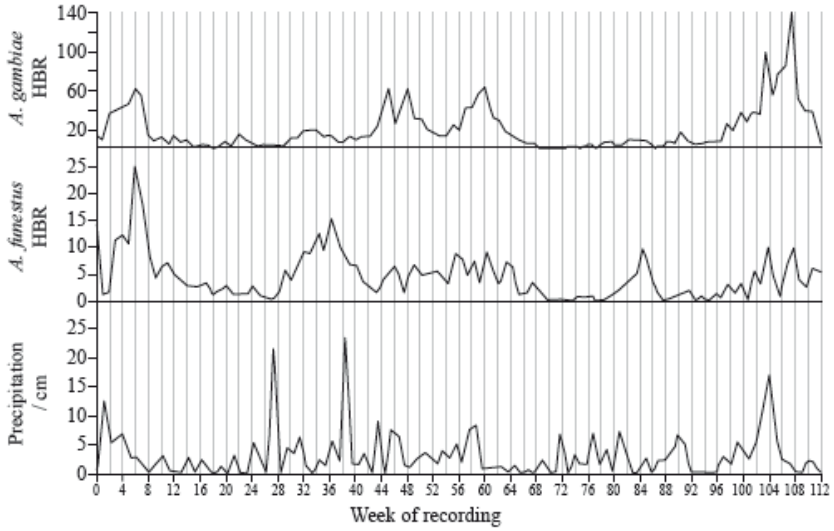
the *S. muticum* site:
the control site:

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]

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.

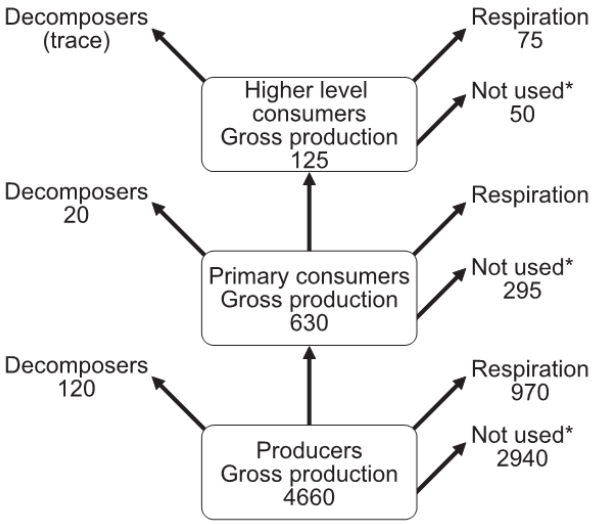
The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[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.

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}.



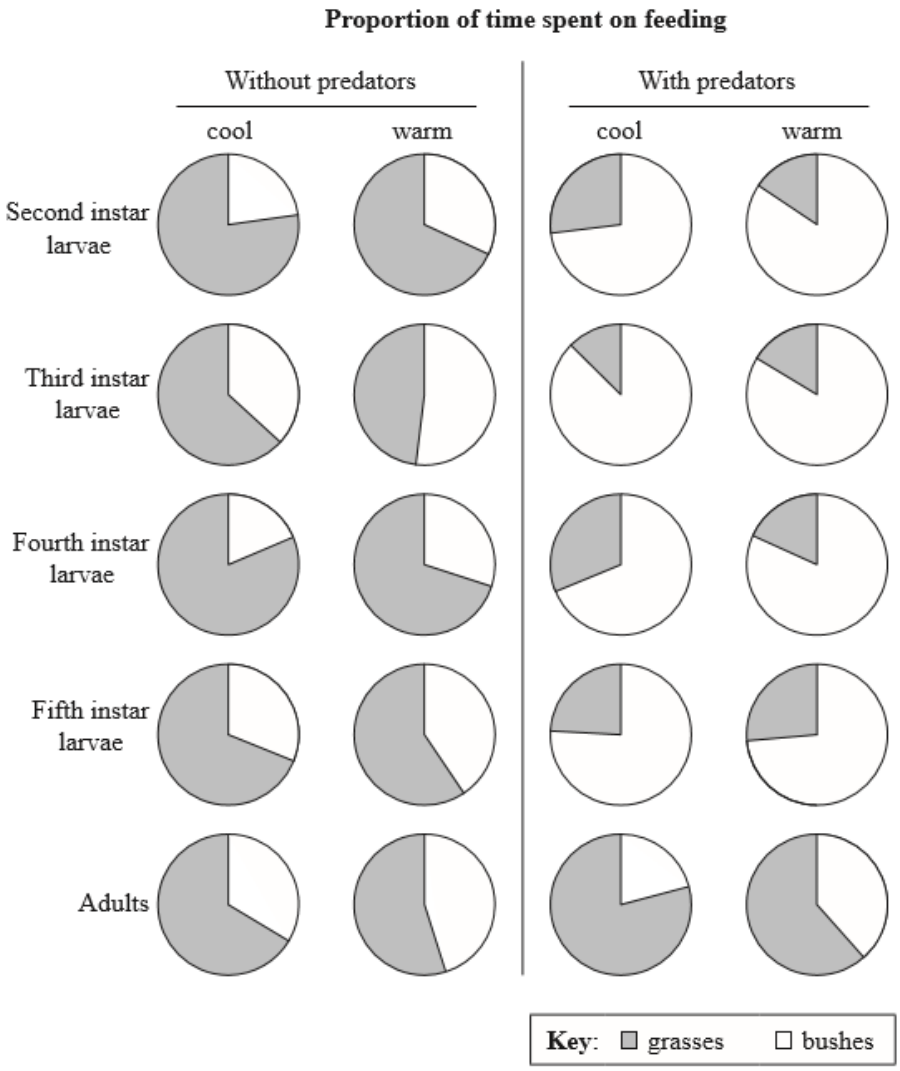
* not used: this refers to organic material sinking to the lake bottom, becoming unavailable to other trophic levels

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]

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]

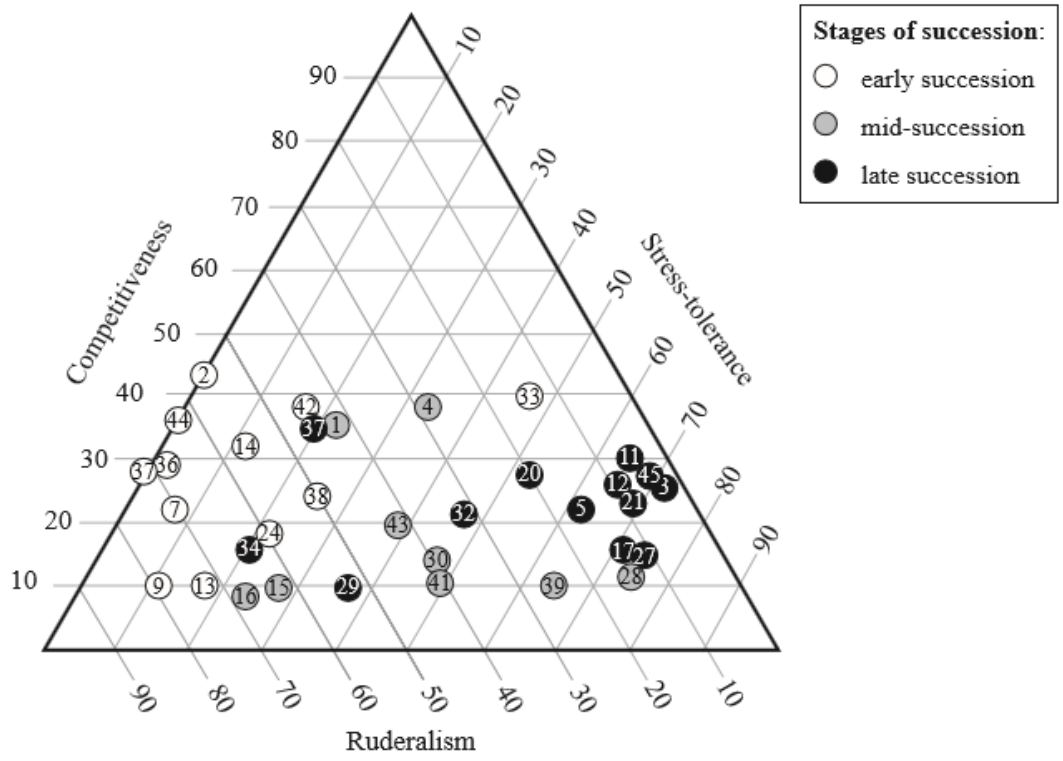
c. Compare adult feeding to instar larval feeding. [2]

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

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]

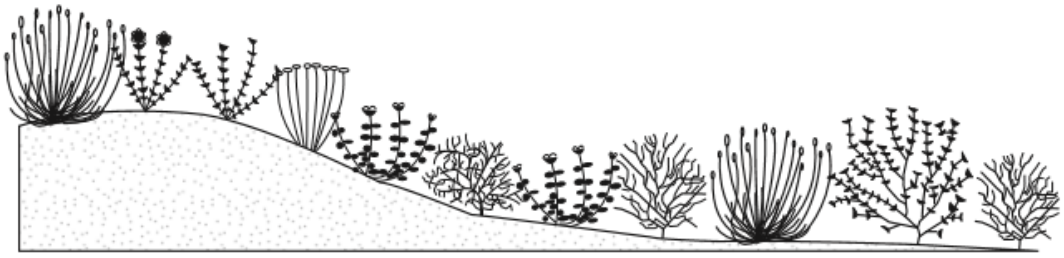
a (ii) Species number 4 has a ruderalism value of 29. State the stress-tolerance value and competitiveness value of this species. [1]

Stress-tolerance value: .....

Competitiveness value: .....

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

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



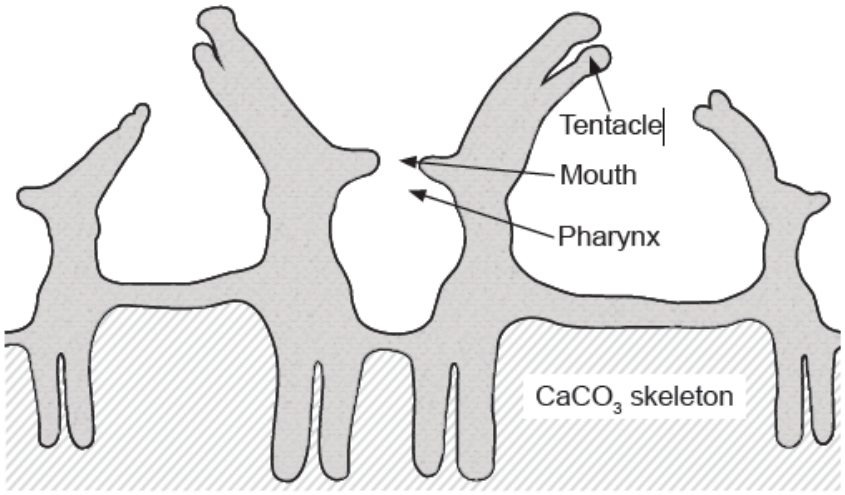
[Source: © International Baccalaureate Organization 2015]

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]

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]

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

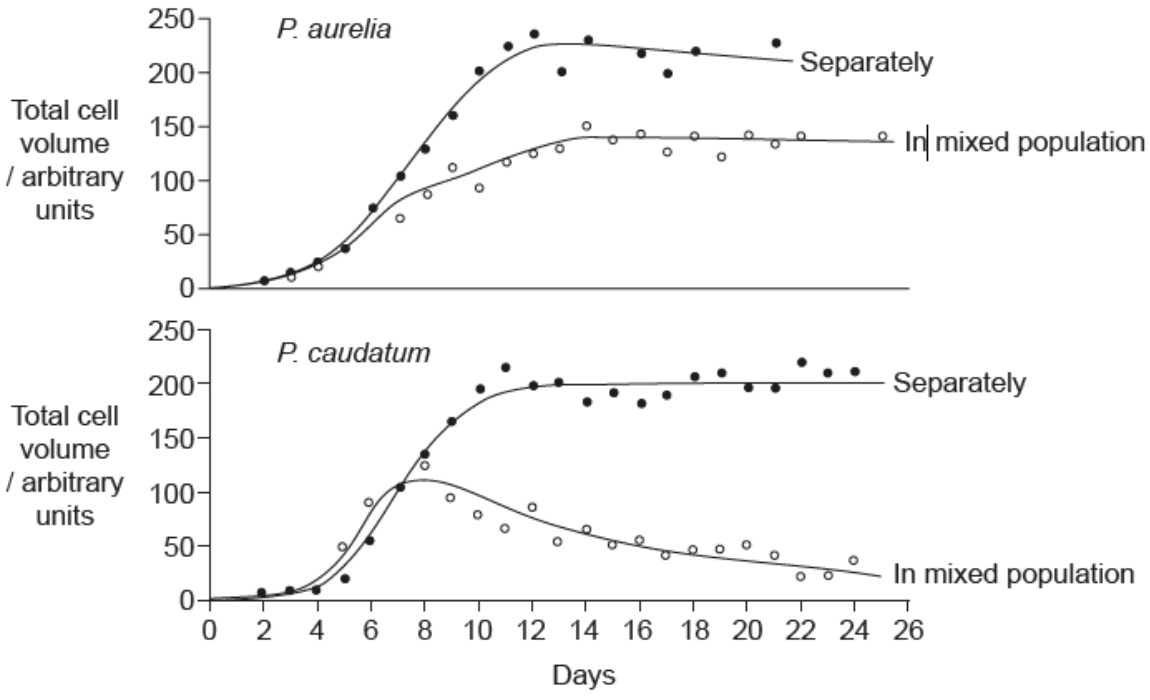
Evaluate these results.

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.

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.

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]

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]

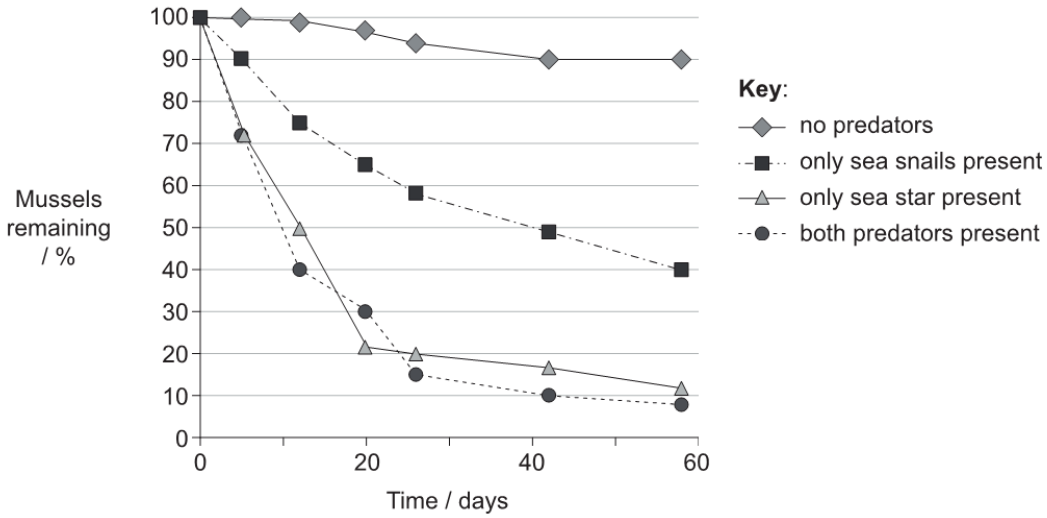
Pisaster ochraceus

[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]