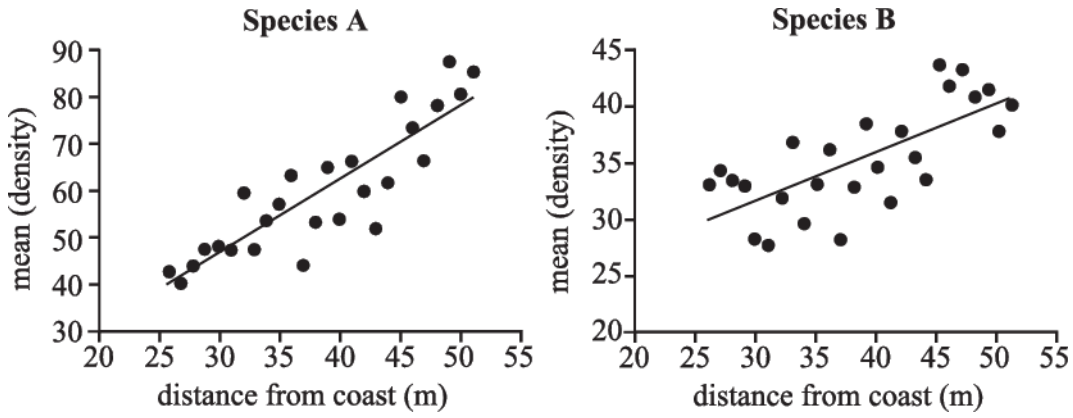
# Ecosystems

**1.** The graphs below show the density of two different plant species as proximity to the coast changes.




Which of the following statements correctly describes one aspect of the technique used to collect these data?

A. Quadrats were randomly placed using a random number generator and coordinates.
B. Larger quadrats were required for **species A** because their mean density was higher.
C. A belt transect has been used to allow calculation of density.
D. Abiotic factors were measured at every point of quadrat sampling.

Your answer ☐

**[1]**

**2.** Deep sea vents on the ocean floor are surrounded by unusual organisms such as chemosynthetic bacteria and eyeless shrimp.

Which of the following statement(s) about these ecosystems is / are true?

**Statement 1:** The temperature of the vents influences the organisms that live there.
**Statement 2:** A predatory octopus would affect the balance of these organisms.
**Statement 3:** The number of eyeless shrimp found at each vent is constant.

A. 1, 2 and 3
B. Only 1 and 2
C. Only 2 and 3
D. Only 1

Your answer ☐

**[1]**

**3.** The list below describes some types of plant found during primary succession on a sand dune.

i. a legume that contains nitrogen fixing bacteria
ii. hardy grasses that can resist desiccation
iii. large mature trees
iv. small herbs that can tolerate salty spray
v. small trees and bushes

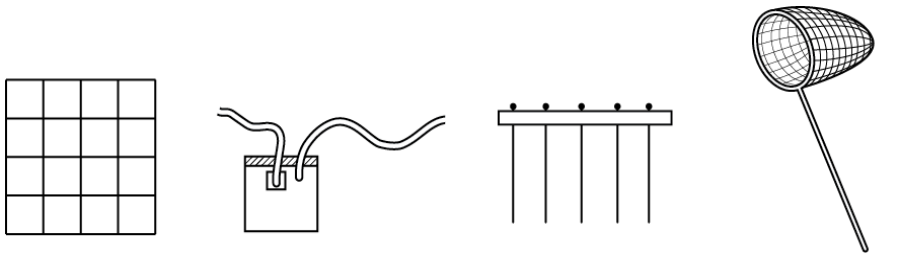
In which order are these plants most likely to grow successfully?

**A** i – ii – iii – iv – v
**B** ii – v – iv – i – iii
**C** ii – iv – i – v – iii
**D** ii – iv – iii – v – i

Your answer ☐

**[1]**

**4.** The images show four pieces of apparatus that could be used to collect data about biodiversity in the field.



frame quadrant **P** | pooter **Q** | point quadrant **R** | sweep net **S**

Which row, **A** to **D**, describes when each piece of apparatus would be used to measure species evenness and richness in a meadow?

| Row | Measuring species richness | Measuring species evenness |
|---|---|---|
| **A** | Q, S | R |
| **B** | P | P, R |
| **C** | P, Q, R, S | P, Q, R, S |
| **D** | P, Q, R, S | P, Q, S |

Your answer ☐

**[1]**

**5.** The first stage of primary succession is the pioneer community.

Which of the following statements about a pioneer community are correct?

1 species produce large numbers of wind-carried seeds or spores
2 biomass is low
3 many species are lichens and mosses

**A** 1, 2 and 3
**B** Only 1 and 2
**C** Only 2 and 3
**D** Only 1

Your answer

**[1]**

**6.** Which of the following statements about ecosystems is **not** true?

**A** An ecosystem is affected by biotic and abiotic factors.
**B** An ecosystem is all of the organisms and habitats in a large area.
**C** An ecosystem is dynamic.
**D** There is a flow of biomass between trophic levels in an ecosystem.

Your answer

**[1]**

**7.** A teacher wrote:

"A garden pond is a dynamic environment that is home to a variety of organisms. The temperature of the pond varies depending on the weather and the time of year, and this affects the populations of the species that live there."

Which of the following terms applies to the teacher's description of the garden pond?

**A** a community
**B** an ecosystem
**C** a habitat
**D** a niche

Your answer

**[1]**

**8.** Ash trees are common throughout the UK. They often grow in dense woodland.

Which of the following, **A** to **D**, is an abiotic factor that is likely to affect the growth of young ash trees?

**A** the availability of light underneath larger trees in the wood
**B** the availability of oxygen in the air
**C** the presence of a pathogen that causes ash dieback disease
**D** the species of bacteria present in the soil

Your answer ☐

**[1]**

**9.** Which of the following bacteria, **A** to **D**, convert ammonium compounds to nitrites?

**A** *Azotobacter*
**B** *Nitrobacter*
**C** *Nitrosomonas*
**D** *Rhizobium*

Your answer ☐

**[1]**

**10.** The nitrogen cycle involves a range of reactions and microorganisms.

Which of the following processes, **A** to **D**, usually occurs under anaerobic conditions?

**A** conversion of amino acids to ammonium compounds
**B** conversion of urea to ammonium compounds
**C** nitrification
**D** nitrogen fixation

Your answer ☐

**[1]**

**11(a).** A student investigated the distribution of buttercups (*Ranunculus bulbosus*) in a field which contained a pond. The student noticed that the buttercups near the pond looked slightly different from those further away. After further investigation the student identified the buttercups near the pond as a different species (*Ranunculus repens*).

i. Describe how the student would use a belt transect to investigate the distribution of the two buttercup species.

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**[3]**

ii. Use the space below to show the format of a results table suitable for recording the results of the student's investigation. (You do not need to include any suggested data.)

**[2]**

**(b).** As the ground dipped towards the pond the soil became obviously wetter. The student thought that the soil moisture might affect the distribution of the two buttercup species.

Suggest **one** biotic factor that might affect the distribution of the buttercups.

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**[1]**

**12(a).** Beavers were hunted to extinction in the UK about 500 years ago. Recently a trial reintroduction in Scotland was hailed as a great success after researchers found that the animals had 'transformed the landscape'. After five years the beavers had:

- constructed dams – the largest of which was 18 m long and 1.6 m high
- felled trees
- created canals
- built lodges (large nests)
- successfully reproduced.

i. Beavers are considered to be a keystone species.

Explain why they are a keystone species in their native Canada.

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---**[2]**

ii. One benefit of the reintroduction of beavers in Scotland was an increase in habitat diversity.

Explain how the following activities could have contributed to increased habitat diversity.

Constructed dams _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Felled trees_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Built lodges_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

**[3]**

iii. Suggest **one** other benefit of the reintroduction of beavers.

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---**[1]**

**(b).** Increasing habitat diversity may lead to an increase in species diversity and genetic diversity.

Explain why species diversity and genetic diversity may be increased as a result of the beavers' activity.

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_____

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_____

_____ **[2]**

**(c).** Some land owners have expressed concern about the impact that beavers can have on rural businesses.

Suggest **two** arguments that may be used by local business leaders against the introduction of beavers. State whether these outweigh the arguments presented by the naturalists.

argument 1 _____

_____

_____

_____

argument 2 _____

_____

_____

_____

**[4]**

**13.** Algae are photosynthetic organisms that live in water.

A rapid increase in the population of algae is known as an algal bloom.

Scientists studied the population of algae in a river in the UK at different times of year. Their results are shown in Fig. 21.1.

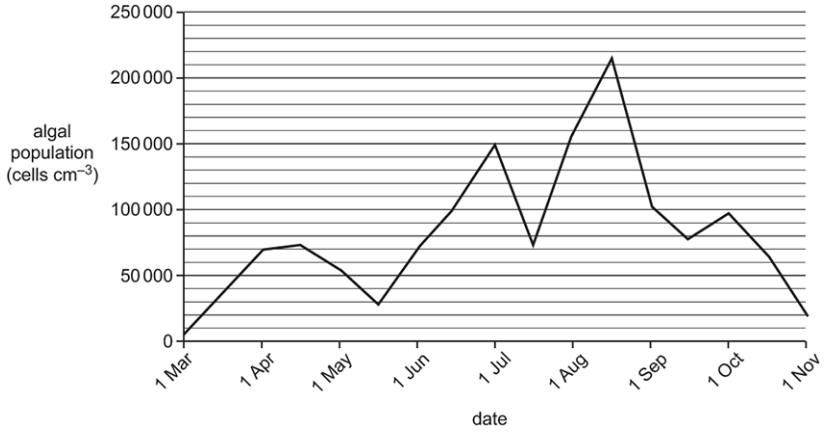


**Fig. 21.1**

i. Calculate the percentage decrease in the population of algae between the peak population and 1 November.

percentage decrease = ..... **[2]**

ii. The river in which the study was conducted is described as a dynamic ecosystem.

Use Fig. 21.1 to explain why this ecosystem could be described as dynamic.

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---**[2]**

iii. A student concluded that the increase in population of algae was due to higher temperatures and higher light intensity in the summer months.

Considering Fig. 21.1 as the student's data source, discuss the weaknesses in this conclusion.

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_____

_____ **[3]**

**14.** This question is about ecosystems in the Southern (Antarctic) Ocean.

Observe the food chain:

phytoplankton (producers) → krill (shrimps etc.) → small fish → large fish → seals

**Table 21.1** shows the transfers of energy and the quantities of energy stored as biomasses for the food chain. Magnitudes are given in kilojoules per square metre of sea surface per year.

| | **Phyto-plankton** | **Krill** | **Small fish** | **Large fish** | **Seals** |
|---|---|---|---|---|---|
| **Energy input, by photosynthesis or feeding ($kJ\ m^{-2}\ y^{-1}$)** | 900 | 80 | 11 | 1.4 | |
| **Energy lost to surroundings by respiration ($kJ\ m^{-2}\ y^{-1}$)** | 180 | 64 | 8.8 | 1.2 | 0.105 |
| **Energy input converted to biomass ($kJ\ m^{-2}\ y^{-1}$)** | 720 | 16 | 2.2 | 0.2 | 0.005 |
| **Biomass energy lost to other consumers or decomposers ($kJ\ m^{-2}\ y^{-1}$)** | 640 | 5 | 0.8 | 0.09 | 0.005 |

**Table 21.1**

i. For larger and less numerous organisms, such as the seal, it is more appropriate to record energy flows per square kilometre.

Calculate the energy input to the seal population from large fish. Record your answer in kilojoules per square **kilometre** of sea surface per year.

**Answer** …… **[2]**

ii. Calculate the percentage of energy stored in large fish biomass converted to energy in seal biomass. Show your working.

**Answer** …… **[2]**

**15.** Many species of bacteria act as decomposers within ecosystems by breaking down organic material.

Scientists analysed the energy flow within a grassland ecosystem.

They estimated that the energy in the decomposers' trophic level was 950 000 J $m^{-2}$ $yr^{-1}$.

The energy within the producers' trophic level was 800% greater than that of the decomposers.

i. Calculate the energy in the producers' trophic level in **kJ $m^{-2}$ $yr^{-1}$**.

Answer: ..... kJ $m^{-2}$ $yr^{-1}$ **[2]**

ii. Calculate the percentage efficiency of the energy transfer from producers to decomposers.

Give your answer to **two** significant figures.

Answer: ..... % **[1]**

**16(a).** The spruce pine plant is given the binomial name *Pinus glabra*.

A scientist sampled the species of trees present in two different habitats containing *Pinus glabra.*

The results of the sampling are shown in Table 5.

| Species | Number of individuals in habitat A | Number of individuals in habitat B |
|---|---|---|
| *P. glabra* | 45 | 60 |
| *M. grandiflora* | 23 | 10 |
| *F. grandiflora* | 55 | 20 |
| *L. styraciflua* | 0 | 10 |
| *L. tulipifera* | 0 | 0 |
| *S. shumardii* | 23 | 4 |

**Table 5**

Using Simpson's Index of Diversity, the scientist calculated the biodiversity (*D*) of Habitat A as 0.71.

Use the formula given to calculate the biodiversity of Habitat B.

Show your working.

State which habitat, A or B, has the greater biodiversity.

$$D = 1 - \left(\Sigma\left(\frac{n}{N}\right)^2\right)$$

*D* (Habitat A) = 0.71

*D* (Habitat B) = .....

Habitat with the greater biodiversity = .....

**[2]**

**(b).** Habitat B was situated beside a lake and showed evidence of ecological succession.

The scientist planned to investigate how the biodiversity changed from the edge of the lake to the other side of habitat B.

i. State the collective name of the animal and plant populations that are present at the end of primary succession.

_____ **[1]**

ii. Suggest how the scientist could achieve the following during their investigation:

Sample all stages of succession in the habitat

_____

_____

Minimise sampling bias

_____

_____

Sample insect biodiversity

_____

_____

**[3]**

iii. The scientist also measured primary production in both the woodland and lake habitats. Suggest the units the scientist should use to measure primary production in the two habitats.

Woodland

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Lake

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**[1]**

**17.** Beet armyworm larvae eat a variety of plants, including tomato plants.

Scientists wanted to investigate how effective a chemical called methyl jasmonate was in stopping beet armyworm larvae from eating plants. They sprayed tomato plants with different concentrations of methyl jasmonate and recorded the final biomass of the plants.

The results are shown in Fig. 5.1.

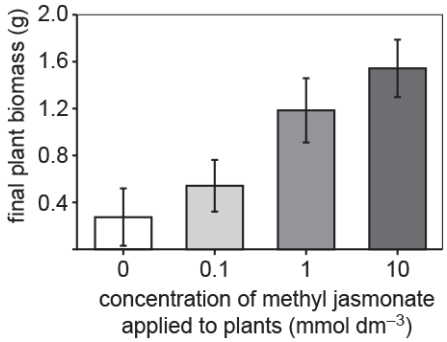


**Fig. 5.1**

The scientists wrote the following hypothesis:
Plants use methyl jasmonate as a defence against herbivory.

i. What additional information do the scientists need to confirm their hypothesis?

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**[2]**

ii. Suggest **one** valid conclusion it is possible for the scientists to draw from the results in Fig. 5.1.

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**[1]**

iii. The scientists also recorded the level of cannibalism amongst the beet armyworm larvae. Cannibalism was measured as the number of beet armyworm larvae eaten by other beet armyworm larvae.

The results are shown in Fig. 5.2.

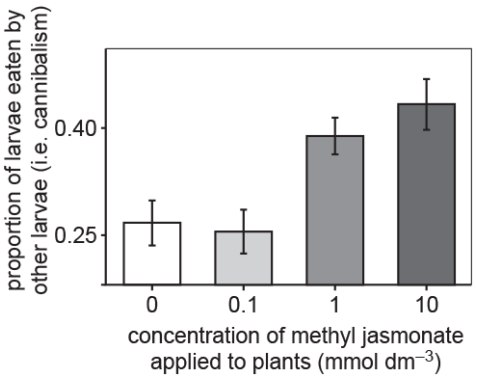


**Fig. 5.2**

Suggest **one** valid conclusion it is possible for the scientists to draw from their results shown in Fig. 5.2.

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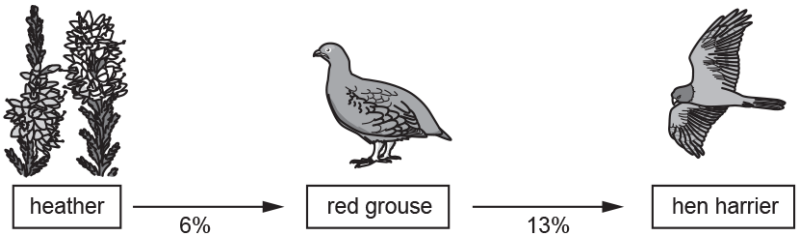
--- **[1]**

**18.** Heather is a plant with a woody stem that grows on upland areas of the UK such as the North York Moors. These areas are often described as heather moorland.

Heather moorland is a habitat that is relatively common in the UK but rare elsewhere in the world.

The diagram shows an example of biomass transfer in a heather moorland ecosystem.




The numbers below the arrows represent the percentage of biomass transferred to the species shown in the next trophic level.

Sunlight that can potentially be used in photosynthesis by green plants such as heather is called photosynthetically active radiation (PAR).

i. In one year, $8.94 \times 10^9$ kJ $m^{-2}$ of PAR fell on an area of heather moorland.

The heather plants then converted $9.08 \times 10^7$ kJ $m^{-2}$ of this energy into biomass.

Calculate the energy in the PAR that the heather did **not** convert into biomass.

Energy = ..... kJ $m^{-2}$ **[2]**

ii. Scientists were able to estimate the increase in biomass in heather plants in one year.

Suggest how the increase in biomass over time in a plant such as heather could be determined experimentally.

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**[1]**

iii. Some of the solar radiation that falls on the leaves of plants is reflected. Some solar radiation is of a wavelength that is not suitable for use in photosynthesis.

List **one** other reason why much of the PAR is not used by the plant in the production of biomass.

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**[1]**

iv. Suggest and explain why the percentage of biomass transferred between heather and grouse is smaller than the percentage of biomass transferred between grouse and hen harrier.

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_____

_____ **[2]**

**19(a).** A small, permanent pond is the habitat for a climax community of producers (aquatic plants and algae) and consumers (bacteria, protoctista, worms, snails, arthropods and small vertebrates like newts and fish).

Why might ecologists call this a 'climax community'?

_____ **[1]**

**(b).** The protoctist *Paramecium caudatum* is usually between 200 and 300 μm in length. An accurate measurement would help in the correct identification of a specimen from this pond.

What laboratory equipment would you select to make an accurate measurement of the length of *Paramecium caudatum*?

_____

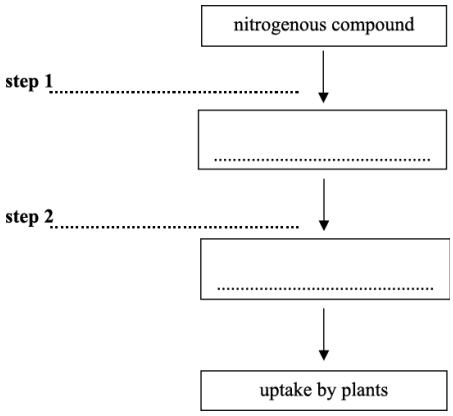
_____ **[2]**

**(c).** An animal fell into the pond. It drowned and decayed. Within a year the biological compounds in its body had been completely recycled.

i. What nitrogenous excretory molecule from the decomposers would pass to the next stage of the nitrogen cycle?

_____ **[1]**

ii. Complete the flow chart to show what happens to this nitrogenous compound, and name the groups of bacteria involved at steps 1 and 2, as it is converted to a form that plants can take up and use.




**[4]**

**20(a).** Nitrogen cycling within ecosystems is controlled by various bacterial species. The table below lists four groups of bacterium that are involved in the nitrogen cycle.

Complete the table to show the locations of each type of bacterium in the cycle and the reactions they perform.

| Type of bacteria | Location | Reactant(s) | Product | Oxidation or reduction of nitrogen? |
|---|---|---|---|---|
| *Rhizobium* | | N2 and $H^+$ ions | $NH_3$ | reduction |
| *Nitrosomonas* | soil | | | oxidation |
| *Nitrobacter* | soil | | $NO_3^-$ | |
| Denitrifying bacteria | | $NO_3^-$ | | |

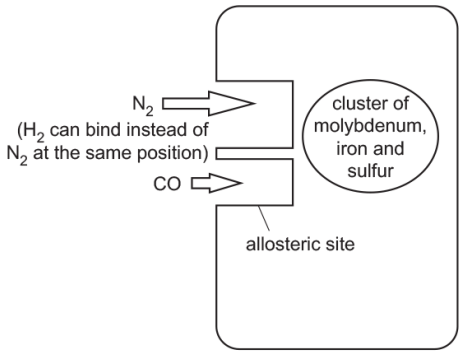
**[4]**

**(b).** Nitrogen fixation is an important part of the nitrogen cycle.

The rate of nitrogen fixation is reduced by the presence of oxygen.

*Rhizobium* uses the enzyme nitrogenase to fix atmospheric nitrogen.

Fig. 4 shows a simplified representation of the structure of nitrogenase and the reaction that it catalyses.




Overall reaction: $N_2 + 8H^+ + 8e^- + 16ATP \rightarrow 2NH_3 + H_2 + 16ADP + 16P_i$

**Fig. 4**

i. What can you conclude from Fig. 4 about the molecules or ions that affect the functioning of the nitrogenase enzyme?

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**[4]**

ii. Leghaemoglobin is a molecule that improves the performance of nitrogenase. It has very similar properties to mammalian haemoglobin.

Suggest **two** ways in which leghaemoglobin improves the performance of the nitrogenase enzyme.

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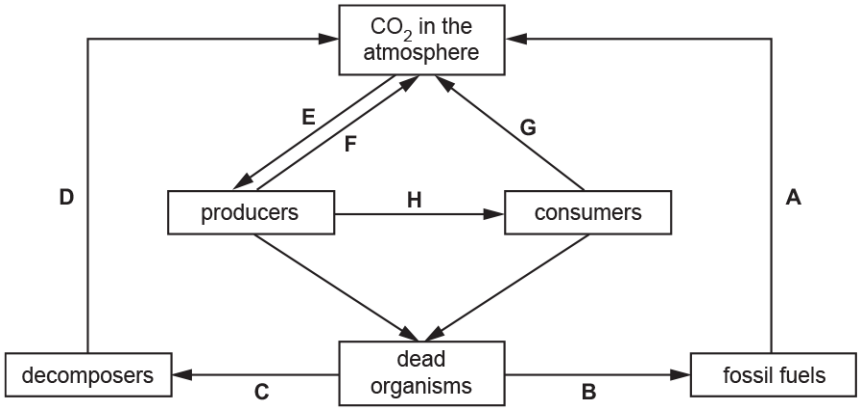
_____ **[2]**

**21(a).** Carbon and nitrogen are elements that are recycled.

The flow chart shows the carbon cycle.




i. Identify the processes occurring at **A** and **F**.

**A** ..... **F** ..... **[2]**

ii. The concentration of carbon dioxide ($CO_2$) in the atmosphere varies depending on the time of year.

Suggest why the concentration of $CO_2$ in the atmosphere increases during the winter months and decreases during the summer months.

_____

_____ **[1]**

**(b).** The nitrogen cycle shares many similarities with the carbon cycle.

Describe the similarities between the nitrogen cycle and the carbon cycle.

**[6]**

**22.** In a newly-available area of land, the communities change over time. The process of change is known as succession.

Outline the process of primary succession **and** explain why heather moorland is an example of deflected succession.

**[6]**

**23.** The Madidi National Park, in the South American rainforest, is home to a wide variety of species. The largest predator in the area is the jaguar. These large cats are well camouflaged and hunt mostly at night. A single individual can cover a very large area.

In 2007 the Wildlife Conservation Society (WCS) attempted to estimate the population of jaguars in the Madidi National Park.

- Digital camera traps were placed in areas that jaguars were likely to visit.
- If an infrared beam was broken by an animal, the camera was activated.
- The camera then took a photograph of the animal.

i. Suggest why it was **not** appropriate to estimate the number of jaguars using the capture-recapture technique.

_____

_____

_____

_____ **[2]**

ii. Most studies estimate the population density of jaguars in the South American rainforest to be 5 individuals per 100 $km^2$.

In the 2007 study:

- 100 camera traps were set up covering an area of 271 $km^2$.
- 28 images of 9 different jaguars were recorded.

How well do these results support a population estimate of 5 individuals per 100 $km^2$?

_____

_____

_____

_____

_____

_____

_____ **[4]**

iii. Other evidence used to estimate the jaguar population includes footprints and reports of sightings by local humans.

Suggest one disadvantage of each of these methods for estimating the size of the jaguar population.

*human sightings*

_____

_____

*footprints*

_____

_____

**24.** Ecologists sampled an area to estimate insect biodiversity.

Two of the insect species that were sampled were the large heath butterfly and the bog hoverfly.

The ecologists used the capture-mark-recapture technique and estimated population sizes using two different calculations: the Lincoln estimate and the Chapman estimate.

i. Calculate the population sizes of the two insect species using each of the formulae below.

Write your answers in the table.

**Lincoln estimate formula:** $$\text{population size} = \frac{n1 \times n2}{m}$$

**Chapman estimate formula:** $$\text{population size} = \left(\frac{(n1 + 1) \times (n2 + 1)}{(m + 1)}\right) - 1$$

$n$ = number of individuals in a particular sample

$m$ = number of marked individuals in the second sample

| Species | Number captured and marked in sample 1 | Total number in sample 2 | Number of marked individuals in sample 2 | Population estimate (number of individuals) | |
|---|---|---|---|---|---|
| | | | | Lincoln estimate | Chapman estimate |
| large heath butterfly | 77 | 73 | 4 | | |
| bog hoverfly | 5 | 6 | 1 | | |

**[2]**

ii. The Lincoln and Chapman formulae give different estimates for population size.

Give **two** further conclusions about the difference in population estimates given by the Lincoln and Chapman formulae.

1 ----------

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2 ----------

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**[2]**