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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

## Ecosystems (10)

### A Level Biology B Topic 10

25 questions · 309 marks · Mark schemes included

*Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025*

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**HOW TO USE THIS BOOKLET**

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

| QUESTION                                          | SOURCE                        | MARKS                           | PAGE      |
|---------------------------------------------------|-------------------------------|---------------------------------|-----------|
| <b>10(a) ECOSYSTEMS AND ENERGY TRANSFER</b>       |                               | <b>8 questions · 105 marks</b>  | <b>3</b>  |
| 1. <b>Q7</b> <i>also Topic 4</i>                  | A Level Paper 2 October 2020  | 11                              | <b>4</b>  |
| 2. <b>Q7</b> <i>also Topic 3</i>                  | A Level Paper 2 November 2021 | 11                              | <b>8</b>  |
| 3. <b>Q9</b>                                      | A Level Paper 2 June 2018     | 13                              | <b>11</b> |
| 4. <b>Q9</b>                                      | A Level Paper 1 October 2020  | 13                              | <b>15</b> |
| 5. <b>Q10</b> <i>also Topic 3</i>                 | A Level Paper 3 June 2022     | 13                              | <b>18</b> |
| 6. <b>Q10</b>                                     | A Level Paper 3 October 2020  | 14                              | <b>20</b> |
| 7. <b>Q9</b>                                      | A Level Paper 2 June 2023     | 15                              | <b>23</b> |
| 8. <b>Q8</b>                                      | A Level Paper 2 June 2025     | 15                              | <b>27</b> |
| <b>10(c) POPULATIONS, SUCCESSION AND SAMPLING</b> |                               | <b>16 questions · 192 marks</b> | <b>31</b> |
| 9. <b>Q8</b>                                      | A Level Paper 2 June 2017     | 9                               | <b>32</b> |
| 10. <b>Q8</b>                                     | A Level Paper 3 June 2025     | 9                               | <b>35</b> |
| 11. <b>Q3</b>                                     | A Level Paper 3 June 2017     | 10                              | <b>39</b> |
| 12. <b>Q8</b>                                     | A Level Paper 2 June 2019     | 10                              | <b>42</b> |
| 13. <b>Q10</b>                                    | A Level Paper 3 November 2021 | 10                              | <b>44</b> |
| 14. <b>Q4</b> <i>also Topic 4</i>                 | A Level Paper 2 June 2023     | 11                              | <b>45</b> |
| 15. <b>Q6</b>                                     | A Level Paper 3 June 2025     | 11                              | <b>49</b> |
| 16. <b>Q6</b> <i>also Topic 4</i>                 | A Level Paper 3 June 2019     | 12                              | <b>52</b> |
| 17. <b>Q8</b> <i>also Topic 4</i>                 | A Level Paper 2 June 2022     | 12                              | <b>55</b> |
| 18. <b>Q7</b> <i>also Topic 9</i>                 | A Level Paper 3 October 2020  | 13                              | <b>58</b> |
| 19. <b>Q7</b> <i>also Topic 4</i>                 | A Level Paper 3 June 2022     | 13                              | <b>61</b> |
| 20. <b>Q7</b>                                     | A Level Paper 3 June 2023     | 13                              | <b>64</b> |
| 21. <b>Q3</b> <i>also Topic 3</i>                 | AS Paper 2 June 2016          | 14                              | <b>70</b> |
| 22. <b>Q4</b> <i>also Topic 5</i>                 | A Level Paper 3 June 2024     | 14                              | <b>74</b> |
| 23. <b>Q8</b>                                     | A Level Paper 3 June 2024     | 14                              | <b>78</b> |
| 24. <b>Q11</b>                                    | A Level Paper 3 June 2023     | 17                              | <b>83</b> |
| <b>10(d) HUMAN IMPACT AND CLIMATE CHANGE</b>      |                               | <b>1 questions · 12 marks</b>   | <b>86</b> |
| 25. <b>Q5</b> <i>also Topic 3</i>                 | A Level Paper 2 June 2024     | 12                              | <b>87</b> |



# QUESTIONS

25 questions · 309 marks · grouped by sub-topic, lowest tariff first



SUB-TOPIC 10(a)

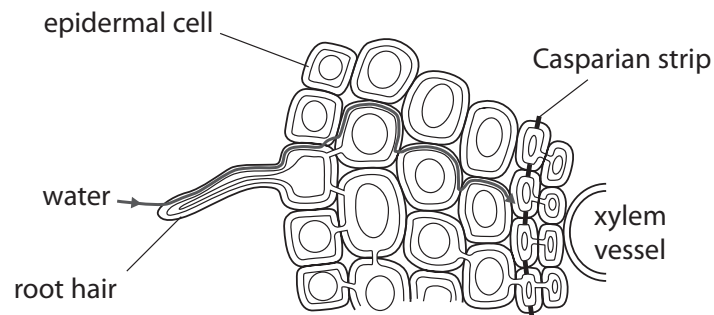
# ECOSYSTEMS AND ENERGY TRANSFER

8 questions in this sub-topic · 105 marks · lowest tariff first



- 7 The primary productivity of plants depends on their ability to synthesise carbohydrates and transport solutes to cells.

(a) The diagram shows the movement of water across a root.



What is the name of the water movement pathway shown in the diagram?

(1)

- ☐ A apoplastic pathway
- ☐ B diffusion pathway
- ☐ C osmotic pathway
- ☐ D symplastic pathway

- (b) Explain how the mass-flow hypothesis accounts for the movement of sugars from leaves to roots.

(4)

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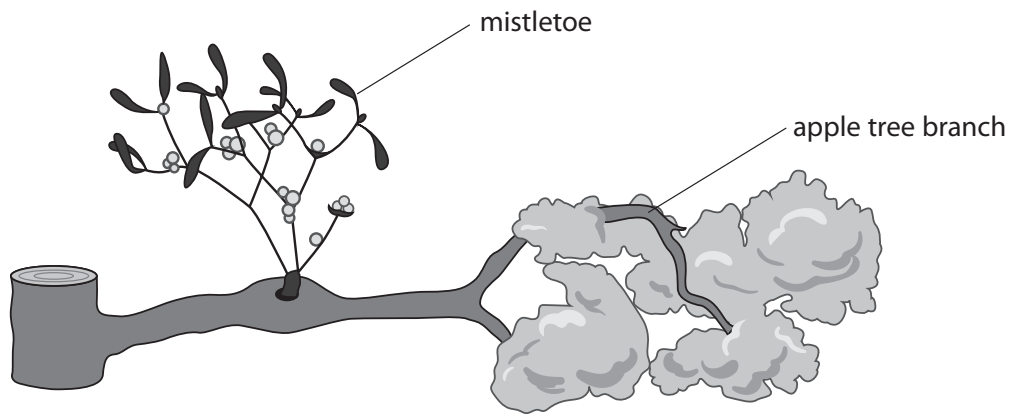
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\*(c) Mistletoe is a plant that is a parasite on trees.

Mistletoe has green leaves. Mistletoe also has a modified root that grows into the xylem of a tree.

The diagram shows mistletoe growing on an apple tree branch.



The effect of mistletoe on the growth of apple trees was investigated.

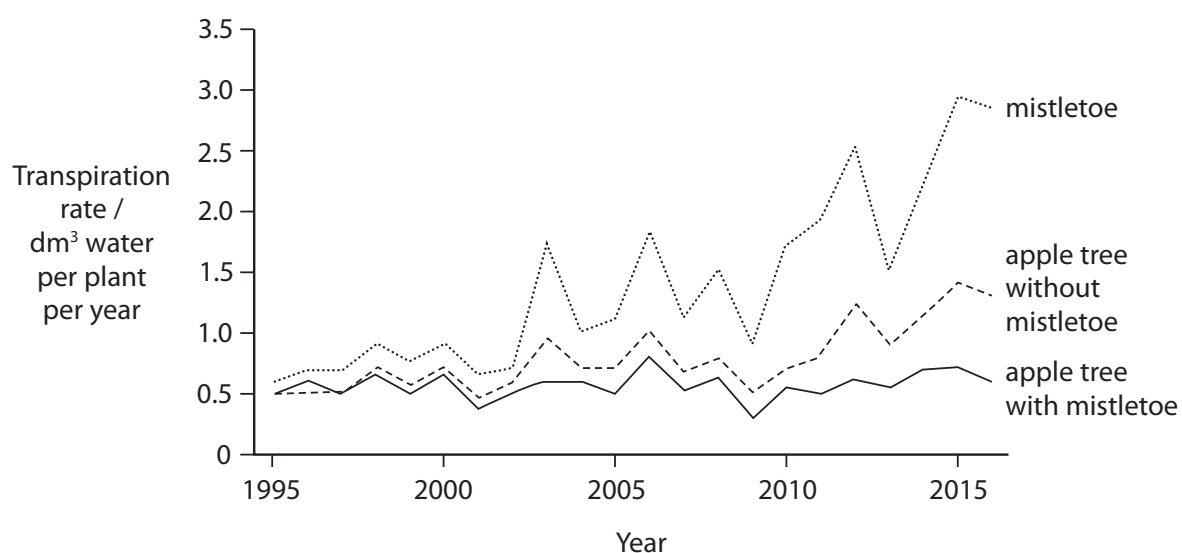
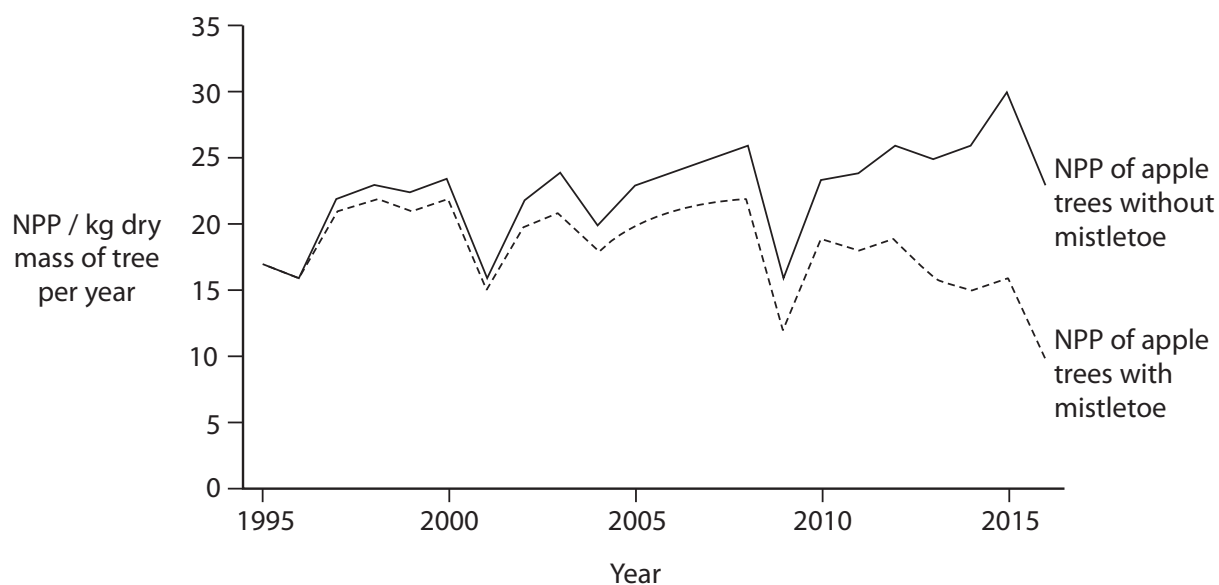
Every year for 20 years, scientists selected apple trees infected with mistletoe and measured the:

- mean net primary productivity (NPP) of the apple trees
- transpiration rate of the apple trees
- transpiration rate of the mistletoe branches on the apple trees

They also determined the mineral content of the apple tree leaves after 20 years.

A control group of apple trees not infected with mistletoe was included in this investigation.

The graphs and table show the results of the investigation.



| Apple tree leaves from            | Nitrogen content / mg per g of leaf | Calcium content / mg per g of leaf |
|-----------------------------------|-------------------------------------|------------------------------------|
| trees infected with mistletoe     | 8.50                                | 6.45                               |
| trees not infected with mistletoe | 10.60                               | 8.90                               |

Analyse the data to explain the effect of mistletoe on the NPP of apple trees.

(6)

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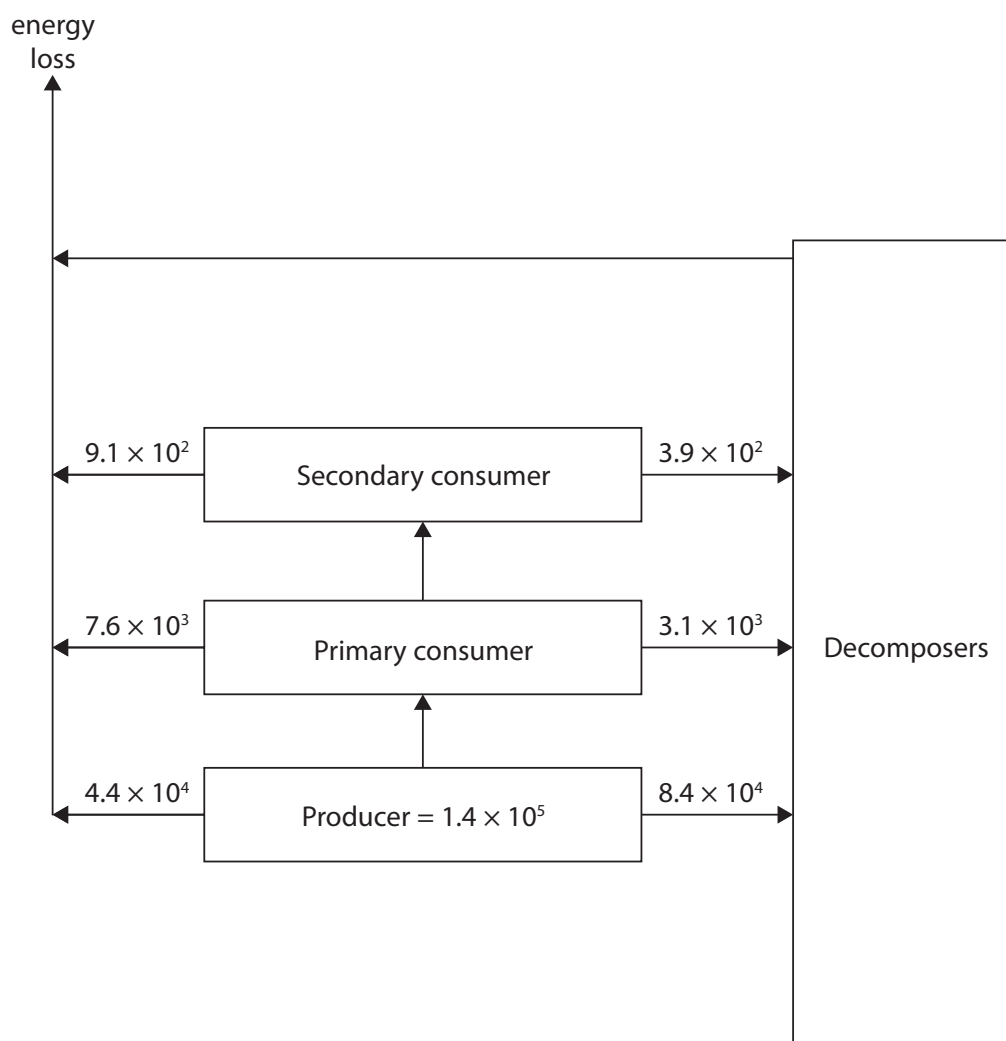
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- 7 (a) (i) The diagram shows the transfer of energy through a grassland food chain.

All values are given in  $\text{kJ m}^{-2} \text{yr}^{-1}$ .



Calculate the percentage efficiency of the energy transfer from the producer to the primary consumer.

(2)

Answer.....



- (ii) Explain the differences in the efficiency of energy transfer between the trophic levels in a food chain.

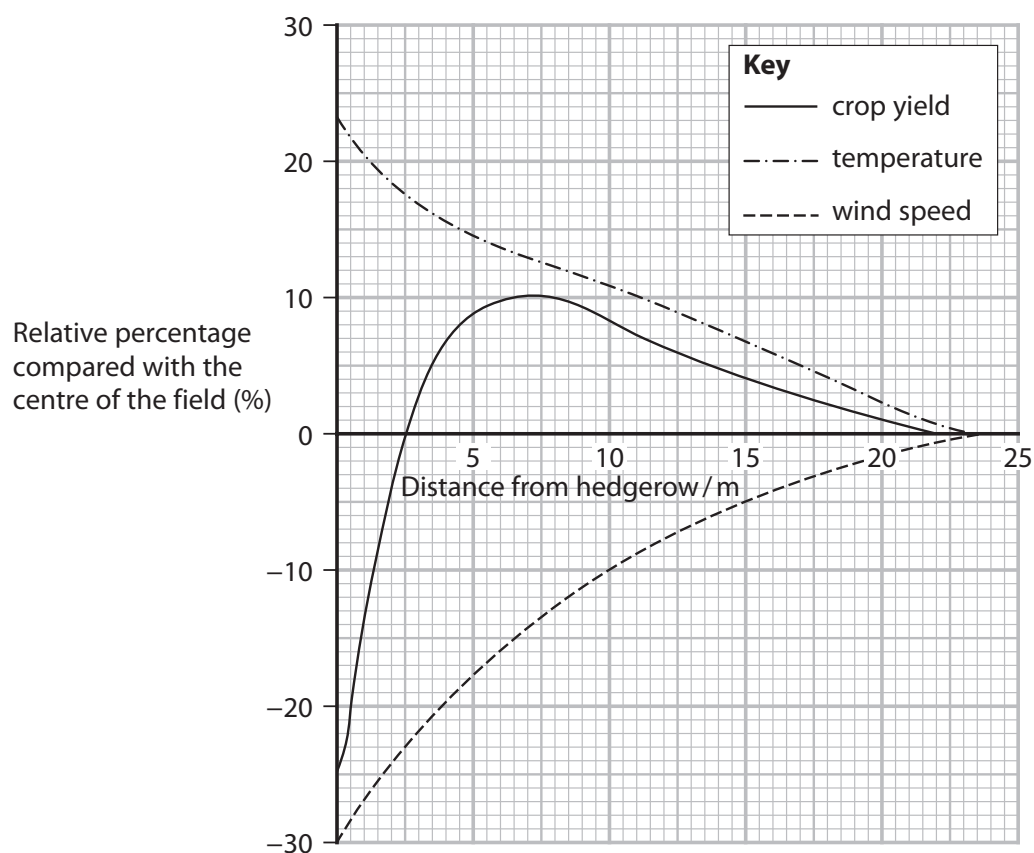
(3)

- \*(b) For many years, hedgerows have been removed to increase field sizes to grow crop plants.

Hedgerows provide a habitat for many species of plants and animals.

Some animals that live in hedgerows eat pests of crops and some pollinate crop plants.

The crop yield, temperature and wind speed were measured across the field starting at the hedge. These factors and the crop yield are shown as a relative percentage compared with the centre of the field in the graph.



Analyse the information to comment on the value of conserving hedges around fields used for growing crops.

(6)

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- 9 The table shows information about one area of the North Atlantic Ocean.

| Month     | Mean hours of daylight / hr | Mean monthly temperature / °C | Net primary productivity (NPP) / g carbon m <sup>-2</sup> day <sup>-1</sup> |
|-----------|-----------------------------|-------------------------------|-----------------------------------------------------------------------------|
| January   | 9.0                         | 2.8                           | −1.0                                                                        |
| February  | 10.0                        | 3.1                           | −1.2                                                                        |
| March     | 11.0                        | 6.7                           | −0.5                                                                        |
| April     | 13.0                        | 9.4                           | +3.0                                                                        |
| May       | 14.0                        | 15.5                          | +4.0                                                                        |
| June      | 15.0                        | 20.6                          | +8.0                                                                        |
| July      | 14.0                        | 23.9                          | +7.0                                                                        |
| August    | 13.5                        | 23.3                          | +7.0                                                                        |
| September | 12.0                        | 21.1                          | +5.0                                                                        |
| October   | 11.0                        | 16.1                          | +4.0                                                                        |
| November  | 10.0                        | 11.1                          | +3.0                                                                        |
| December  | 9.0                         | 4.0                           | −1.2                                                                        |

- (a) (i) State what is meant by the term **net primary productivity** (NPP).

(1)

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- (ii) Analyse the data to explain the effect of daylight and temperature on NPP.

(3)

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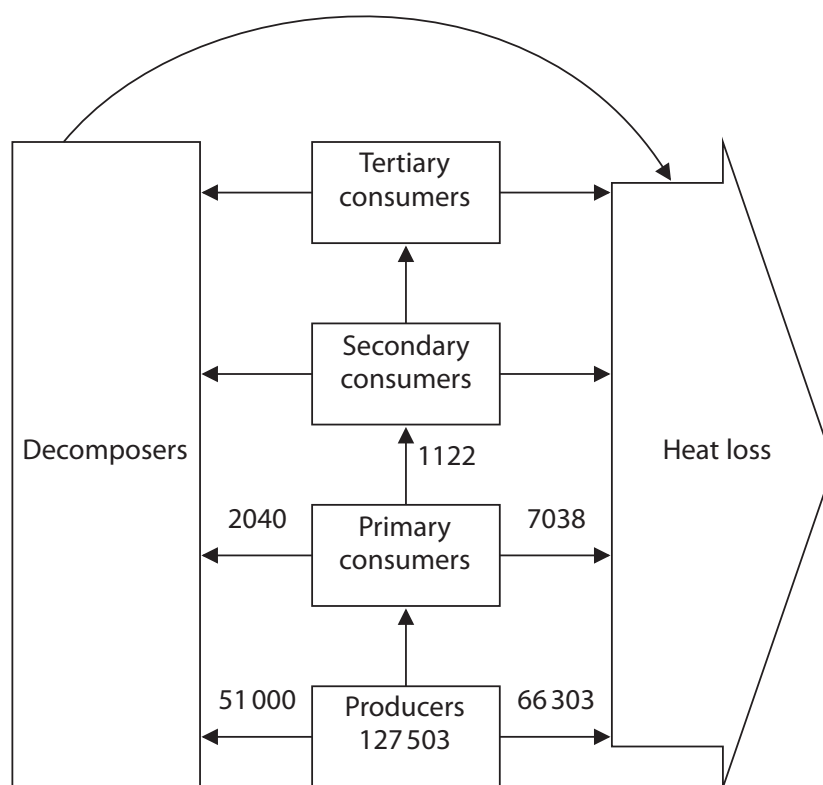
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(b) The diagram shows some of the energy transfers through a food chain from this area.

The figures show the energy transfer in  $\text{kJ m}^{-2} \text{yr}^{-1}$ .



(i) Calculate the percentage efficiency of energy transfer from the producers to the primary consumers.

(2)

Answer .....

- (ii) Explain why the efficiency of energy transfer differs between different trophic levels. (3)

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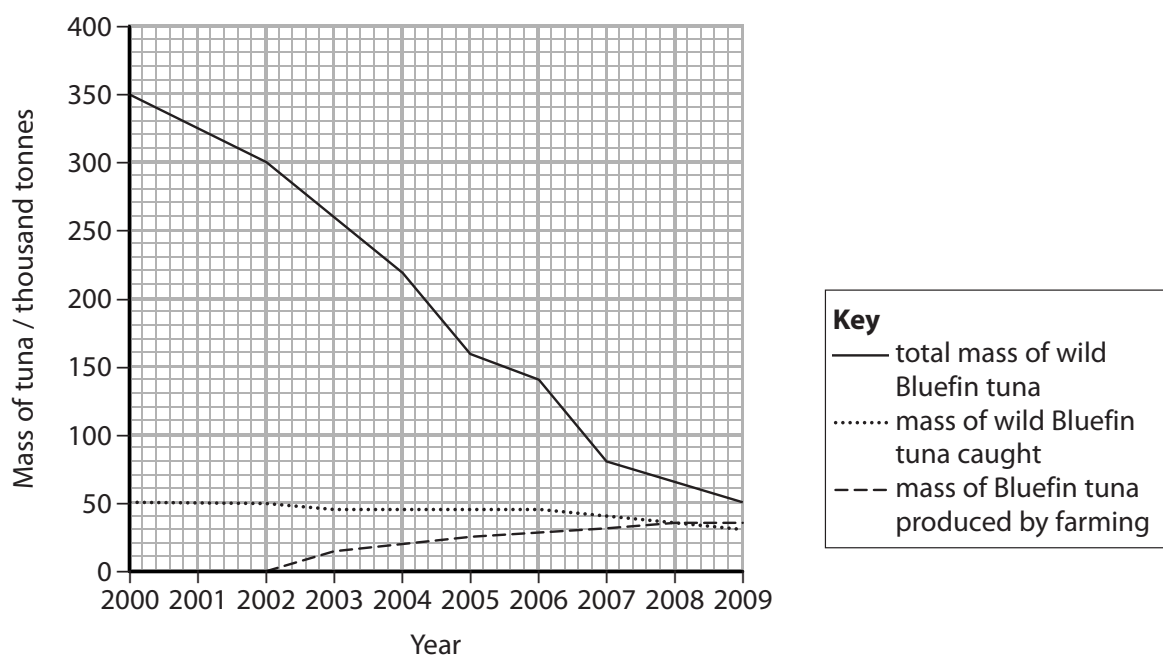
- (c) Bluefin tuna are the top predators in this ocean.

Bluefin tuna are caught by the fishing industry for human consumption. The demand is very high.

One method to help meet the demand for Bluefin tuna is tuna farming.

This method traps young sexually immature fish from the wild. They are placed in submerged cages and fed on a diet of prey species captured from the ocean.

The graph shows the masses of wild Bluefin tuna caught and Bluefin tuna produced by farming. It also shows the total mass of wild Bluefin tuna in an area of the North Atlantic Ocean.



Comment on the impact of Bluefin tuna farming.

(4)

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- 9 The photograph shows a wombat, an animal that lives in dry parts of Australia.



Source: © Blue Gum Pictures/Alamy Stock Photo

Wombats are herbivores, feeding on grasses, leaves and bark. Wombats also dig in the soil for roots.

They have behavioural and physiological adaptations to survive periods of severe drought.

The effect of drought on the health of wild wombats was investigated.

Changes in body mass, body condition and the chemical constituents of stomach contents and faeces were recorded.

These changes were related to the changes in the quality and quantity of the food of wombats.

- (a) Explain why drought affects the quality and quantity of the food of wombats.

(5)

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(b) The table shows some of the measurements made in this investigation.

| Measurement                                               | Before drought | 10 months into drought | 14 months into drought | 2 months after rain |
|-----------------------------------------------------------|----------------|------------------------|------------------------|---------------------|
| Body condition index                                      | .....          | 0.86                   | 0.76                   | 0.85                |
| Body mass / kg                                            | 26.4           | 25.1                   | 21.2                   | 25.2                |
| Organic matter in stomach / g kg <sup>-1</sup> dry matter | 946            | 732                    | 704                    | 822                 |
| Mineral ion content in stomach                            | low            | high                   | high                   | low                 |
| Moisture content of faeces / g kg <sup>-1</sup> wet mass  | 815            | 603                    | 522                    | 748                 |

(i) The body condition was expressed as a body condition index (BCI).

The BCI can be calculated using the formula

$$\text{BCI} = \frac{\text{body mass of wombat}}{\text{mass-for-length of wombat (Y)}}$$

The mass-for-length (Y) of a wombat can be calculated using the formula

$$Y = (\text{body length} \times 0.73) - 34.5$$

A wombat before the drought had a body length of 86.4 cm and a mass of 26.4 kg.

Calculate the BCI of this wombat.

(2)

Answer .....



\*(ii) Analyse the data to explain the results of this investigation.

(6)

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**10** Grassland is an important habitat for grazing animals such as cattle.

(a) Fields used for grazing cattle must have a high gross primary productivity.

State what is meant by the term gross primary productivity and include the units in which it is measured.

(2)

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(b) Cattle graze on the plants on grassland.

Describe what happens to the energy in the plants that are not eaten by cattle.

(2)

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- \*(c) When grazing animals such as cattle, sheep and horses are kept in fields, their faeces are left on the ground, and are known as dung.

The dung is eaten by dung beetles, which in turn are eaten by other animals.

Dung beetles bury dung up to one metre underground in tunnels they have made. This removes the dung from the surface of the field.

A cow can produce over eight tonnes of dung per year.

There are around 60 species of dung beetle in the UK. In 2016, 50% of these were identified as being scarce or threatened.

The photograph shows a dung beetle.



(Source: © Simon Webster/Alamy Stock Photo)

Scientists believe factors causing the decline of dung beetles include:

- farmers using more land to grow crops, and using more land for building and development
- keeping some grazing animals in sheds over the winter, rather than them spending the winter in fields
- fewer habitats for dung beetles, leading to populations of dung beetles becoming isolated and preventing outbreeding
- grazing animals routinely being treated with anti-parasitic drugs that can kill dung beetles.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

(9)

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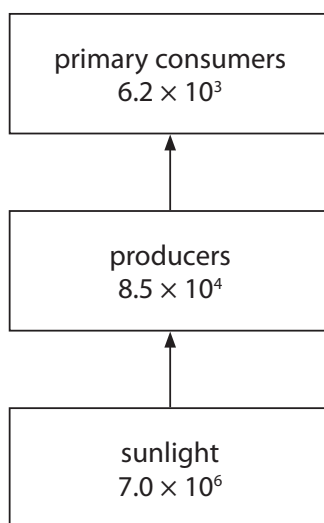
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**10** The diagram shows the flow of energy in an ecosystem.

The numbers represent the energy in  $\text{kJ m}^{-2}\text{yr}^{-1}$  in each category.



- (a) (i) Calculate the percentage efficiency of energy transfer from sunlight to the producers. (2)

Answer ..... %

- (ii) Give one reason why the energy transfer from sunlight to the producers is less than 100% efficient. (1)

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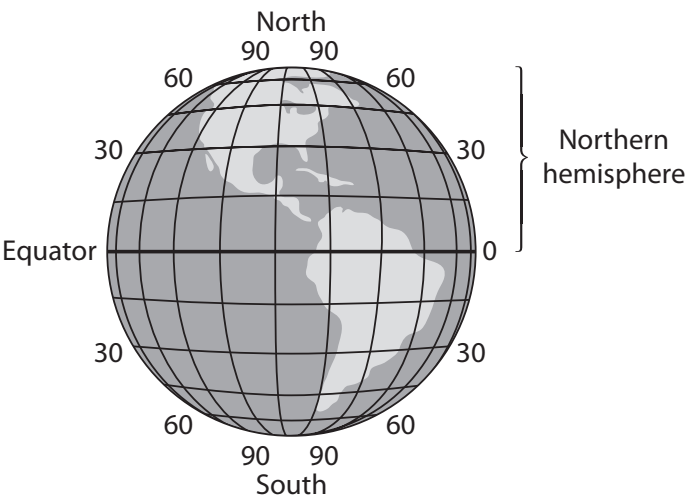
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(iii) Explain the energy difference between the producers and the primary consumers. (2)

(b) Plant productivity is affected by the abiotic and biotic factors that exist at different latitudes.

The diagram shows latitudes of the Earth.



The table shows the productivity of plants growing on land at different latitudes in the Northern hemisphere.

| Latitude / degrees                        | Productivity / g m <sup>-2</sup> yr <sup>-1</sup> |
|-------------------------------------------|---------------------------------------------------|
| 0 to 10<br>(equatorial conditions)        | 900 to 1500                                       |
| 30 to 40<br>(warm temperate conditions)   | 400 to 800                                        |
| 40 to 60<br>(cool temperate conditions)   | 200 to 600                                        |
| 60 to 70<br>(alpine to arctic conditions) | 0 to 200                                          |

A student concluded that primary productivity is determined by abiotic factors that affect the light-dependent and light-independent stages of photosynthesis.

Discuss the validity of this conclusion.

(9)

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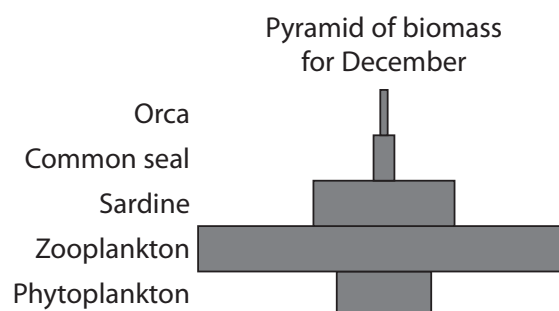
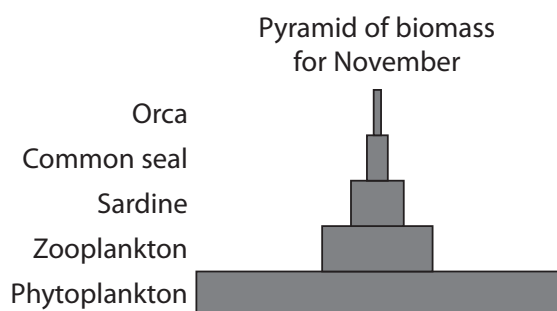
9 Phytoplankton are producer organisms in marine ecosystems.

Zooplankton are small animals that live in the surface waters of the oceans.

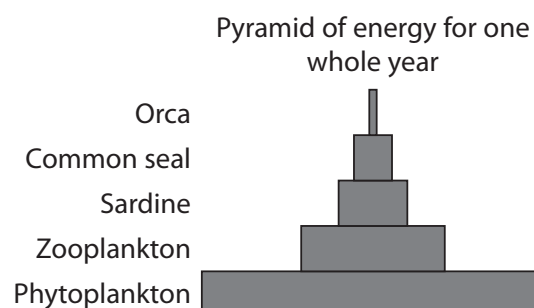
The diagram shows a food chain for the South Atlantic Ocean.

phytoplankton → zooplankton → sardine → common seal → orca

The diagrams below show ecological pyramids for this food chain.



The units for biomass are  $\text{kg m}^{-3}$   
The units for energy are  $\text{kJ m}^{-3} \text{yr}^{-1}$



(a) Comment on the shapes of these three ecological pyramids.

(3)

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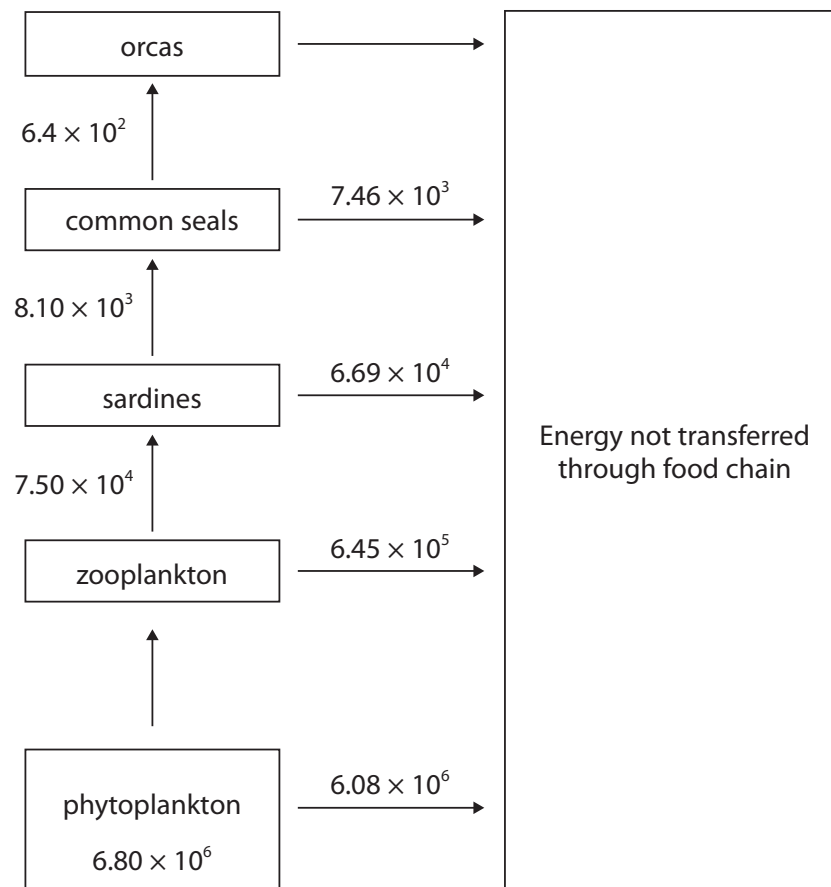
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(b) The diagram shows the flow of energy through this food chain.



All values are measured in  $\text{kJ m}^{-3} \text{yr}^{-1}$

- (i) Calculate the percentage efficiency of energy transfer between the phytoplankton and the zooplankton.

Give your answer to the nearest whole number.

(2)

Answer .....%

- (ii) Common seals and orcas are endotherms.

Sardines are ectotherms.

Explain why the transfer of energy from sardines to orcas is less efficient than the transfer of energy from zooplankton to common seals.

(3)

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- (c) Scientists investigated the impact of global warming on marine productivity.

They determined the effect of temperature and light intensity on the net primary productivity (NPP) of phytoplankton.

Phytoplankton were exposed to different light intensities at three different temperatures for one month. After one month, the scientists measured the increase in dry biomass of phytoplankton.

The results are shown in the table.

| Light intensity<br>/ arbitrary units | Mean increase in dry biomass of phytoplankton / g |      |      |
|--------------------------------------|---------------------------------------------------|------|------|
|                                      | 10°C                                              | 20°C | 30°C |
| 5                                    | 4                                                 | 6    | 2    |
| 10                                   | 8                                                 | 10   | 4    |
| 15                                   | 10                                                | 20   | 15   |
| 20                                   | 12                                                | 24   | 28   |
| 25                                   | 12                                                | 28   | 35   |

- (i) State what is meant by the term net primary productivity (NPP).

(1)

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\*(ii) Some effects of global warming include the following:

- Atmospheric carbon dioxide could cause an increase in temperature.
- Increased atmospheric temperature could increase cloud cover.
- Increased ocean temperature could reduce the movement of nutrients such as nitrates from the seabed to the surface water.
- The scientists concluded that if the use of fossil fuels is not reduced, there will be a fall in populations of orcas in the South Atlantic Oceans.
- Analyse the data in the table and the information given to discuss this conclusion.

(6)

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- 8 The photograph shows a grouse on a heather moor. Heather moors are areas of countryside that are dominated by heather plants.



(Source: © Ben Hall/2020VISION/Nature Picture Library/SCIENCE PHOTO LIBRARY)

Heather moors are habitats for a variety of plants and animals. They are also used for sheep farming and as areas to raise grouse.

The net primary productivity (NPP) of a heather moor decreases with the age of the heather plants.

- (a) Which of the following is the correct formula to calculate NPP?

(1)

- ☐ A  $\text{NPP} = \text{gross primary productivity (GPP)} - \text{respiration}$
- ☐ B  $\text{NPP} = \text{gross primary productivity (GPP)} + \text{respiration}$
- ☐ C  $\text{NPP} = \text{gross primary productivity (GPP)} + \text{photosynthesis}$
- ☐ D  $\text{NPP} = \text{gross primary productivity (GPP)} - \text{photosynthesis}$

- (b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

| Age of heather plant / years | Rank of age of heather plant | Ratio of leaf area : woody stem area | Rank of leaf area : woody stem area | d    | d <sup>2</sup> |
|------------------------------|------------------------------|--------------------------------------|-------------------------------------|------|----------------|
| 16                           | 4                            | 0.7                                  | 4.5                                 | −0.5 | 0.25           |
| 15                           | 5                            | 0.4                                  | 8                                   | −3   | 9              |
| 12                           | 6                            | 0.6                                  | 6                                   | 0    | 0              |
| 4                            | 9                            | 2.0                                  | 1                                   | 8    | 64             |
| 7                            | 8                            | 1.1                                  |                                     | 5.5  | 30.25          |
| 22                           | 1                            | 0.2                                  | 10                                  | −9   | 81             |
| 20                           | 2                            | 0.3                                  | 9                                   | −7   | 49             |
| 3                            | 10                           | 1.1                                  |                                     |      |                |
| 17                           | 3                            | 0.5                                  | 7                                   | −4   | 16             |
| 11                           | 7                            | 0.7                                  | 4.5                                 | 2.5  | 6.25           |

- (i) Calculate the missing values to complete the table.  
Write your answers in the table.

(2)

- (ii) Calculate the Spearman's rank correlation coefficient for the data in the table.  
Use the formula

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

(3)

Answer .....



(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

| n  | Level of significance |            |
|----|-----------------------|------------|
|    | $P = 0.05$            | $P = 0.01$ |
| 5  | 1.000                 | –          |
| 6  | 0.886                 | 1.000      |
| 7  | 0.786                 | 0.929      |
| 8  | 0.738                 | 0.881      |
| 9  | 0.700                 | 0.833      |
| 10 | 0.648                 | 0.794      |
| 11 | 0.618                 | 0.755      |

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

- \*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

Several factors have to be considered before a decision on rewilding is made.

- The heather moors are areas of peat containing dead organic waste that decomposes very slowly.
- Heather moors are an area of income for farmers.
- Over time, heather becomes very dominant and lies flat over the ground, blocking light.
- A variety of small species of plants live around areas of older heather.
- Heather seeds need to be heated to germinate efficiently.
- Some endangered species consume grouse.
- Grouse are raised by humans for profit.
- Heather moors have been managed for many years and many species that lived in the area are now extinct.

Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

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SUB-TOPIC 10(c)

# POPULATIONS, SUCCESSION AND SAMPLING

16 questions in this sub-topic · 192 marks · lowest tariff first

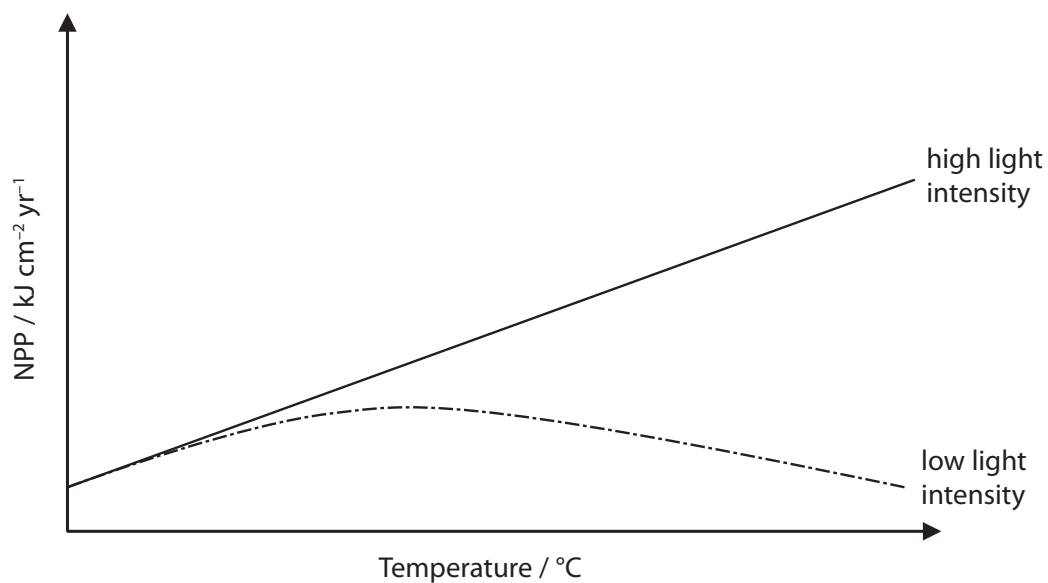


- 8 The effects of light intensity and temperature on the net primary productivity (NPP) of young willow trees were investigated.

Young willow trees were grown in two greenhouses: one with high light intensity and one with low light intensity.

In each greenhouse, groups of these willow trees were kept at different temperatures for six months.

The results are shown in the graph.



- (a) (i) State what is meant by the term net primary productivity.

(1)

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- (ii) Explain why temperature has different effects on NPP at these two light intensities.

(2)

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\*(b) In a further investigation, succession was monitored for fifty years in an abandoned field.

The field was originally used to grow crops.

After fifty years, large numbers of coniferous trees were growing in the field.

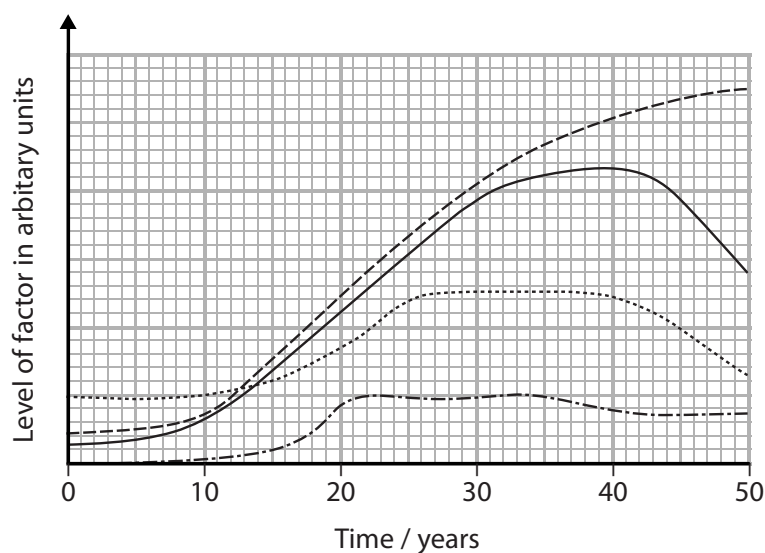
These coniferous trees do not shed many leaves.

When compared with younger trees, older coniferous trees have a much higher proportion of tree stem, branches and roots and a lower proportion of leaves.

The following factors were monitored:

- plant biomass
- NPP
- mineral ion content of soil
- index of diversity of animals

The line graphs show the trends that happened over fifty years for each of the factors.



#### Key

- plant biomass
- NPP
- ..... mineral ion content of soil
- · - · index of diversity of animals

Analyse the data to explain how succession is linked to the changes in this abandoned field.

(6)

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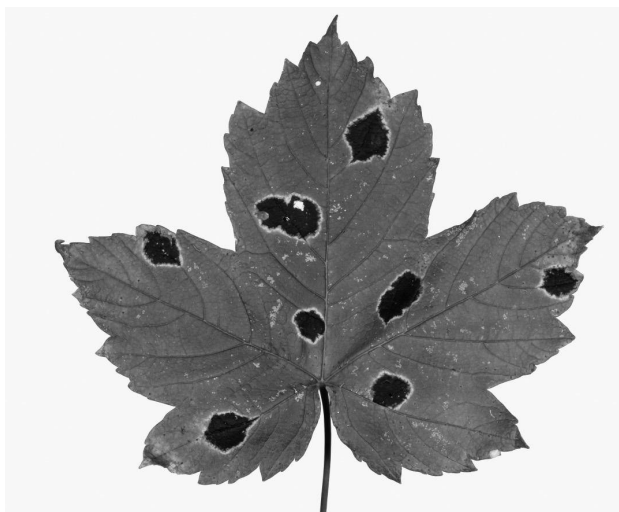
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- 8 The photograph shows tar spots on a sycamore leaf.



(Source: Nigel Cattlin / Alamy Stock Photo)

Tar spots are caused by a fungus, *Rhytisma acerinum*, growing on the sycamore leaf.

Fungal spores spend the winter in dead leaves on the ground. When new leaves emerge in the spring, they are infected by these spores and tar spots develop.

The fungus is known to be sensitive to sulfur dioxide and oxides of nitrogen in the air.

The fungus grows more slowly when these gases are present.

- (a) A student investigated whether there were fewer tar spots on sycamore leaves close to busy roads where air pollution is higher.

This is the method the student used.

**Step 1** Choose one sycamore tree close to a busy road and one sycamore tree in parkland away from busy roads.

**Step 2** Choose 15 leaves from each tree.

**Step 3** Record the number of tar spots on each leaf.

- (i) Give a suitable null hypothesis for this investigation.

(1)

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(ii) The table shows the data the student recorded.

| Location  | Number of tar spots per leaf |    |    |    |    | Mean  | SD   |
|-----------|------------------------------|----|----|----|----|-------|------|
| Near road | 8                            | 17 | 21 | 4  | 15 | 12.93 | 6.78 |
|           | 12                           | 5  | 3  | 7  | 13 |       |      |
|           | 18                           | 22 | 24 | 16 | 9  |       |      |
| Parkland  | 20                           | 17 | 13 | 14 | 24 | 17.07 | 4.06 |
|           | 10                           | 21 | 16 | 13 | 18 |       |      |
|           | 14                           | 23 | 21 | 15 | 17 |       |      |

The student analysed the data with a  $t$ -test.

Calculate the value of  $t$ .

Use the formula 
$$t = \frac{(\bar{x}_A - \bar{x}_B)}{\sqrt{\frac{(S_A)^2}{n_A} + \frac{(S_B)^2}{n_B}}}$$

where:

$\bar{x}$  is the mean for each set of data

$n$  is the number of samples in each set of data

$S$  is the standard deviation for each set of data

(3)

Answer .....



(iii) The table shows the critical values of  $t$  for different degrees of freedom.

| Degrees of freedom | $p = 0.10$ | $p = 0.05$ | $p = 0.01$ |
|--------------------|------------|------------|------------|
| 14                 | 1.76       | 2.14       | 2.98       |
| 15                 | 1.75       | 2.13       | 2.95       |
| 16                 | 1.75       | 2.12       | 2.92       |
| 17                 | 1.74       | 2.11       | 2.90       |
| 18                 | 1.73       | 2.10       | 2.88       |
| 19                 | 1.73       | 2.09       | 2.86       |
| 20                 | 1.72       | 2.09       | 2.85       |
| 21                 | 1.72       | 2.08       | 2.83       |
| 22                 | 1.72       | 2.07       | 2.82       |
| 23                 | 1.71       | 2.07       | 2.81       |
| 24                 | 1.71       | 2.06       | 2.80       |
| 25                 | 1.71       | 2.06       | 2.79       |
| 26                 | 1.71       | 2.06       | 2.78       |
| 27                 | 1.70       | 2.05       | 2.77       |
| 28                 | 1.70       | 2.05       | 2.76       |
| 29                 | 1.70       | 2.05       | 2.76       |
| 30                 | 1.70       | 2.04       | 2.75       |



Analyse the data to comment on the results of this investigation.

(3)

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(b) Justify **two** improvements to the method used by the student.

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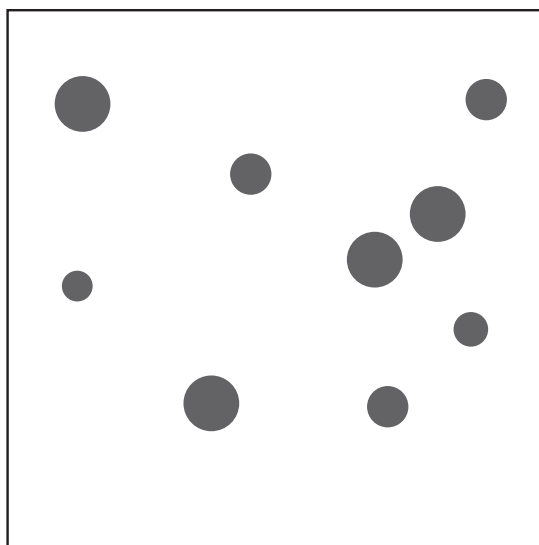
- 3 The drawing shows a plant called white clover, *Trifolium repens*.



A student used a 50 cm × 50 cm quadrat to compare the abundance of white clover in a trampled area of grassland and an untrampled area of grassland.

Each area measured 90 m × 45 m.

The diagram shows the distribution of white clover plants in one quadrat from the area of trampled grassland. Each circle represents one clover plant.



- (a) (i) Use the results from this quadrat to calculate the total number of white clover plants present in the area of trampled grassland.

(2)

Answer .....

- (ii) The student used the same method to calculate the total number of white clover plants in the area of untrampled grassland.

The student decided that the calculated values were not accurate.

Explain how you would modify the method to obtain more accurate results.

(3)

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- (b) The student investigated the effect of one abiotic factor on the abundance of white clover plants.

- (i) Name one abiotic factor, other than soil water content, that could affect the abundance of white clover plants in these areas.

(1)

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- (ii) Describe how you would measure the abiotic factor named in (b)(i).

(2)

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- (iii) The student obtained the following results for soil water content and the abundance of white clover plants in these two areas of grassland.

| Area of grassland | Soil water content (%) | Abundance of white clover plants |
|-------------------|------------------------|----------------------------------|
| Trampled          | 54.9                   | low                              |
| Untrampled        | 88.8                   | high                             |

Explain the effect of trampling on the abundance of white clover plants.

(2)

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8 The island of Surtsey was formed by a volcanic eruption in the Atlantic Ocean in 1965.

The photographs show the formation of Surtsey in 1965 and part of the island in 2018.



volcanocafe.files.wordpress.com



vulkaner.no

Scientists have been studying the development of ecosystems on this island since its formation.

(a) (i) State what is meant by the term ecosystem.

(1)

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(ii) Explain how ecosystems have developed on Surtsey since 1965.

(5)

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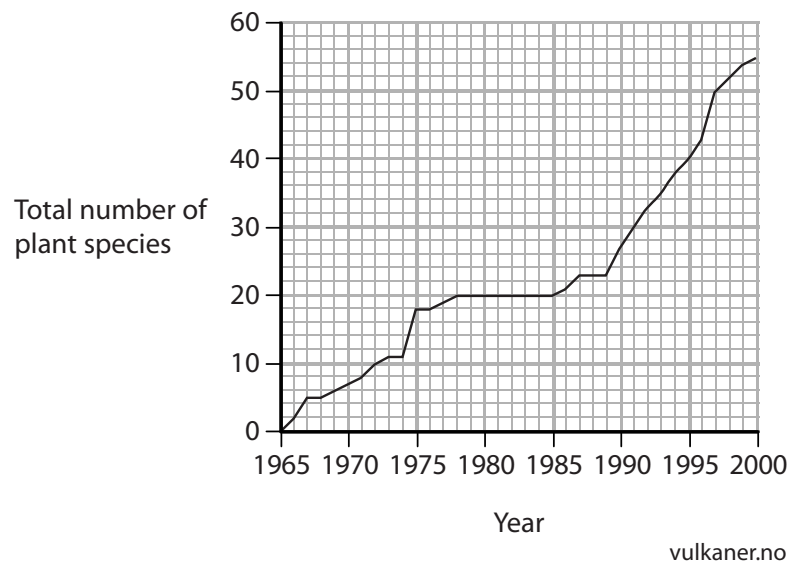
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- (b) The scientists recorded the number of different plant species on the island each year from 1965 to 2000.

The number of new plant species present at each survey was recorded.

The graph shows the total number of plant species that have been found on the island.



A few groups of one species of seagull arrived on the island in 1974.

In 1985 a large group of a different species of seagull, the black-backed gull, arrived on the island.

Comment on the effects of these two species of seagull on the number of plant species.

(4)

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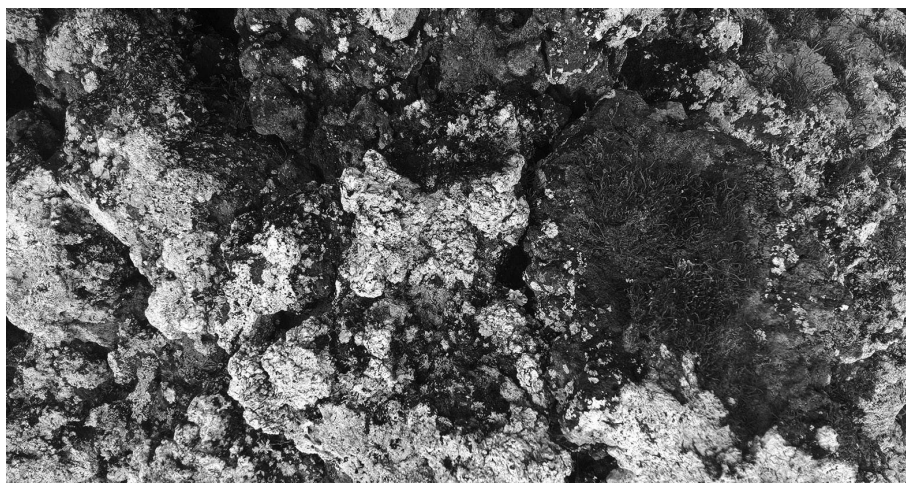
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**10** Lanzarote is a volcanic island in the Atlantic Ocean. It lies near the coast of West Africa.

The photograph shows lichens growing on volcanic rock in Lanzarote.



Lichens are organisms composed of a fungus and algae living together.

Lichens colonise bare rock.

- (a) Explain how colonisation of bare rock by lichens can result in succession over long periods of time.

(4)

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- (b) Devise an investigation to show how the lichen distribution is affected by a named abiotic factor.

(6)

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- 4 Saltmarshes are coastal habitats where silt (mud) is deposited. Saltmarshes are colonised by different species of plants and are regularly flooded with seawater.

The photograph shows an area of salt marsh.



(Source ©BOB GIBBONS / SCIENCE PHOTO LIBRARY)

- (a) Conditions close to the sea are very windy.

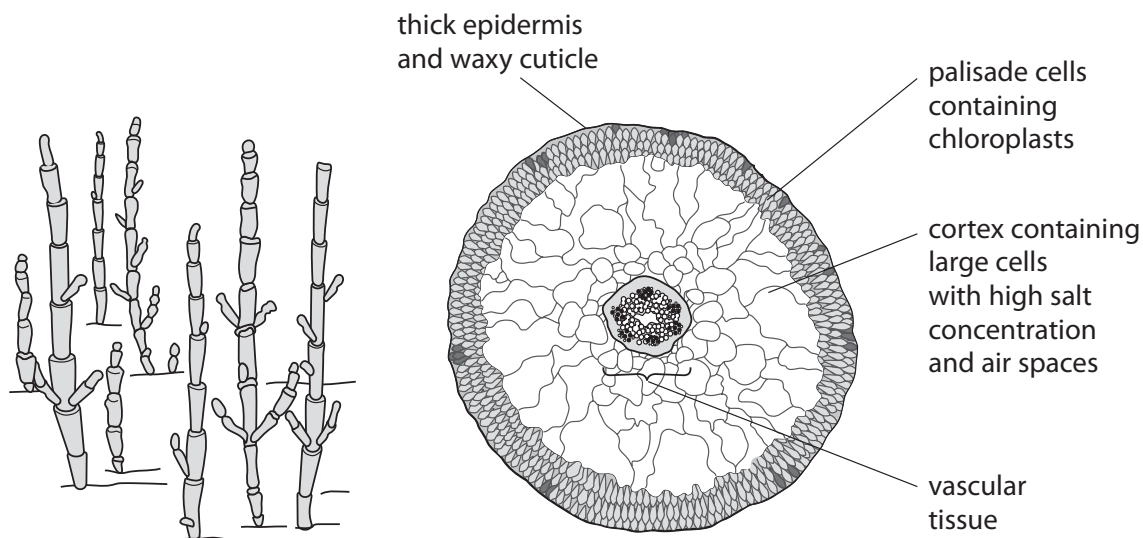
- (i) Which row in the table causes the highest rate of transpiration from a plant?

(1)

|                          |   | Temperature | Wind speed | Air humidity |
|--------------------------|---|-------------|------------|--------------|
| <input type="checkbox"/> | A | high        | high       | high         |
| <input type="checkbox"/> | B | high        | high       | low          |
| <input type="checkbox"/> | C | high        | low        | high         |
| <input type="checkbox"/> | D | low         | high       | low          |

- (ii) Samphire is one of the few plants that can grow in the areas close to the sea. Samphire plants have very small leaves and swollen stems.

The diagrams show a samphire plant and a cross section through the stem of a samphire plant.



Explain how samphire is adapted to grow in areas of saltmarshes closest to the sea.

(4)

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(b) A group of students investigated succession in a saltmarsh.

The students measured several factors at 5 m intervals along a transect, starting at the edge of the sea.

The factors measured were:

- ACFOR scales for samphire, sea lavender, and scurvy grass
- index of diversity of all plant species
- percentage of silt (mud) made up of organic material.

The results are shown in the table.

| Factor                                             |              | Distance from sea / m |        |        |            |          |
|----------------------------------------------------|--------------|-----------------------|--------|--------|------------|----------|
|                                                    |              | 0                     | 5      | 10     | 15         | 20       |
| ACFOR scales                                       | Samphire     | Abundant              | Common | Rare   | Absent     | Absent   |
|                                                    | Sea lavender | Absent                | Rare   | Common | Common     | Rare     |
|                                                    | Scurvy grass | Absent                | Absent | Rare   | Occasional | Abundant |
| Index of diversity for all plant species           |              | 0.20                  | 0.54   | 0.85   | 2.54       | 2.85     |
| Percentage of silt made up of organic material (%) |              | 15                    | 10     | 25     | 35         | 55       |

(i) Give **two** limitations of using ACFOR scales to compare the distribution of different plant species.

(2)

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(ii) Saltmarshes are produced by deposits of silt (mud) from rivers.

As the distance from the sea increases, the age of the saltmarsh increases.

Explain the changes in distribution of the species as distance from the sea increases.

(4)

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- 6 (a) The photograph shows a dandelion plant.

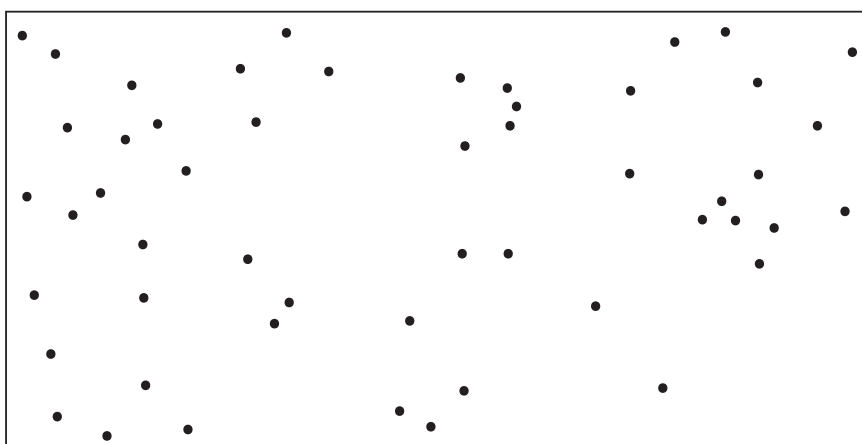


(Source: C Hurford)

A student wanted to carry out a survey to estimate the number of dandelion plants growing in a large field.

The student carried out a pilot study on an area of grassland 5 m by 10 m, to find the size of quadrat which would give the most accurate estimate.

The diagram shows the position of each dandelion plant in the pilot study.



Three sizes of quadrat were tested:

- $1\text{ m} \times 1\text{ m}$  ( $1\text{ m}^2$ )
- $0.5\text{ m} \times 0.5\text{ m}$  ( $0.25\text{ m}^2$ )
- $10\text{ cm} \times 10\text{ cm}$  ( $0.01\text{ m}^2$ ).

The quadrats were placed randomly and the number of dandelion plants in each quadrat was recorded.

The total number for all quadrats was then calculated.

The table shows the results obtained.

|                                           |   |      |      |
|-------------------------------------------|---|------|------|
| Size of quadrat / m <sup>2</sup>          | 1 | 0.25 | 0.01 |
| Number of quadrats used                   | 5 | 20   | 500  |
| Total number of dandelion plants recorded | 1 | 3    | 6    |

(i) Describe how the quadrats would be placed randomly.

(2)

(ii) The total number of dandelion plants in this area of grassland was 53.

Analyse the data to determine the size of quadrat that gives the most accurate estimate of the number of dandelion plants.

(4)



- (b) In a different survey, the student wanted to measure the biodiversity of the grassland, using a biodiversity index.

Describe the data that must be collected so that the biodiversity index can be calculated.

(2)

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- (c) (i) State the meaning of the term **species**.

(1)

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- (ii) Describe how scientists can use DNA from two similar looking plants to investigate whether they are closely related.

(2)

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6 A student measured the distribution of two plant species at the coast.

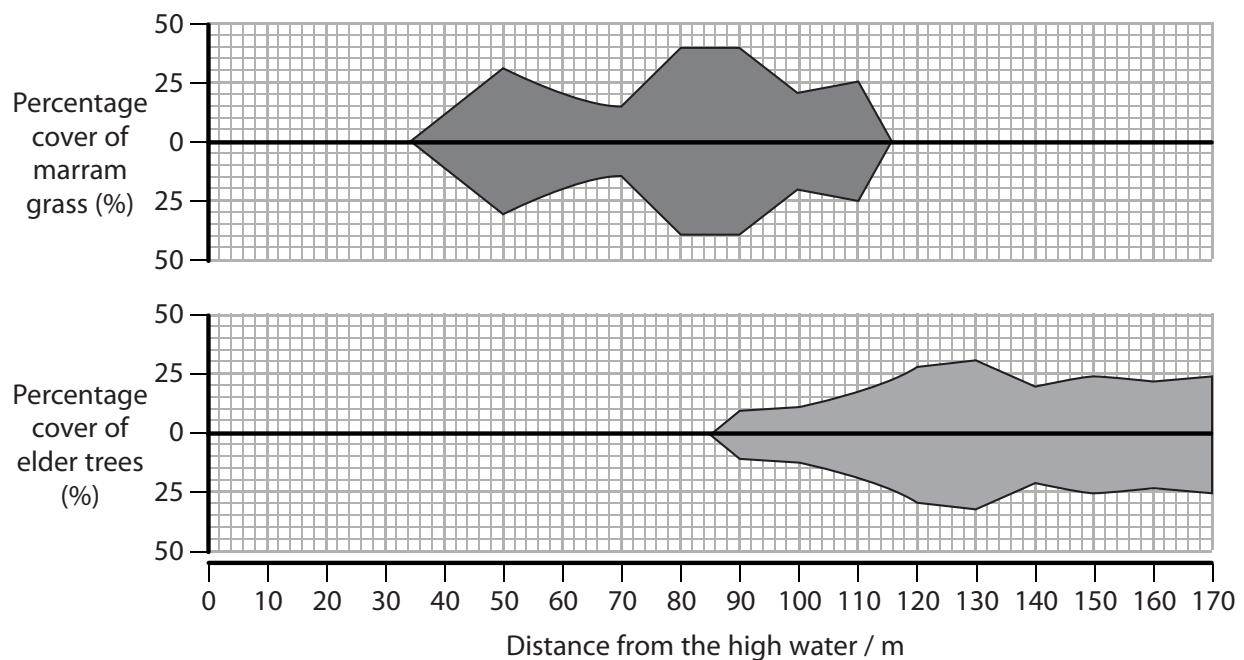
The distribution was measured from the high water line to 170m inland.

(a) State what is meant by the term species.

(1)

(b) The student represented the distribution of the two plant species in a kite diagram as shown.

The height of each kite diagram represents the percentage cover of plant species at different distances from the high water line.



(i) Compare and contrast the distribution of marram grass and elder trees.

(2)

(ii) Explain how the student could have collected the data shown in the diagram.

(3)

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(c) The student measured the water content of the soil from the high water line to 170 m inland.

Describe how the student could have carried out these measurements.

(3)

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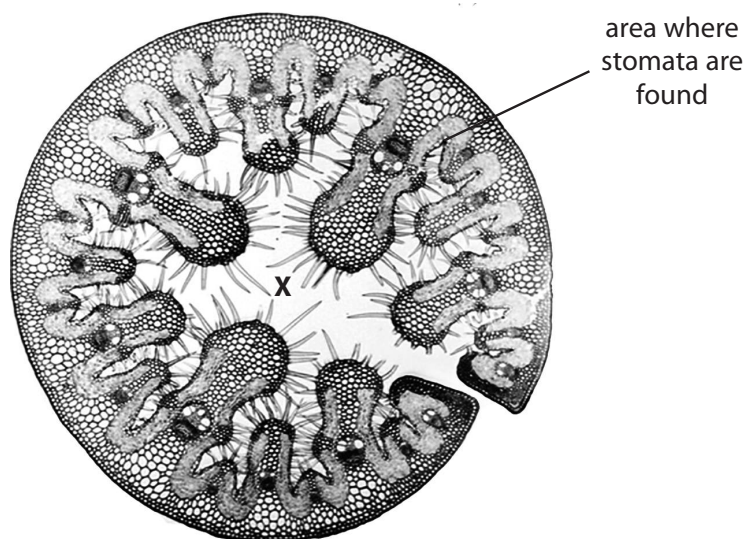
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(d) Marram grass leaves are adapted to enable the plants to survive in dry soil.

The photograph shows a section of a marram grass leaf, as seen using a light microscope.



Explain how the structure of this leaf ensures that the water potential at X remains high.

(3)

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- 8 The photograph shows a glacier that is melting. As the glacier gradually melts, it leaves behind bare rock.



melting glacier

(Source: © CHARLES D. WINTERS/SCIENCE PHOTO LIBRARY)

Scientists sampled the soil from areas that had been uncovered for different lengths of time after the glacier ice had melted.

The table shows the results from the samples.

| Length of time since glacier melted / years | Soil depth / cm | Mass of nitrate in soil / $\text{mg m}^{-2}$ | Mass of leaf litter that falls to ground each year / $\text{g m}^{-2} \text{yr}^{-1}$ |
|---------------------------------------------|-----------------|----------------------------------------------|---------------------------------------------------------------------------------------|
| 5                                           | 5.2             | 3.8                                          | 1.5                                                                                   |
| 15                                          | 6.4             | 4.1                                          | 1.7                                                                                   |
| 40                                          | 7.0             | 5.3                                          | 12.8                                                                                  |
| 100                                         | 9.2             | 21.8                                         | 277.0                                                                                 |
| 150                                         | 10.8            | 35.4                                         | 335.0                                                                                 |
| 200                                         | 15.1            | 53.3                                         | 277.0                                                                                 |
| 250                                         | 16.2            | 61.4                                         | 261.0                                                                                 |

- (a) Which of the following should be used to determine if there is an association between length of time since the glacial ice has melted and soil depth?

(1)

- ☐ A chi squared
- ☐ B correlation coefficient
- ☐ C standard deviation
- ☐ D t-test

- (b) Explain how succession brings about the changes in the soil during this period of time.

(5)

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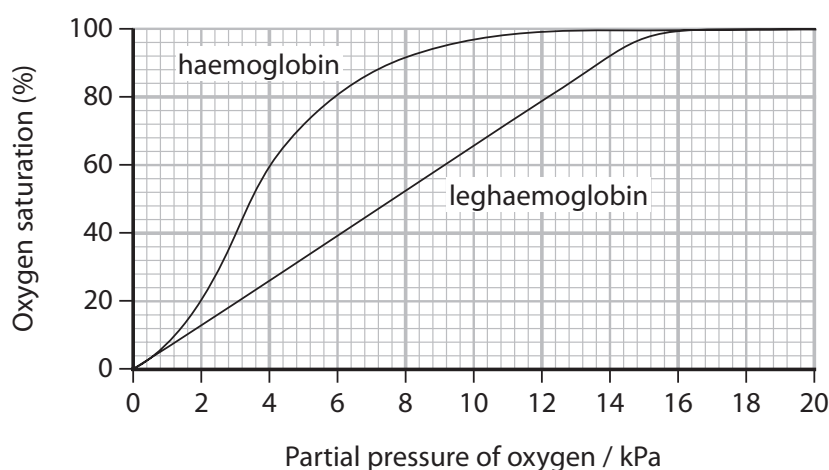
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- (c) The roots of some of the plants growing around the glacier were found to contain an oxygen binding protein called leghaemoglobin.

The graph shows the oxygen dissociation curve for leghaemoglobin and the oxygen dissociation for haemoglobin.



- (i) Leghaemoglobin is a protein that is similar in structure to myoglobin. Both of these proteins have one subunit.

Explain how the oxygen dissociation curve shows that the structure of leghaemoglobin is more similar to myoglobin than to haemoglobin.

(3)

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(ii) Explain how leghaemoglobin enables these plants to grow in waterlogged and compact soils.

(3)

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7 The photograph shows a wood mouse, *Apodemus sylvaticus*.



(Source: © Eric Isselee/Shutterstock)

A scientist measured the population size of these mice living in a woodland habitat.

The scientist used the capture-mark-recapture method (CMR) to sample the population.

This is the CMR method used by the scientist:

- randomly place mammal traps in the woodland for one day
- put a coloured band on a leg of each captured mouse (S1)
- release these marked mice
- after one week place mammal traps in the woodland again for one day
- count the number of mice captured (S2)
- count the number of mice with leg bands in this second sample (L).

The table shows some of the results.

| Number of mice captured |     |
|-------------------------|-----|
| S1                      | S2  |
| 200                     | 250 |

- (a) The scientist calculated that the number of mice in the woodland was 1000, using the formula

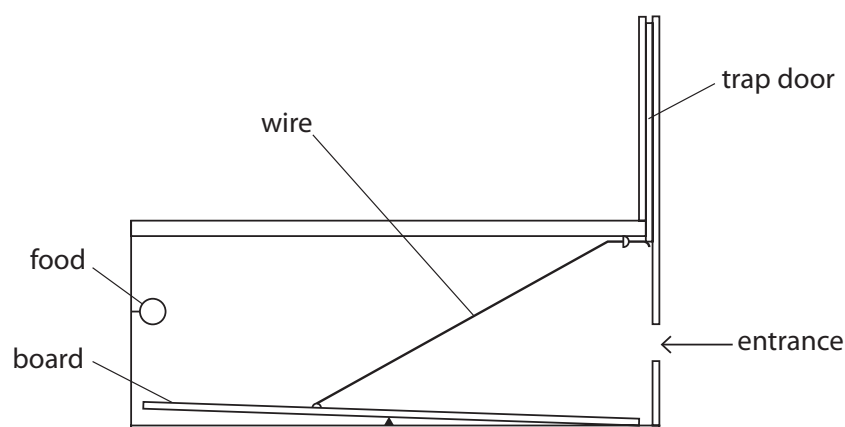
$$\text{number of mice} = \frac{S1 \times S2}{L}$$

Determine the number of mice that had leg bands (L) in the second sample.

(1)

Answer .....

- (b) The diagram shows a section of the trap used by the scientist.



Explain how the design of the trap is effective for capturing mice.

(3)

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(c) Wood mice are small mammals.

They cannot maintain their body temperature and will die if left in the trap for a long period of time.

Explain why wood mice cannot maintain their body temperature if left in the trap.

(4)

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(d) Comment on the claim that the CMR method produces an accurate measure of the population size of mice in the woodland.

(5)

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**7** Plants require mineral ions from the soil for healthy growth.

(a) (i) Describe how mineral (inorganic) ions are taken up by active transport.

(3)

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(ii) Describe the function of a named mineral ion that is vital for the growth of plants.

(2)

Mineral ions

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Function

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- (b) The photograph shows *Galium verum* (Lady's bedstraw), a plant that grows in meadows, hedges, road verges and sand dunes.



(Source: © Alfio Scisetti/Alamy Stock Photo)

This plant grows to between 15 cm and 60 cm in height.

A student investigated whether *Galium verum* growing in meadows was taller than *Galium verum* growing on sand dunes.

- (i) Give a suitable null hypothesis for this investigation.

(1)

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(ii) Devise a method that can be used to collect valid results to test this null hypothesis.

(5)

(iii) Explain which statistical test would be most suitable to test this null hypothesis.

(2)

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- 7 The photograph shows hedge woundwort (*Stachys sylvatica*).



(Source: © imageBROKER/Alamy Stock Photo)

This plant grows on the edge of woodlands and can be up to one metre in height.

A student investigated whether light intensity had an effect on the leaf area of hedge woundwort.

The student measured the area of 20 leaves from plants growing in full sun and 20 leaves from plants growing in shady conditions.

- (a) (i) Give a suitable null hypothesis for this investigation.

(1)

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- (ii) Devise a valid fieldwork method that the student could use to compare the leaf areas of the plants growing in full sunlight with the leaf areas of the plants growing in shady areas.

(4)

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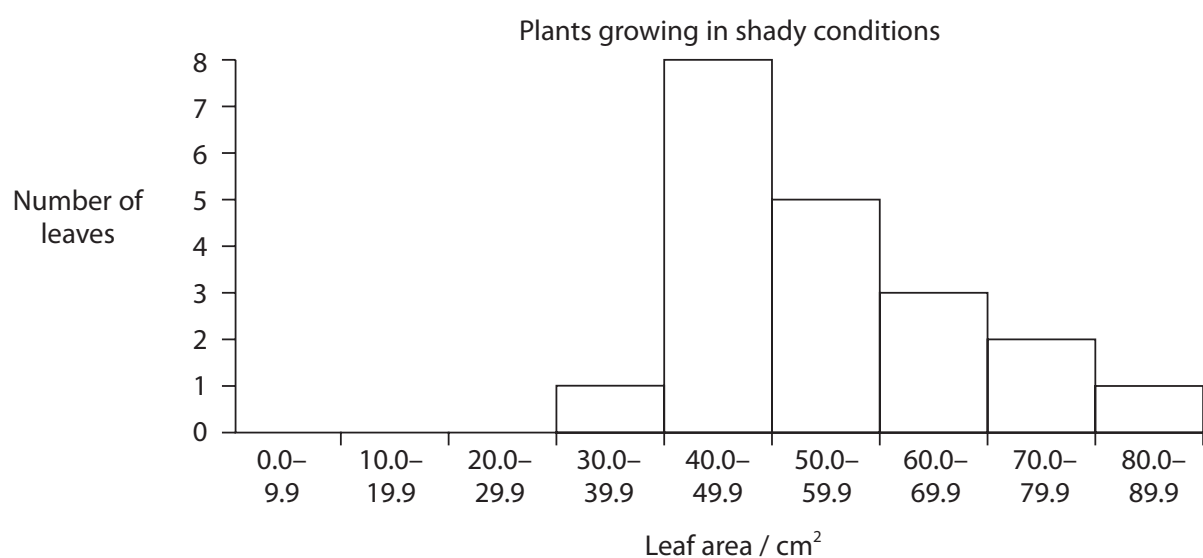
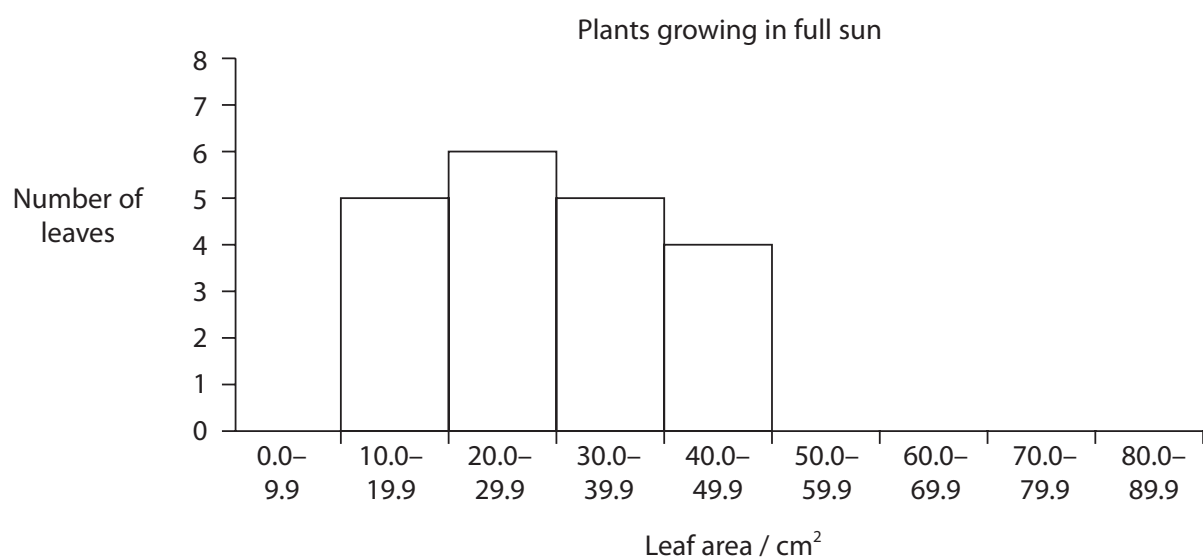
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(b) The student plotted histograms to display the data collected.



- (i) The mean leaf area for leaves from plants in full sun is  $27.55 \text{ cm}^2$  with a standard deviation of  $9.62 \text{ cm}^2$ .

The mean leaf area for leaves from plants in shady conditions is  $55.50 \text{ cm}^2$  with a standard deviation of  $13.40 \text{ cm}^2$ .

Two standard deviations on either side of the mean will include 95% of the leaves.

Determine the size range that would include 95% of leaves from plants in full sun, using the standard deviation value.

(2)

Answer .....  $\text{cm}^2$



- (ii) The student analysed the data using a  $t$ -test.

Calculate the value of  $t$ .

Use the formula

$$t = \frac{(\bar{x}_A - \bar{x}_B)}{\sqrt{\frac{(S_A)^2}{n_A} + \frac{(S_B)^2}{n_B}}}$$

where:

$\bar{x}$  is the mean for each set of data

$n$  is the number of samples in each set of data

$S$  is the standard deviation for each set of data

(3)

Answer .....



(iii) The table shows the critical values of  $t$  for different degrees of freedom.

| Degrees of freedom | $p = 0.10$ | $p = 0.05$ | $p = 0.01$ |
|--------------------|------------|------------|------------|
| 20                 | 1.73       | 2.09       | 2.85       |
| 21                 | 1.72       | 2.08       | 2.83       |
| 22                 | 1.72       | 2.07       | 2.82       |
| 23                 | 1.71       | 2.07       | 2.81       |
| 24                 | 1.71       | 2.06       | 2.80       |
| 25                 | 1.71       | 2.06       | 2.79       |
| 26                 | 1.71       | 2.06       | 2.78       |
| 27                 | 1.70       | 2.05       | 2.77       |
| 28                 | 1.70       | 2.05       | 2.76       |
| 29                 | 1.70       | 2.05       | 2.76       |
| 30                 | 1.70       | 2.04       | 2.75       |
| 31                 | 1.70       | 2.04       | 2.74       |
| 32                 | 1.69       | 2.04       | 2.74       |
| 33                 | 1.69       | 2.03       | 2.73       |
| 34                 | 1.69       | 2.03       | 2.73       |
| 35                 | 1.69       | 2.03       | 2.72       |
| 36                 | 1.69       | 2.03       | 2.72       |
| 37                 | 1.69       | 2.03       | 2.72       |
| 38                 | 1.69       | 2.02       | 2.71       |
| 39                 | 1.69       | 2.02       | 2.71       |
| 40                 | 1.68       | 2.02       | 2.70       |

Comment on the results of this investigation.

Use the information in the table to support your answer.

(3)

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- 3 Organic farming does not use artificial insecticides, herbicides or fertilisers, all of which are used in conventional farming.

Students investigated the effect of organic farming on the species diversity of butterflies.

They compared fields used for growing crops on an organic farm and on a conventional farm.

Butterflies were sampled three times on both farms during July. They were collected by walking around the fields using a sweep net. On each sampling exercise, the butterflies were collected until no more butterflies were seen.

Sampling was only carried out when the temperature exceeded 25°C and the wind speed was low.

The results are shown in the table.

| Species of butterfly | Number of butterflies |              |
|----------------------|-----------------------|--------------|
|                      | Organic farm          | Conventional |
| Cabbage white        | 22                    | 44           |
| Common blue          | 12                    | 0            |
| Large skipper        | 4                     | 0            |
| Monarch              | 3                     | 0            |
| Painted lady         | 11                    | 0            |
| Peacock              | 14                    | 5            |
| Red admiral          | 35                    | 6            |
| Small copper         | 2                     | 0            |
| Swallowtail          | 14                    | 4            |

- (a) (i) The index of diversity for the conventional farm is 1.54

Use the formula to calculate the index of diversity for the organic farm.

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

N = total number of organisms of all species

n = total number of organisms of a particular species

(2)

Answer .....



(ii) Explain why the organic farm has a higher index of diversity than the conventional farm.

(3)

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(iii) Criticise the method used by the students to obtain these results.

(4)

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(b) Some conventional farms have converted to organic farming.

A further experiment was carried out to investigate the effect on species diversity of how long the farms have used organic methods.

(i) Butterflies and plant species were sampled from a range of farms that had used organic farming methods for different lengths of time.

The number of plant species and the number of butterfly species were recorded.

The results are shown in the table.

| Years of organic farming | Number of plant species | Number of butterfly species |
|--------------------------|-------------------------|-----------------------------|
| 0                        | 17                      | 4                           |
| 1 to 5                   | 38                      | 12                          |
| 6 to 15                  | 42                      | 14                          |
| 16 to 25                 | 39                      | 12                          |

Explain how the number of years of organic farming affects the biodiversity of butterfly species.

(3)

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(ii) Creeping thistle is considered to be a weed.

Creeping thistle has a deep root system and takes many years to be completely removed by organic farming methods.

The moth population and the number of creeping thistle plants were counted.

The results are shown in the table.

| Years of organic farming | Number of moth species | Number of creeping thistle plants |
|--------------------------|------------------------|-----------------------------------|
| 0                        | 15                     | 10                                |
| 1 to 5                   | 27                     | 235                               |
| 6 to 15                  | 20                     | 74                                |
| 16 to 25                 | 10                     | 14                                |

Explain the changes in the number of moth species.

(2)

(Total for Question 3 = 14 marks)

- 4 Woodlice are crustaceans found in many gardens and woodland habitats.

There are several species that are native to the UK and Ireland.

They obtain oxygen through gills, which are on their legs.

The photograph shows one species of woodlouse, *Armadillidium vulgare*.



Magnification  $\times 2$

(Source: © TED KINSMAN / SCIENCE PHOTO LIBRARY)

- (a) (i) Describe how you could measure the respiration rate of woodlice collected from a garden.

(5)

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- (ii) Identify **one** safety issue and **one** ethical issue involved in your method in part (a)(i) and state how you would minimise the effect of these.

(2)

Safety issue

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Ethical issue

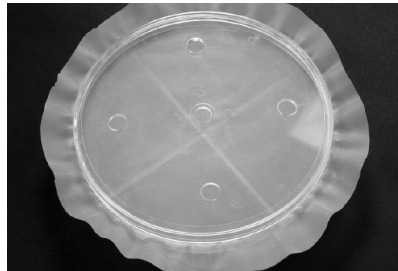
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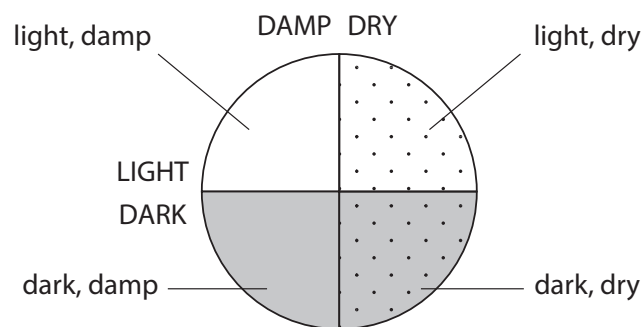
- (b) A student used a choice chamber to investigate the habitat preferences of woodlice.

The photograph shows a choice chamber.



(Source: © TREVOR CLIFFORD PHOTOGRAPHY / SCIENCE PHOTO LIBRARY)

The diagram shows the conditions in each of the four sections.



Woodlice were able to move freely to all areas of the chamber.

The student suggested the hypothesis that woodlice show no habitat preference.

- Five woodlice were placed in each of the four sections and left to move.
- The position of the woodlice was recorded after five minutes.
- This was repeated three more times.

The table shows the results obtained.

| Section        | Number of woodlice in each section of the chamber after 5 minutes |         |         |         |
|----------------|-------------------------------------------------------------------|---------|---------|---------|
|                | Trial 1                                                           | Trial 2 | Trial 3 | Trial 4 |
| Light and dry  | 2                                                                 | 1       | 0       | 2       |
| Light and damp | 4                                                                 | 4       | 1       | 5       |
| Dark and dry   | 4                                                                 | 3       | 3       | 3       |
| Dark and damp  | 10                                                                | 12      | 16      | 10      |

(i) Explain which statistical test could be used to analyse these results.

(2)



(ii) The results suggest woodlice prefer some conditions to others.

Explain why it is an advantage for them to live in these conditions.

(2)

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(iii) Describe **three** improvements that could be made to this investigation to ensure the conclusion is valid.

(3)

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- 8 The photograph shows a celandine plant, *Ficaria verna*, that is commonly found in woodlands in the UK.



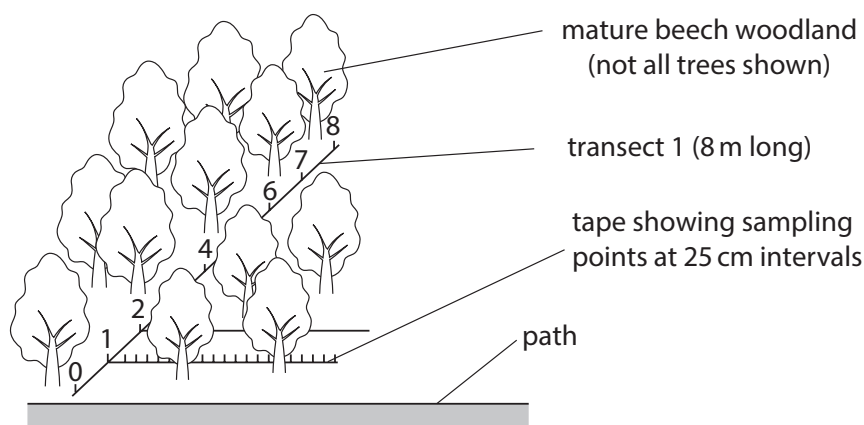
(Source: © TH FOTO-WERBUNG / SCIENCE PHOTO LIBRARY)

A student noticed that many of these plants grew in a mature beech woodland, but seemed to be less abundant as the distance from a path increased.

The student investigated the distribution of celandine using this method:

- set up a transect at 90° to the path (transect 1)
- at 1 metre intervals along the transect, place a tape parallel to the path
- record the presence or absence of celandine every 25 cm along the tape
- repeat for two more transects in the woodland (transects 2 and 3).

The diagram shows the arrangement of the transect and the tape.



- (a) Give a null hypothesis for this investigation.

(1)

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(b) Table 1 shows the results collected.

| Distance from path / m | Number of celandine plants recorded |            |            |      |
|------------------------|-------------------------------------|------------|------------|------|
|                        | Transect 1                          | Transect 2 | Transect 3 | Mean |
| 0                      | 18                                  | 19         | 20         | 19.0 |
| 1                      | 19                                  | 16         | 17         | 17.3 |
| 2                      | 17                                  | 15         | 12         | 14.7 |
| 3                      | 15                                  | 8          | 13         | 12.0 |
| 4                      | 9                                   | 9          | 6          | 8.0  |
| 5                      | 3                                   | 16         | 6          | 8.3  |
| 6                      | 5                                   | 4          | 4          | 4.3  |
| 7                      | 2                                   | 3          | 2          | 2.3  |
| 8                      | 1                                   | 6          | 2          | 3.0  |

**Table 1**

Table 2 shows how the student analysed this data to calculate the Spearman's Rank correlation coefficient.

| Distance from path / m | Mean number of celandine plants | Rank distance from path | Rank number of celandine plants | $d$ | $d^2$ |
|------------------------|---------------------------------|-------------------------|---------------------------------|-----|-------|
| 0                      | 19.0                            | 1                       | 9                               | -8  | 64    |
| 1                      | 17.3                            | 2                       | 8                               | -6  | 36    |
| 2                      | 14.7                            | 3                       | 7                               | -4  | 16    |
| 3                      | 12.0                            | 4                       | 6                               | -2  | 4     |
| 4                      | 8.0                             | 5                       | 4                               | 1   | 1     |
| 5                      | 8.3                             | 6                       | 5                               | 1   | 1     |
| 6                      | 4.3                             | 7                       | 3                               | 4   | 16    |
| 7                      | 2.3                             | 8                       | 1                               | 7   | 49    |
| 8                      | 3.0                             | 9                       | 2                               | 7   | 49    |

**Table 2**



- (i) Calculate the correlation coefficient,  $r_s$ .

Use the formula:

(3)

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Where:

$\sum$  = the sum of

$d$  = the difference between each pair of ranks

$n$  = the size of the sample (number of pairs of values)

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

Answer .....



(ii) The table shows some critical values for this correlation coefficient.

| Number of pairs of values | Level of significance |       |       |
|---------------------------|-----------------------|-------|-------|
|                           | 0.10                  | 0.05  | 0.01  |
| 4                         | 1.000                 | –     | –     |
| 5                         | 0.900                 | 1.000 | –     |
| 6                         | 0.829                 | 0.886 | 1.000 |
| 7                         | 0.714                 | 0.786 | 0.929 |
| 8                         | 0.643                 | 0.738 | 0.881 |
| 9                         | 0.600                 | 0.700 | 0.833 |
| 10                        | 0.564                 | 0.648 | 0.794 |

Analyse the data to explain the conclusion that can be drawn from this investigation.

Use the table of critical values and your calculated correlation coefficient.

(3)



- (c) (i) Name **one** abiotic factor that might influence the distribution of celandine plants.

(1)

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- (ii) Describe a method that could be used to measure how this abiotic factor changes along the transect.

(3)

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- (iii) Explain why the factor you have chosen would change along the transect **and** how this affects the growth of celandine plants.

(3)

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**11** Citizen science involves members of the public collecting scientific data.

In 2019 and 2020, a citizen science project was carried out in the UK to investigate the numbers of flowers of wild plant species found in lawns.

Volunteers across the UK were asked to survey their own lawns to find out which wild flowering plants were growing there.

Participants were asked to mark out a one metre-squared area on their lawn, chosen at random, and count the number of flowers of each species within this area.

In 2020, the data were recorded from over 9 000 one metre-squared areas.

The table shows data for the five most commonly recorded wild plant species in 2020.

| Wild plant species  | Total number of flowers recorded in 2020 | Percentage change from 2019 (%) |
|---------------------|------------------------------------------|---------------------------------|
| Daisy               | 208 589                                  | –40                             |
| White clover        | 101 117                                  | +16                             |
| Selfheal            | 73 344                                   | –11                             |
| Creeping buttercup  | 56 719                                   | +48                             |
| Bird's-foot trefoil | 30 646                                   | –32                             |

- (a) Scientists who analysed the data suggested that the unusually warm weather in Spring 2020 might be responsible for the change in the numbers of flowers recorded in 2020 compared to 2019.

- (i) Name **one** factor, other than temperature, that could cause the change in the numbers of flowers of these five species.

(1)

- (ii) The scientists concluded that for all species recorded, the number of flowers of wild plants in lawns decreased 19% in 2020 compared to 2019.

Evaluate the method of data collection in this survey.

(5)



(b) The table shows the total data collected in one quadrat placed on a lawn.

| Wild plant species | Total number of flowers recorded |
|--------------------|----------------------------------|
| Daisy              | 11                               |
| Dandelion          | 8                                |
| Cat's-ear          | 14                               |
| Selfheal           | 2                                |

(i) Calculate the biodiversity index (D) for the quadrat, using the data in the table.

Use the formula

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

(3)

Answer .....

(ii) Describe **two** improvements which should be made to the method to give a more accurate measure of the biodiversity index for this quadrat.

(2)

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- (c) (i) Bees feed on nectar in flowers.

The mean mass of nectar sugar produced per square metre of lawn was calculated for 2019 and 2020.

Scientists then calculated the mean number of bees per square metre that could be supported by the nectar.

The table shows the data.

| 2019                                           |                                                | 2020                                           |                                                |
|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| Mean mass of nectar sugar / $\text{mg m}^{-2}$ | Mean number of bees supported per $\text{m}^2$ | Mean mass of nectar sugar / $\text{mg m}^{-2}$ | Mean number of bees supported per $\text{m}^2$ |
| 41 912                                         | 3.8                                            | 38 885                                         |                                                |

Calculate the mean number of bees supported per square metre of lawn in 2020.

(2)

Answer .....

- (ii) Bees are important pollinators of a variety of plants.

Explain the possible short-term **and** long-term consequences of the decline in flowers of wild plant species in lawns in 2020.

(4)

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SUB-TOPIC 10(d)

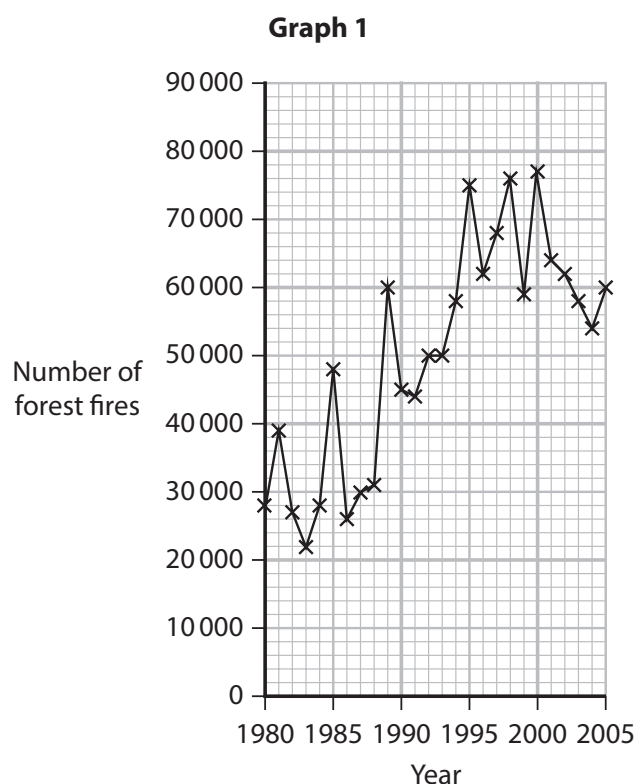
# HUMAN IMPACT AND CLIMATE CHANGE

1 question in this sub-topic · 12 marks · lowest tariff first



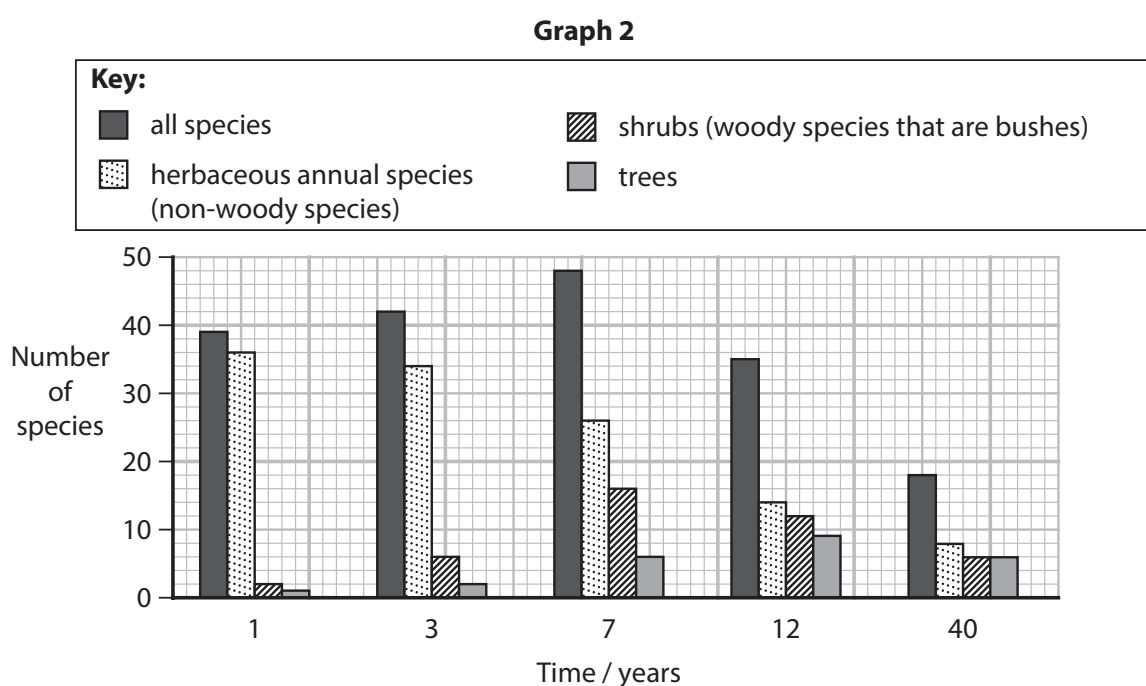
- 5 Forest fires often occur in areas with old, dry trees.

Graph 1 shows the number of forest fires recorded in Europe from 1980 to 2005.



Scientists investigated the changes in plant species for 40 years after a forest fire.

The results are shown in Graph 2.



- \* (a) Some scientists have stated that the number of forest fires is increasing due to climate change and that measures need to be taken to stop forest fires.

Analyse the data to discuss whether measures to prevent climate change need to be taken to prevent further forest fires.

(6)

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(b) In this investigation, the scientists compared the numbers of different plant species.

The scientists also calculated a diversity index for tree species 40 years after the fire. This index gave a value of 7.33.

The table shows data for an area of forest seven years after the fire.

| Tree species | Number of trees |
|--------------|-----------------|
| Aleppo pine  | 45              |
| Silver fir   | 30              |
| Beech        | 14              |
| Oak          | 12              |
| Chestnut     | 18              |
| Plane        | 11              |

(i) Calculate the index of biodiversity (D) for the trees shown in the table for this area of forest.

Use the formula

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

Give your answer to **two decimal places**.

(3)

Answer .....

- (ii) State why using the index of diversity is a more valid way of comparing biodiversity of areas than comparing the number of species.

(1)

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- (iii) Explain why a high species diversity means that an area is more resistant to environmental changes.

(2)

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# MARK SCHEMES

official Pearson Edexcel mark schemes



| Number | Answer                                                                                                                                                                                                      | Additional Guidance | Mark |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 7 (a)  | A is correct <i>apoplastic pathway</i><br><br>B is incorrect as this is an incorrect term<br>C is incorrect as the water passes through cell walls<br>D is incorrect as the water passes through cell walls |                     | 1    |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 7 (b)           | An answer that makes reference to four from the following: <ul style="list-style-type: none"> <li>sugars are loaded / pumped / transferred into phloem / sieve tubes in leaf (1)</li> <li>lowering water potential so that water enters phloem (1)</li> <li>pressure in phloem increases (moving sugars) (1)</li> <li>sugars are converted to (insoluble) starch in root cells / low sugar concentration in root cells (1)</li> <li>increasing the water potential, so water moves out (1)</li> </ul> |                     | 4    |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7 (c)*          | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <ul style="list-style-type: none"> <li>mistletoe lowers the NPP of apple trees over time (D)</li> <li>NPP of trees without mistletoe shows an upward trend over 20 years (D)</li> <li>NPP of trees with mistletoe shows a downward trend over 20 years (D)</li> <li>mistletoe decreases the transpiration rate of the trees (D)</li> <li>mistletoe has a higher transpiration rate than the apple tree (D)</li> <li>higher transpiration rate of mistletoe diverts transpiration stream to mistletoe rather than apple tree / mistletoe takes the water from apple tree (E)</li> <li>so less minerals are given to the apple tree (E)</li> <li>less water for photosynthesis (E)</li> <li>nitrogen content of apple trees is lower (D)</li> <li>less amino acid / protein synthesis occurs (E)</li> <li>less enzyme production so less photosynthesis (E)</li> <li>lowering NPP (due to less enzymes) (E)</li> <li>less nucleic acid synthesis (E)</li> <li>less chlorophyll synthesis (E)</li> <li>calcium content of the apple trees is lower (D)</li> <li>so there is less production of cell walls / calcium pectate (E)</li> </ul> |

**Level 1: one or two D or E**

**Level 2: three or four from both D and E**

**Level 3: five or six from both D and E, must explain effect of either low nitrogen / calcium and have no major errors**

| Level | Marks |                                                                                                                                                                                                                                                                                                                                     |
|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level | Marks |                                                                                                                                                                                                                                                                                                                                     |
| 0     | 0     | No awardable content                                                                                                                                                                                                                                                                                                                |
| 1     | 1-2   | <p>An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>            |
| 2     | 3-4   | <p>An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p>                                                                              |
| 3     | 5-6   | <p>An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> |



| Number  | Answer                                                                                                                                                                                | Additional Guidance                                                              | Mark |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------|
| 7(a)(i) | <ul style="list-style-type: none"> <li>correct calculation of energy in primary consumers (1)</li> <li>correct calculation of percentage efficiency of energy transfer (1)</li> </ul> | $1.2 \times 10^4 / 12000$<br><br>$(1200 / 14000) \times 100 = 8.6 \%$ Allow 8.57 | 2    |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional Guidance                                                                                                                                                                                                                                                                                                    | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(a)(ii)        | <p>An explanation that makes reference to three from:</p> <ul style="list-style-type: none"> <li>(large amounts of) energy from producers is not transferred to primary consumers as producers have more {indigestible parts / inedible parts / parts not consumed}(1)</li> <li>animals / primary consumers / secondary consumers have higher respiration rates than producers (1)</li> <li>as more energy lost in {movement / heat loss} (1)</li> <li>animals / primary consumers / secondary consumers lose more energy as {urea / excretion} (compared with producers) (1)</li> </ul> | <p><b>Allow</b> more faeces released when consuming producers</p> <p><b>Allow</b> different organisms have different amounts of indigestible / inedible parts</p> <p><b>Allow</b> different organisms have different respiration rates</p> <p><b>Allow</b> organisms have different levels of movement / heat loss</p> | 3    |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 7 (b)*          | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><b>Descriptions</b></p> <ul style="list-style-type: none"> <li>crop yield is highest between 5 m and 10 m from hedgerow D</li> <li>crop yield is lowest next to the hedgerow / crop yield is lower than the centre of the field up to 2.5 m</li> <li>crop yield increases up to between 5 m and 10 m from the hedge and then decreases D</li> <li>wind speed is lowest by the hedge D</li> <li>wind speed increases with distance from the hedge D</li> <li>temperature is higher by hedgerow / falls with distance D</li> <li>hedgerows can increase crop yields, but fields need to be smaller D</li> <li>hedgerows can take up land that could be used to grow crops D</li> </ul> <p><b>Abiotic Explanations</b></p> <ul style="list-style-type: none"> <li>humidity is higher by the hedgerow A</li> <li>reduced wind speed (by the hedge) increases the temperature A</li> <li>transpiration / water loss / evaporation will be lower around hedgerow A</li> <li>hedgerow acts as a wind break A</li> <li>less than 2m from hedgerow productivity is lower due to competition / shading reducing photosynthesis A</li> <li>between 5m and 15 m, higher temperature will increase photosynthesis rate A</li> <li>higher temperature is closer to optimal enzyme temperatures A</li> <li>wind can affect crops pollinated by wind A</li> </ul> | 6 |

|                |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |
|----------------|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|                |              | <b>Biotic Explanations</b> <ul style="list-style-type: none"> <li>• pollinating species and predators increase productivity B</li> <li>• predators consume herbivores / pests B</li> <li>• pollinators are essential for seeded crops / example B</li> <li>• hedgerow may compete for nutrients / water / light B</li> <li>• less need for pesticides to be used when predator species live in hedgerows B</li> </ul>                                                                |  |
| <b>Level</b>   | <b>Marks</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |
| <b>Level 0</b> | Marks        | No awardable content                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
| <b>Level 1</b> | 1-2          | <p>Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified.</p> <p>A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.</p> <p><b>Descriptions of factors</b><br/> <b>one mark: any two from D</b><br/> <b>two marks: three from D</b></p>                                                           |  |
| <b>Level 2</b> | 3-4          | <p>A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified.</p> <p>A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.</p> <p><b>Descriptions and explanations</b><br/> <b>three marks: any four points from D, A or B</b><br/> <b>four marks: any five points from D, A or B and</b></p> |  |
| <b>Level 3</b> | 5-6          | <p>A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information.</p> <p>A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.</p>                                                                                                                                     |  |
|                |              | <b>Detailed explanation of all factors and how use of hedges can be beneficial</b> <p><b>Descriptions and explanations</b><br/> <b>five marks: any six points from D, A and B</b><br/> <b>six marks: any seven points from D, A and B</b></p>                                                                                                                                                                                                                                        |  |

| Question | Answer | Additional Guidance | Mark |
|----------|--------|---------------------|------|
|----------|--------|---------------------|------|



| Number  | Answer                                                                                                                                                                                                               | Additional Guidance   | Mark |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------|
| 9(a)(i) | An answer that makes reference to one of the following:<br><br>gross primary productivity – respiration<br><br>OR<br><br>{energy / biomass} in producers which transfers to {next trophic level / primary consumers} | <b>ACCEPT</b> GPP – R | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance                                                                                                                                                                                                                                                                      | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 9(a)(ii)        | An explanation that makes reference to three of the following: <ul style="list-style-type: none"> <li>NPP increases as daylight and temperature increase (1)</li> <li>because photosynthesis is greater than respiration (1)</li> <li>NPP falls if respiration rate rises more than photosynthesis rate / GPP (1)</li> <li>light is limiting factor (of photosynthesis) between {June and July / December and January} (1)</li> </ul> | <b>ACCEPT</b> converse<br><br><br><br><br><br><br><br><br><br><b>ACCEPT</b> NPP is negative if the rate of respiration exceeds GPP / NPP is negative when respiration is greater than photosynthesis<br><br><br><b>ACCEPT</b> other correct examples of where light is a limiting factor | (3)  |

| Question Number | Answer                                                                                                                                                                       | Additional Guidance                                                                                                                                                                                                                | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 9(b)(i)         | An answer that makes reference to the following: <ul style="list-style-type: none"> <li>add losses and subtract from 127503 (1)</li> <li>calculate percentage (1)</li> </ul> | Correct answer gains full marks<br>Correct answer: 8%<br><br>$127\,503 - 117\,303 = 10\,200$<br>$(10\,200 \div 127\,503) \times 100 = 8(\%)$<br><br>If answer wrong award one mark for 10 200 or division by $127\,503 \times 100$ | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance                                                                                                                                                                                                                                     | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 9(b)(ii)        | An explanation that makes reference three of the following: <ul style="list-style-type: none"> <li>different {organisms / trophic levels} {use / lose} different proportions of energy (1)</li> <li>and <b>two</b> from: <ul style="list-style-type: none"> <li>because of respiration for {movement / maintaining body temperature} (1)</li> <li>because of material that is not digested (1)</li> <li>because some parts are not consumed (1)</li> <li>because some is lost due to excretion (1)</li> </ul> </li> </ul> | <b>ACCEPT</b> different {organisms / trophic levels} {use / lose} energy in different ways<br><br><br><br><br><br><br><br><br><br><b>ACCEPT</b> heat loss<br><br><br><b>ACCEPT</b> material is lost as faeces<br><br><br><b>ACCEPT</b> shedding of skin | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance                                                                                                                 | Mark       |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------------|
| 9(c)            | <p>An answer that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>mass of wild tuna decreases more steeply (after 2002) (1)</li> <li>there is a decrease in (wild tuna) caught after 2002 (1)</li> <li>because farming takes {immature / young} from the wild population that have not reproduced / so breeding of tuna is reduced (1)</li> <li>farming reduces food available for the wild population (reducing population) (1)</li> <li>farming has not replaced the catch of wild tuna / consumer demand has risen (1)</li> </ul> | <p><b>ACCEPT</b> idea of bigger increase after fish farming started</p> <p><b>ACCEPT</b> total of caught + farmed has increased</p> | <b>(4)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional Guidance                                                                      | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|------|
| 9(a)            | <p>An explanation that makes reference to five of the following:</p> <ul style="list-style-type: none"> <li>because there would be less water to take up from the soil (1)</li> <li>therefore there will be fewer {mineral ions / minerals} (transported to the rest of the plant / taken up) (1)</li> <li>example of a mineral ion deficiency on the plant explained (1)</li> <li>there will be less water for {photolysis / light-dependent reaction / photosynthesis} (1)</li> <li>therefore there will be less GALP produced in the {light-independent reaction / Calvin cycle} (1)</li> <li>therefore less {NPP / plant biomass} (1)</li> </ul> | <p>ACCEPT plants will {wilt / die} without water</p> <p>ACCEPT less glucose produced</p> | (5)  |

| Question Number | Answer                                                                                                                   | Additional Guidance                                                                                                                                                      | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 9(b)(i)         | <ul style="list-style-type: none"> <li>Y calculated (1)</li> <li>body condition index calculated to 2 dps (1)</li> </ul> | <p><u>Example of calculation:</u></p> <p><math>Y = 0.73 \times 86.4 - 34.5 = 28.572</math></p> <p><math>26.4 \div 28.572 = 0.92</math><br/>ecf from calculation of Y</p> | (2)  |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *9(b)(ii)       | <p>Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><u>Indicative content</u></p> <ul style="list-style-type: none"> <li>decrease in body mass (D)</li> <li>therefore decrease in condition index (D / E)</li> <li>because less nutritious plant material available (E)</li> <li>decrease in organic matter in stomach (D)</li> <li>because less plant material available (E)</li> <li>increase in mineral ion content (D)</li> <li>because more foraging for roots (E)</li> <li>and therefore soil is consumed (E)</li> <li>less water in faeces (D)</li> </ul> |

|       |       | <ul style="list-style-type: none"> <li>as plant material does not contain as much water (E)</li> <li>therefore wombat had to conserve water (E)</li> </ul><br><ul style="list-style-type: none"> <li>2 months after drought measurements start returning back to normal (D)</li> <li>as quality and quantity of plant material increases (E)</li> </ul> <p><b>Level 1 :</b></p> <p>1 mark = 1 description (1 D)<br/> 2 marks = 2 descriptions (2 D) or 1 description and 1 explanation (D + E)</p> <p><b>Level 2 :</b></p> <p>3 marks = 3 descriptions that include what happens after rain (3D + D) or 2 descriptions and 1 explanations (2D +1E)<br/> 4 marks = 2 descriptions and 2 explanations (2D +2E)</p> <p><b>Level 3 :</b></p> <p>5 marks = 3 descriptions and 3 explanations (3D +3E)<br/> 6 marks = 4 descriptions and 4 explanations that include an explanation of why mineral content in stomach is higher (4D + 4E)</p> |
|-------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level | Marks |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 0     | 0     | No awardable content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 1     | 1-2   | <p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 2     | 3-4   | <p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts to provide the explanation being presented.</p> <p>Lines of argument occasionally supported through the application of relevant evidence (scientific ideas, processes, techniques and procedures).</p> <p>The explanation shows some linkages and lines of reasoning with some structure.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 3     | 5-6   | <p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to provide the explanation being presented.</p> <p>Line(s) of argument supported throughout by sustained application of relevant evidence (scientific ideas, processes, techniques and procedures).</p> <p>The explanation shows a well-developed and sustained line of reasoning which is clear, coherent and logically structured.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

| Number       | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                               | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark       |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(a)</b> | <p>An answer that includes the following</p> <ul style="list-style-type: none"> <li>the rate at which producers make organic material (by photosynthesis) /</li> <li>the rate at which light energy is incorporated into organic matter (by plants / producers) /</li> <li>rate at which carbon is fixed into organic matter (by photosynthesis) (1)</li> <li>suitable units of biomass per area per time or energy per area per time (1)</li> </ul> | <p>Accept organic matter / carbon compounds / biomass<br/>Accept plants / autotrophs</p> <p>Do not accept: energy produced<br/>Accept energy converted / turned into</p> <p>Accept eg <math>\text{g m}^{-2} \text{ year}^{-1}</math>, <math>\text{kg m}^{-2} \text{ year}^{-1}</math>, <math>\text{kJ m}^{-2} \text{ year}^{-1}</math><br/><math>\text{g (of carbon) m}^{-2} \text{ year}^{-1}</math><br/>Accept <math>\text{cm}^{-2}</math> or <math>\text{min}^{-1}</math> as units<br/>Accept <math>\text{m}^{-3}</math></p> | <b>(2)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                               | Additional Guidance                                                                                                                                                                                                                                                                                                           | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(b)</b>    | <p>A description that includes two of the following:</p> <ul style="list-style-type: none"> <li>(energy passes) to other appropriate animals (1)</li> <li>(energy remains) in plant biomass (1)</li> <li>(energy) released in respiration (in plants) (1)</li> </ul> | <p>Accept eaten by herbivores / primary consumers / insects / rabbits etc</p> <p>Accept plants grow / energy stored in plants (remain in the field and) broken down by decomposers remains in humus in the soil</p> <p>Accept lost as heat from respiration used for active transport / other correct metabolic processes</p> | <b>(2)</b> |

| Level | Marks |                      |
|-------|-------|----------------------|
| 0     | 0     | No awardable content |



|   |     |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | 1-3 | <p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context</p>        |
| 2 | 4-6 | <p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.</p> <p>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion shows some linkages and lines of scientific reasoning with some structure.</p>                                                |
| 3 | 7-9 | <p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.</p> <p>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.</p> <p>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 10(c)           | <p>Level 1: links information given to effect on dung beetles (up to 3 points from anywhere)</p> <p>Level 2: links information given to effect on dung beetles (up to 6 points from a minimum of two categories)</p> <p>Level 3: links information given to effect on dung beetles (up to 9 points with at least two from each of three categories)</p> <p><b>Indicative content</b></p> <p><b>Threats to dung beetles (T points)</b></p> <ul style="list-style-type: none"> <li>• (less grazing animals on land) so less dung available ie reduced food source</li> <li>• (farmland used for building / development) so reduced habitat</li> <li>• (animals kept in sheds overwinter) so food source unreliable / not constant</li> <li>• (routine use of anti-parasitic drugs) so drugs in animal faeces which kill dung beetles</li> <li>• (isolated populations of dung beetles) so genetic diversity is reduced</li> <li>• (isolated populations of dung beetles) - small populations of dung beetle species have a small gene pool, so allele frequencies can change rapidly</li> <li>• small populations are more vulnerable to disease</li> <li>• (many) dung beetles feed specifically on the dung of particular species, so reduction in species of grazing animals decreases diversity</li> </ul> <p><b>Benefits of dung beetles (B points)</b></p> <ul style="list-style-type: none"> <li>• (remove dung from fields) so more access for grazing by animals / plants get light for photosynthesis</li> <li>• (remove dung from fields) so less chance of parasites living in dung and re-infecting cattle</li> <li>• (bury dung underground) so decomposers can break it down</li> <li>• decomposition of dung is faster if dung beetles are present</li> <li>• (decomposed dung) increases mineral content of soil</li> <li>• (eaten by birds etc) so provide food for other animals / loss of dung beetles could lead to collapse of food chains</li> </ul> |      |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>Wider points and consequences for farming (W points)</b></p> <ul style="list-style-type: none"> <li>• no evidence or stats to prove or disprove statement</li> <li>• if farming practices change animals will suffer eg may die if left outside over winter</li> <li>• if farming practices change, less economically viable to farm / yields may be lower</li> <li>• if farming practices change, less food produced for human consumption</li> <li>• climate change may have an effect on decline of dung beetles eg rise in temperatures, changed rainfall patterns</li> <li>• a new predator might be responsible for decline</li> <li>• urbanisation might be causing change, not farming practices</li> <li>• (routine use of anti-parasitic drugs) kill other beneficial invertebrates (as well as dung beetles)</li> <li>• pesticides (anti-parasitic drugs) may affect other animals in food chain: accumulation</li> <li>• adding fertilisers disrupts dung beetle life cycle</li> <li>• ploughing pasture disrupts dung beetle life cycle</li> <li>• (digging tunnels) improves soil structure by aeration</li> <li>• dung beetles may be involved in seed dispersal (seeds in faeces being moved around by beetles)</li> <li>• cattle contribute to global warming, so better not to farm cattle</li> </ul> |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Total for Question 10 = 13 marks

|                  |                                                                                                                                              |                                                                                                                      |            |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------|
| <b>10 (a)(i)</b> | An explanation that makes reference to the following:<br><br>divide energy in producers by energy in sunlight (1)<br><br>multiply by 100 (1) | $85\,000 \div 7\,000\,000$<br><br>$\times 100 = 1.21$<br><br>Correct answer gains full marks, with no working shown. | <b>(2)</b> |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------|

| Question Number   | Answer                                                                                                                                                                                                                                         | Additional Guidance                                                                                                                                    | Mark       |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10 (a)(ii)</b> | An answer that makes reference to one of the following: <ul style="list-style-type: none"> <li>light reflected (from leaf) (1)</li> <li>light misses {chloroplast / chlorophyll} (1)</li> <li>only certain wavelengths absorbed (1)</li> </ul> | Accept transmitted / not absorbed by {chloroplast / chlorophyll}<br><br>Accept limiting factors eg lack of CO <sub>2</sub> , water etc may reduce rate | <b>(1)</b> |

| Question Number    | Answer                                                                                                                                                                                                                                                                                     | Additional Guidance | Mark       |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>10 (a)(iii)</b> | An explanation that makes reference to two of the following: <ul style="list-style-type: none"> <li>because some of the energy is lost through {respiration / heat / movement} (1)</li> <li>some of the producers not eaten (1)</li> <li>some of the producers not digested (1)</li> </ul> |                     | <b>(2)</b> |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>*10(b)</b>   | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><u>Light: (L)</u></p> <ul style="list-style-type: none"> <li>more light at equator / less light at higher latitudes</li> </ul> <p><u>Light dependent stage: (L)</u></p> <ul style="list-style-type: none"> <li>light excites electrons</li> <li>photolysis occurs</li> <li>ATP made / photophosphorylation</li> <li>NADPH / reduced NADP made</li> </ul> <p><u>Light independent stage: (L)</u></p> <ul style="list-style-type: none"> <li>Calvin cycle</li> <li>NADPH / ATP used</li> <li>Carbon fixation</li> <li>to reduce carbon dioxide to carbohydrate / GP / GALP / glucose</li> </ul> <p><u>Temperature: (L)</u></p> <ul style="list-style-type: none"> <li>temperature is higher at the equator / lower at higher latitudes</li> <li>temperature affects enzymes</li> <li>eg. RUBISCO enzyme</li> <li>temperature affects active uptake of mineral ions</li> <li>temperature affects rate of transpiration</li> </ul> <p><u>Other abiotic variables: (A)</u></p> |



- identifies other abiotic variables eg carbon dioxide / water / mineral ions / pH
- carbon dioxide unlikely to be a limiting factor
- comment on lack of available water eg in deserts / polar regions or excess of water eg flooded areas
- water needed for photolysis / mineral ion transport
- use of named mineral ion eg. nitrate for amino acids / protein
- soil edaphic factors
- abiotic factors in the oceans discussed

**Biotic factors: (B)**

- biotic factors also affect productivity
- disease / infection / bacteria / fungi / named pathogen
- grazing / herbivore populations / pest populations
- competition eg for light
- decomposition is slower at higher latitudes (affects mineral ion availability)
- human factors eg deforestation / pesticide use / fertilizer use / crop planting
- biotic factors in the oceans discussed

**Productivity factors (B)**

- productivity subject to limiting factors
- productivity in cool temperate can exceed warm temperate
- productivity in the oceans not taken into account
- unequal size of latitude ranges (makes comparison difficult)
- idea of interaction between multiple / complex factors affecting productivity

| Level | Marks |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0     | 0     | No awardable content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1     | 1-3   | <p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> <p><b>Up to three from L, A or B</b></p>                                                             |
| 2     | 4-6   | <p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.</p> <p>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion shows some linkages and lines of scientific reasoning with some structure.</p> <p><b>At least two from L and at least two from A or B</b></p>                                                                                |
| 3     | 7-9   | <p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.</p> <p>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.</p> <p>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> <p><b>At least two from L plus at least two from A and two from B with no major errors</b></p> |



| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Additional guidance                                                                                                                                                                                                                                                                                                  | Mark     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>9(a)</b>     | <p>An answer that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>• phytoplankton (biomass) is {higher in November / lower in December} <b>and</b> {zooplankton / sardines} (biomass) is {lower in November / higher in December} (1)</li> <li>• phytoplankton were consumed (by zooplankton) / sardines (increased) as had more {food / zooplankton} (1)</li> <li>• energy decreases (along the food chain) / not all energy transferred (1)</li> <li>• as energy is lost due to respiration / egestion / excretion / not eaten (1)</li> <li>• biomass pyramids have different shapes as they are {calculated per month / one moment in time} but energy pyramids are calculated for a year (1)</li> </ul> | <p><b>Allow</b><br/>phytoplankton biomass decreases (in December)<br/><b>and</b><br/>{zooplankton / sardines} biomass increases (in December)<br/><b>Allow</b><br/>phytoplankton is highest in November and zooplankton is highest in December</p> <p><b>Allow</b> energy pyramid does not show seasonal changes</p> | <b>3</b> |

| Question Number | Answer                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                                                                                                                                                     | Mark     |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>9(b)(i)</b>  | <ul style="list-style-type: none"> <li>correct calculation of energy that is transferred (1)</li> <li>calculation of percentage of energy that is transferred and given to nearest whole number (1)</li> </ul> | <p>Example of calculation<br/> <math>6800000 - 6080000 = 720000</math></p> <p><math>720000/6800000 \times 100 = 11 \%</math></p> <p><b>11(%) = 2 marks</b></p> <p>720000 <b>OR</b><br/> <math>6800000 - 6080000</math><br/> <b>OR</b><br/> 10.588 <b>for one mark</b></p> <p><b>Correct answer with no working gains full marks</b></p> | <b>2</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                    | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>9(b)(ii)</b> | <p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> <li>seals maintain (constant) body temperature / sardines are same temperature (as environment) (1)</li> <li>so seals maintain high metabolic rate / have high respiration (rate) / fast metabolism (1)</li> <li>because seals lose (more) <b>heat</b> (to the environment) (1)</li> <li>seals may have more indigestible parts / less edible eaten / excretion (1)</li> </ul> | <p><b>Allow</b> sardines can not control temperature<br/> <b>Allow</b> sardines rely on environment for temperature<br/> <b>Allow</b> converse for sardines</p> <p><b>Allow</b> converse</p> <p><b>Allow</b> converse</p> <p><b>Allow</b> converse</p> | <b>3</b> |

| Question Number | Answer                                                        | Additional guidance                                                                                                                                   | Mark     |
|-----------------|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>9(c) (i)</b> | <ul style="list-style-type: none"> <li>GPP – R (1)</li> </ul> | <p><b>Allow</b> energy available for (primary) consumers / energy available for growth / energy left after respiration / energy stored in biomass</p> | <b>1</b> |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>9*(c)</b>    | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><b>Description (D)</b></p> <ul style="list-style-type: none"> <li>• increasing light intensity increases biomass (of phytoplankton)</li> <li>• at 10 °C, as LI increases biomass increases then levels off</li> <li>• at 20 °C as LI increases biomass increases and does not level off</li> <li>• at 30 °C increase in biomass is low(er) at low LI</li> <li>• at 30 °C, increase in biomass is greater at higher LI</li> <li>• at (high LI / 20-25) increase in temperature increases biomass / at (low LI / 5-15) increase in temperature increases then decreases biomass</li> </ul> <p><b>Explanations (E)</b></p> <ul style="list-style-type: none"> <li>• at 10 °C, temperature limits biomass production at high LI</li> <li>• at 20 °C / 30 °C, light limits biomass production</li> <li>• respiration rate increases with temperature</li> <li>• warmer temperatures increase evaporation so more clouds</li> <li>• clouds decrease light intensity (so less photosynthesis)</li> <li>• (so) at low light intensity with high temperatures there is less NPP / phytoplankton growth / less energy for food chain</li> <li>• lower phytoplankton growth means less food for orcas so fewer orcas / population decreases</li> <li>• at warmer temperatures and high LI more energy entering food chain / higher GPP so orca population would stay same / increase</li> <li>• NPP shows relationship between photosynthesis and respiration</li> <li>• nitrates used to make proteins / amino acids / DNA (or other named nutrients) (so can limit phytoplankton)</li> <li>• increased carbon dioxide may increase GPP / photosynthesis</li> </ul> <p><b>Fossil fuel hypothesis and validity (F)</b></p> <ul style="list-style-type: none"> <li>• fossil fuel use releases carbon dioxide</li> <li>• lowering fossil fuel use will lead to less global warming and cloud cover</li> <li>• the data is only from one experiment / only one month trial</li> <li>• no evidence cloud cover will increase</li> <li>• other factors (rather than fossil fuel use) can affect global temperature / carbon dioxide levels</li> <li>• other greenhouse gases are present (e.g. methane)</li> <li>• carbon dioxide could cause acidification affecting photosynthesis /</li> </ul> |

|       |              | <p>phytoplankton growth / GPP</p> <ul style="list-style-type: none"> <li>• phytoplankton are affected by other factors / eaten by other organisms / part of other food chains</li> <li>• other factors may affect orcas</li> <li>• orcas eat other food sources / orcas are part of other food chains</li> </ul>                                                                                                                                                                                                                                                                                     |
|-------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Level | Marks        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 0     | 0            | No awardable content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 1     | 1-2<br>(1-3) | <p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> <p><b>1 any one point described from any of D, E, or F</b><br/> <b>2 any two points described from any of D, E, or F</b></p>                                          |
| 2     | 3-4<br>(4-6) | <p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.</p> <p>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion shows some linkages and lines of scientific reasoning with some structure.</p> <p><b>3 any three points, from at <u>least two</u> of D, E, F</b><br/> <b>4 any four points, from at <u>least two</u> of D, E, F</b></p>                                                                       |
| 3     | 5-6<br>(7-9) | <p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.</p> <p>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.</p> <p>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> <p><b>5 any four points and must be from <u>all</u> three of D, E, and F</b><br/> <b>6 any five points and must be from <u>all</u> three of D, E, and F</b></p> |

| Question Number | Answer                                                                                                                                                                                                                 | Mark     |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>8 (a)</b>    | <p>The only correct answer is A</p> <p><i>B is incorrect as R should not be added</i></p> <p><i>C is incorrect as photosynthesis is not added</i></p> <p><i>D is incorrect as photosynthesis is not subtracted</i></p> | <b>1</b> |

| Question Number | Answer                                                               |                           |                             |                                  |      |                | Additional guidance | Mark |  |
|-----------------|----------------------------------------------------------------------|---------------------------|-----------------------------|----------------------------------|------|----------------|---------------------|------|--|
| 8(b)(i)         | Age of heather plant                                                 | Rank age of heather plant | Leaf area : woody stem area | Rank leaf area : woody stem area | d    | d <sup>2</sup> |                     | 2    |  |
|                 | 16                                                                   | 4                         | 0.7                         | 4.5                              | -0.5 | 0.25           |                     |      |  |
|                 | 15                                                                   | 5                         | 0.5                         | 8                                | -3   | 9              |                     |      |  |
|                 | 12                                                                   | 6                         | 0.6                         | 6                                | 0    | 0              |                     |      |  |
|                 | 4                                                                    | 9                         | 2                           | 1                                | 8    | 64             |                     |      |  |
|                 | 7                                                                    | 8                         | 1.1                         | 2.5                              | 5.5  | 30.25          |                     |      |  |
|                 | 22                                                                   | 1                         | 0.2                         | 10                               | -9   | 81             |                     |      |  |
|                 | 20                                                                   | 2                         | 0.3                         | 9                                | -7   | 49             |                     |      |  |
|                 | 3                                                                    | 10                        | 1.1                         | 2.5                              | 7.5  | 56.25          |                     |      |  |
|                 | 17                                                                   | 3                         | 0.5                         | 7                                | -4   | 16             |                     |      |  |
|                 | 11                                                                   | 7                         | 0.7                         | 4.5                              | 2.5  | 6.25           |                     |      |  |
|                 | <b>one mark</b> for correct ranks (2.5 and 2.5) (1)                  |                           |                             |                                  |      |                |                     |      |  |
|                 | <b>one mark</b> for correct d and d <sup>2</sup> (7.5 and 56.25) (1) |                           |                             |                                  |      |                |                     |      |  |

| Question Number | Answer                                                                                                                                                                                                                         | Additional guidance                                                                                                                                                                                                                                                                                                                                 | Mark     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>8(b)(ii)</b> | <ul style="list-style-type: none"> <li>• calculation of <math>6 \sum d^2</math> (<b>1872</b>) (1)</li> <li>• calculation of <math>n(n^2-1)</math> (<b>990</b>) (1)</li> <li>• calculation of <math>r_s</math> value</li> </ul> | <p><b>Allow ecf</b> from (i)</p> <p><b>-0.89(1) = three marks</b><br/>(note must be negative)</p> <p><b>Allow 1.89 for two marks only</b></p> <p><b>Allow 0.89(1) (with no minus) for two marks only</b></p> <p><b>Allow 1872 for one mark</b><br/><b>Allow 990 for one mark</b></p> <p><b>Correct answer with no working gains full marks.</b></p> | <b>3</b> |

| Question Number  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark     |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>8(b)(iii)</b> | <p>An answer that makes reference to the following:</p> <ol style="list-style-type: none"> <li>there is a <b>significant</b> (negative) <b>correlation</b> (1)</li> </ol> <p><b>and two from</b></p> <ol style="list-style-type: none"> <li>(because) the calculated value is <b>greater</b> than the critical value (1)</li> <li>critical value is 0648 / 0.794 (1)</li> <li>there is a less than 0.05 / 0.01 <b>probability</b> that the correlation is due to <b>chance</b> (1)</li> </ol> | <p><b>Allow ECF from (ii)</b></p> <p><b>Allow as</b> age of heather increases, ratio of leaf area : woody stem area <b>significantly</b> decreases</p> <p><b>Allow</b> correlation at the (5% / 1%) <b>significance</b> level</p> <p><b>Do not accept</b> positive correlation</p> <p><b>Ignore</b> significant relationship / significant difference</p> <p><b>Allow</b> 5% / 1%</p> <p><b>Allow</b> {0.95 / 0.99 / 99% / 95%} probability that the correlation is not due to chance</p> | <b>3</b> |

| Question Number | Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8 *(c)          | <p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><b>Productivity / effects of age of heather (P)</b></p> <ul style="list-style-type: none"> <li>old heather is less productive / has low NPP / young heather is more productive / has high NPP</li> <li>old heather has low leaf area ratio / young heather has high leaf area ratio</li> <li>old heather fixes less carbon / young heather fixes more carbon</li> <li>old heather has low photosynthesis (compared with respiration) / young heather has high photosynthesis (compared with respiration)</li> <li>with low NPP less energy for food chains / with high NPP more energy for food chains</li> </ul> <p><b>Rewilding (R)</b></p> <p>advantages</p> <ul style="list-style-type: none"> <li>allows (secondary) <b>succession</b> (to return to original ecosystems)</li> <li>increases biodiversity initially</li> <li>which would allow natural species to return</li> <li>peat locks up carbon in peat / peat decomposes slowly so slow release of carbon</li> <li>reducing global warming / climate change</li> </ul> <p>disadvantages</p> <ul style="list-style-type: none"> <li>older heather shades other plants / blocks light from small plants</li> <li>as most species that would colonise area are extinct there are few grazing animals / few predators</li> <li>some species could dominate (and outcompete others)</li> <li>loss of income for farmers / farmers suffer unemployment</li> <li>reduces carbon fixation / energy fixation (from old heather)</li> </ul> <p><b>Burning (B)</b></p> <p>advantages</p> <ul style="list-style-type: none"> <li>removes old (unproductive) heather / allows young heather to grow</li> <li>stimulates (seeds of) heather to germinate (for new plants)</li> <li>stops ground being shaded so more light for other plant species / young heather</li> <li>more grouse / food for birds of prey / increase bird of prey populations</li> <li>more income for farmers (from grouse / sheep farming)</li> <li>increases carbon fixation / energy fixation (from old heather)</li> </ul> <p>disadvantages</p> <ul style="list-style-type: none"> <li>it is not a natural ecosystem / grouse moors are not natural</li> <li>leads to loss of peat / less peat formed</li> <li>kills other species as well as heather / not selective</li> <li>reduces locked up carbon / releases carbon dioxide</li> <li>leads to pollution / global warming / climate change</li> <li>makes farmers <b>dependent</b> on grouse farming</li> <li>unsightly when burning / causes health issues from smoke / can cause fires that get out of control</li> </ul> | 6    |



|                |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |
|----------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|                |              | <p><b>Level 1:</b><br/> <b>1 mark:</b> any <b>one</b> comment<br/> <b>2 marks:</b> any <b>two</b> comments</p> <p><b>Level 2:</b><br/> <b>3 marks:</b> any <b>three</b> comments from at least two of <b>P, B, or R</b><br/> <b>4 marks:</b> any <b>four</b> comments from at least two of <b>P, B, or R</b></p> <p><b>Level 3:</b><br/> <b>5 marks:</b> any <b>four</b> comments must come from all three of <b>P, B, and R</b><br/> <b>6 marks:</b> any <b>five</b> comments must come from all three of <b>P, B, and R</b></p> |  |
| <b>Level 0</b> | Marks        | No awardable content evaluate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |
| <b>Level 1</b> | 1-2<br>(1-3) | <p>Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified.</p> <p>A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.</p>                                                                                                                                                                                                                       |  |
| <b>Level 2</b> | 3-4<br>(4-6) | <p>A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified.</p> <p>A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.</p>                                                                                                                                                                                                             |  |
| <b>Level 3</b> | 5-6<br>(7-9) | <p>A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information.</p> <p>A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.</p>                                                                                                                                                                                  |  |

(Total for Question 8 = 15 marks)

| Indicative content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p>ing to candidates' deployment of knowledge and understanding of the material in<br/>lis outlined in the generic mark scheme.</p> <p>not prescriptive and candidates are not required to include all the material which<br/>nal content included in the response must be scientific and relevant.</p> <p>eds / roots (from previous crops etc), followed by herbaceous plants, shrubs and<br/>ncreases number of niches for animals, resulting in an increase in index of<br/>at approximately 20 years with herbaceous plants / shrubs providing high<br/>s and then decreases as trees shade area<br/>s / shrub plant species reducing niche number and index of diversity</p> <p>rbaceous plants and shrubs with higher leaf areas grow<br/>unity ages due to increase in proportion of non-photosynthetic tissue (wood /<br/>hesis rate compared to respiration rate<br/>nt due to lack of decay of leaves may reduce NPP</p> <p>ow due to farming<br/>se with time due to humus / dead organic material from plants and animals<br/>posed by microbes to release minerals<br/>ases in climax community as few leaves are dropped from pine trees so there is</p> |  |

|  | Additional Guidance                                                                                                                                                                                                      |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>Accept</b> energy available to other organisms / next trophic level</p> <p><b>Accept</b> <math>NPP = GPP - R</math> / <math>GPP - R</math></p>                                                                     |
|  | Additional Guidance                                                                                                                                                                                                      |
|  | <p><b>Accept</b> increasing temperature increases rate of photosynthesis more than respiration</p> <p><b>Accept</b> photosynthesis rate {does not increase / is limited by light} but respiration rate does increase</p> |

|                                                                                                |
|------------------------------------------------------------------------------------------------|
|                                                                                                |
| focus on mainly just one method, with a few                                                    |
| trating isolated elements of biological knowledge and<br>to support the judgement being made.  |
| <b>) with little / no reference to graph</b>                                                   |
| re application of relevant evidence, with strengths and                                        |
| ages to elements of biological knowledge and understanding, with<br>ment being made.           |
| <b>) as shown in the graph linked to either N or M with</b>                                    |
| upported throughout by sustained application of relevant evidence<br>e scientific information. |
| ained linkages to biological knowledge and understanding with<br>made.                         |
| <b>ession (S) as shown in the graph over 50 years using N and</b>                              |
|                                                                                                |

| Number  | Answer                                                                                                                                                                                              | Additional Guidance                                                                                                                                                                                                 | Mark |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(a)(i) | An answer that includes the following:<br><br>There is no (significant) difference in the (mean) number of tar spots on leaves (from trees) near roads and trees {in parkland / far from roads} (1) | Accept there is no difference in the (mean) number of tar spots on leaves from trees near roads and trees {in polluted and non-polluted areas}<br><br>Ignore relationship / link<br><b>Do not allow</b> correlation | (1)  |

| Question Number | Answer                                                                                                                                                                                                                    | Additional Guidance                                                                                                                                                                                      | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(a)(ii)        | An answer that includes the following: <ul style="list-style-type: none"> <li>• calculation of <math>x - \bar{x}</math> (1)</li> <li>• substitution of values (1)</li> <li>• calculation of <math>t</math> (1)</li> </ul> | Example calculation<br><br>4.14<br>Accept - 4.14<br><br>Accept $3.06 / 1.10 / \sqrt{4.16} / 2.04$<br><br><b>2.03 / 2.029</b><br>Accept minus 2.03<br><br>Correct answer with no working gains full marks | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                      | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark |
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| 8(a)(iii)       | An explanation that includes the following: <ul style="list-style-type: none"> <li>• critical value is 2.05 (at <math>p=0.05</math>) (1)</li> <li>• calculated value (2.03) is less than critical value therefore accept the null hypothesis (1)</li> <li>• there is no <b>significant</b> difference between the tar spots {near the road and in parkland / in both places} (1)</li> </ul> | Allow ecf for wrong calculated value from part ii for appropriate answers in mp2 and 3<br><br>Accept correct value indicated in table<br><br>Accept $2.05 > 2.03$<br><b>Do not accept</b> - $2.03 < \text{critical value}$<br>Accept not enough evidence to reject $H_0$<br><br>Accept there is a <b>more than 5% probability</b> that the difference tar spots {near roads and in parkland / in each place} is due to chance.<br>Ignore refs to $p=0.1$ and $0.01$ | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(b)            | An answer that includes two of the following: <ul style="list-style-type: none"> <li>• select more than one tree in each area so that results are more {representative / repeatable} (1)</li> <li>• select {trees / leaves} using a random sampling method to avoid bias (1)</li> <li>• attempt to control another variable so that {distance from road is the only variable affecting number of tar spots / appropriate reason given / <u>for valid comparison</u>} (1)</li> <li>• {measure actual distance from road to ensure this is constant / select trees at different distance from road to test for a correlation}</li> </ul> | Accept repeat in other places so that results are more representative / repeatable<br>Ignore reference to valid / accurate / precise / calculation of mean<br>Ignore increasing sample size / recording more leaves on same tree<br><br>Accept select leaves of the same size, as bigger leaves could have more tar spots / measure the leaves to calculate number of spots per $\text{cm}^2$<br><br>No need to name variable.<br>If variable named credit appropriate reason<br>eg shading as {light / humidity} might affect development of spots<br>height on tree as height may affect exposure to pollution<br>Ignore time of day<br><br>Accept measure levels of air pollution {as this may depend on how busy the road is / other appropriate reason / to test for a correlation} | (2)  |

(Total for Question 8 = 9 marks)

| Answer                                                                                                                                   | Additional Guidance               | Mark       |
|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------|
| uses reference to three of the<br>s / larger quadrat} (1)<br>sampled (1)<br>dom / use random number<br>onsistent measure of the mean (1) | <b>Accept</b> use of running mean | <b>(3)</b> |

| Answer                      | Additional Guidance                                                   | Mark       |
|-----------------------------|-----------------------------------------------------------------------|------------|
| reference to the following: | e.g. light / temperature / pH /<br>named mineral / salinity /<br>wind | <b>(1)</b> |



| Answer                                                                                                                                                                                         | Additional Guidance                                                                                                                                                                                                                                                                    | Mark       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| quadrat and calculate the area of<br>the number of quadrats in grassland (1)<br>quadrats in area of grassland by number of<br>its per m <sup>2</sup> (1)<br>of grassland in m <sup>2</sup> (1) | <u>Example of calculation</u><br><br>50 × 50 = 2500 cm <sup>2</sup> /<br>0.25 m <sup>2</sup> and<br>90 × 45 = 4050 m <sup>2</sup><br><br>4050 × 4 = 16200<br>16200 × 9 = 145800<br>9 × 4 = 36<br><br>36 × (90 × 45) = 145800<br><br>Correct answer with no working<br>gains full marks | <b>(2)</b> |

| Answer                                                                            | Additional Guidance | Mark       |
|-----------------------------------------------------------------------------------|---------------------|------------|
| reference to the following:<br><br>plants / in each quadrat /<br>time of day} (1) |                     | <b>(2)</b> |

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|      |  |
|------|--|
| mark |  |
| 2)   |  |
| mark |  |
| 1)   |  |
| mark |  |
| 1)   |  |
| mark |  |
| 3)   |  |

| Answer                                                                                                                                                                                                | Additional Guidance | Mark |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| es reference to two of the following :<br><br>ess {water / air / oxygen} (1)<br><br>ynthesis / respiration /<br>eral ions} affected (1)<br><br>o plants / competition from other<br>compact soil) (1) |                     | (2)  |

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|                | Additional Guidance                                                         | Mark |                     |
|----------------|-----------------------------------------------------------------------------|------|---------------------|
| ;              |                                                                             |      | ing:                |
| 1)             | <b>ACCEPT</b> Number of species increases after both seagull species arrive |      | parents) / carriers |
| and 1985 (1)   |                                                                             |      |                     |
| maintaining    |                                                                             |      | for plants to       |
| new niches (1) |                                                                             | 4    | tax community       |
|                |                                                                             |      | 5                   |

unities / li  
s} (1)

| Answer                                                                                                                    | Mark |
|---------------------------------------------------------------------------------------------------------------------------|------|
| <i>neighbouring water molecules</i><br><i>neighbouring water molecules</i><br><i>between neighbouring water molecules</i> | 1    |



| Number       | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                   | Additional Guidance                                                                                                                                                                                                              | Mark       |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(a)</b> | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>lichens are pioneer species (1)</li> <li>they break down surface of rocks to create soil (1)</li> <li>therefore other plants are able to {grow / be established} (1)</li> <li>death and decay helps to {create humus / recycle minerals} (1)</li> <li>therefore providing niches for either plants or animals (1)</li> </ul> | <p>Allow soil {becomes deeper / contains more minerals / more fertile}</p> <p>Allow wider variety of plants or animals can live there.<br/>Allow description of {trees / shrubs} growing<br/>Allow climax community develops</p> | <b>(4)</b> |

| Question Number | Acceptable Answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance                                                                                                                                                                                                                                | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>10(b)</b>    | <p>An answer that makes reference to six of the following:</p> <ul style="list-style-type: none"> <li>relevant abiotic factor named (1)</li> <li>select {sample sites with environmental differences / one site with environmental gradient} (1)</li> <li>{quadrats / point frame} used {at random / in a transect} (1)</li> <li>to measure presence or absence of lichens (1)</li> <li>method used to measure abiotic factor described (1)</li> <li>t test carried out to measure significant difference (1)</li> <li>other named variable controlled or measured (1)</li> </ul> | <p>eg light intensity, temperature, distance from sea, altitude</p> <p>Allow calculation of percentage cover described</p> <p>Allow correlation test carried out to measure correlation if appropriate<br/>Allow standard deviations compared.</p> | <b>(6)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                           | Mark     |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>4 (a)(i)</b> | <p>The only correct answer is B (high high low)</p> <p><i>A is incorrect as high humidity would reduce transpiration rate</i></p> <p><i>C is incorrect as low wind speed would reduce transpiration rate</i></p> <p><i>D is incorrect as low temperature would reduce transpiration rate</i></p> | <b>1</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance | Mark     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------|
| <b>4(a)(ii)</b> | <p>An explanation that makes reference to four the following:</p> <ul style="list-style-type: none"> <li>• {reduced leaf surface area / smaller leaves} so {less transpiration / evaporation / reduces water loss} (1)</li> <li>• {thick epidermis / waxy cuticle} {reduces evaporation / reduce water loss} (1)</li> <li>• stem used as photosynthetic organ / palisade cells (in stem) used for photosynthesis (1)</li> <li>• (when submerged) air spaces provide {oxygen for respiration / carbon dioxide for photosynthesis} (1)</li> <li>• high salt concentration (in cells) {lowers water potential / maintains water potential gradient} (1)</li> <li>• so less water loss by <b>osmosis</b> / water can enter by <b>osmosis</b> (1)</li> </ul> |                     | <b>4</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                          | Mark     |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>4(b)(i)</b>  | <p>A description that makes reference to two of the following:</p> <ul style="list-style-type: none"><li>• not quantitative / it is qualitative / not numerical (1)</li><li>• cannot do statistical tests (1)</li><li>• difficult to standardise / subjective (1)</li></ul> | <p><b>Allow</b> scales are different for different species</p> <p><b>Allow</b> different people make different estimates</p> | <b>2</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                  | Mark     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <b>4(b)(ii)</b> | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>• succession (has occurred) (1)</li> <li>• samphire is a {pioneer (species) / coloniser} (1)</li> <li>• samphire roots bind the silt / stabilises soil / stabilises substrate (1)</li> <li>• more {organic matter / humus} (in silt) due to {death / decomposition} (of plants) / more {nutrients / minerals / named nutrients} in soil (for other plant species) (1)</li> <li>• competition from {sea lavender / scurvy grass} results in less samphire (1)</li> <li>• abiotic factors change further in from sea / more sheltered further from sea (1)</li> </ul> | <p><b>Allow</b> Samphire is only species that can live close to water / only samphire has adaptations to live by water</p> <p><b>Allow</b> increased soil depth due to decomposition<br/><b>Allow</b> decay</p> <p><b>Allow</b> plants have different niches<br/><b>Allow</b> competition between scurvy grass and sea lavender</p> <p><b>Allow</b> named factors e.g. less wind / less salt / less exposed / less often flooded</p> | <b>4</b> |

| Number  | Answer                                                                                                                                                                                                                                                                                                                  | Additional Guidance                                                                                                                                                                                                                                                         | Mark |
|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 6(a)(i) | <p>A description that includes two of the following:</p> <ul style="list-style-type: none"> <li>• set up a grid (5m by 10m) (1)</li> <li>• use random numbers as co-ordinates (1)</li> <li>• placement of quadrat to avoid bias e.g. edge parallel to named axis / bottom LH corner on co-ordinate point (1)</li> </ul> | <p>Allow description of 2 tapes at right angles to each other / forming axes</p> <p><b>Do not allow</b> transect</p> <p>Ignore method of getting random numbers</p> <p>Allow random selection of numbered squares (in grid)</p> <p><b>Do not allow</b> throwing quadrat</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 6(a)(ii)        | <p>An answer that includes four of the following:</p> <ul style="list-style-type: none"> <li>• all three methods tested {same size area / <math>5\text{m}^2</math>} (1)</li> <li>• {correct values calculated for each size of quadrat / correct mean number of dandelions calculated per <math>5\text{m}^2</math> area} (1)</li> <li>• <math>\{0.01\text{m}^2 / \text{smallest quadrat}\}</math> gives an answer closest to actual value (1)</li> <li>• correct numerical reason given for choice (in context of <math>0.01\text{m}^2</math>) (1)</li> <li>• because smallest quadrat allows a more representative sample (1)</li> </ul> | <p>Accept that all three methods tested 10% of sampling area</p> <p>Accept description as part of calculation</p> <p><b>In <math>50\text{m}^2</math>:</b> <math>1\text{m}^2</math> quadrat gives 10 dandelions, <math>0.25\text{m}^2</math> gives 30, <math>0.01\text{m}^2</math> gives 60 /</p> <p><b>In <math>1\text{m}^2</math>:</b> <math>1\text{m}^2</math> quadrat gives 0.2, <math>0.25\text{m}^2</math> gives 0.6, <math>0.01\text{m}^2</math> gives 1.2 /</p> <p><b>The mean number of dandelions in <math>5\text{m}^2</math> is 5.3</b></p> <p>Allow <math>0.01\text{m}^2</math> is most accurate / most effective</p> <p>Accept 60 is closest to 53 / 1.2 is closest to 1.06 / 6 is closest to 5.3</p> <p>Ignore 6 is closest to 53</p> <p>Accept smallest quadrat tests a wider area</p> | (4)  |

| Question Number | Answer                                                                                                                                                                                   | Additional Guidance                                                                                                                               | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 6(b)            | <p>A description that includes the following:</p> <ul style="list-style-type: none"> <li>• number of species present (1)</li> <li>• number of individuals of each species (1)</li> </ul> | <p>Penalise amount once</p> <p>Allow species richness</p> <p>Allow population of each species</p> <p>Allow plants / organisms for individuals</p> | (2)  |

| Question Number | Answer                                                                                                                                                                       | Additional Guidance                               | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------|
| 6(c)(i)         | <ul style="list-style-type: none"> <li>• a group of {individuals / organisms} (with similar characteristics) that can interbreed to produce fertile offspring (1)</li> </ul> | <p>Accept reproduce</p> <p>Ignore mate viable</p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>6(c)(ii)</b> | <p>A description that includes two of the following:</p> <ul style="list-style-type: none"> <li>• gel electrophoresis (1)</li> <li>• detail of method chosen (1)</li> <li>• {look for similarities between the two banding patterns / compare the two banding patterns} (1)</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>• DNA sequencing</li> <li>• detail of method chosen (1)</li> <li>• compare the two base sequences (using bioinformatics) / look for similarities between the two base sequences</li> </ul> | <p>eg use restriction enzymes to cut DNA into fragments / place fragments in wells on agarose gel / pass current through gel</p> <p>Accept if they are related the bands will be similar / the more similarities between the banding patterns, the more closely related they are</p> <p>Accept use of {taq / DNA} polymerase</p> <p>Accept the more similarities between the base sequences, the more closely related they are</p> | <b>(2)</b> |

**(Total for Question 6= 11 marks)**

| Additional Guidance          |  | Mark       | Additional Guidance                                 |  | Mark       | Answer                                           | Mark | M |
|------------------------------|--|------------|-----------------------------------------------------|--|------------|--------------------------------------------------|------|---|
|                              |  |            |                                                     |  |            |                                                  |      |   |
| <b>DO NOT ACCEPT</b> burning |  | <b>(3)</b> | <b>Eg:</b> number of squares occupied / point frame |  | <b>(3)</b> | the following:                                   |      |   |
|                              |  |            |                                                     |  |            | water line (1)<br>116 m (1)                      |      |   |
|                              |  |            |                                                     |  |            | water line /<br>line /<br>rd /                   |      |   |
|                              |  |            |                                                     |  |            | or elder /<br>irram grass /<br>ange is 85 m (1)  |      |   |
|                              |  |            |                                                     |  |            | im is greater than elder /<br>maximum is 30% (1) |      |   |
|                              |  | <b>(3)</b> |                                                     |  |            | <b>DO NOT ACCEPT</b><br>description of data      |      |   |
|                              |  |            |                                                     |  |            |                                                  |      |   |

|      |            |
|------|------------|
| Mark | (3)        |
|      | title} (1) |



| Number | Answer                                                                                                                                                                                                                                                                                     | Additional Guidance | Mark |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 8(a)   | <p>The only correct answer is:</p> <p><b>B</b> correlation coefficient</p> <p>A is incorrect because <i>chi squared compares frequencies</i></p> <p>C is incorrect as <i>standard deviation is a measure of dispersion</i></p> <p>D is incorrect as <i>t-test compares mean values</i></p> |                     | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Additional Guidance                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(b)            | <p>An explanation that makes reference to five of the following points:</p> <ul style="list-style-type: none"> <li>{pioneer species / mosses / lichens arrive} (after glaciers melt and colonise bare rock) (1)</li> <li>{decomposition /decay} increases the soil depth / humus content / minerals / nutrients (1)</li> <li>therefore (larger) plants can grow (due to soil depth / minerals / nutrients) (1)</li> <li>leaf litter increases after 40 / 100 years as more herbaceous plants / shrubs / trees are present (1)</li> <li>(steep) increase in nitrate after 40 / 100 years as more leaves / plants / animals / faeces (1)</li> <li>leaf litter falls (towards the end / from 150 – 250 years) as climax community has emerged (1)</li> </ul> | <p><b>Accept</b> animals arrive / increased niches</p> <p><b>Accept</b> larger plants</p> <p><b>Accept</b> increase from 12.8 to 277 as equivalent to 40/100</p> <p><b>Accept</b> increase from 5.3 to 21.8 as equivalent to 40 / 100</p> <p><b>Accept</b> nitrate continues to increase due to presence of animals / faeces (as leaf litter falls)</p> | (5)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                           | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                          | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(c)(i)         | <p>An explanation that makes reference to three of the following points:</p> <ul style="list-style-type: none"> <li>(leghaemoglobin / myoglobin) is not S shaped / is linear / is a straight line (1)</li> <li>because (leghaemoglobin / myoglobin) affinity for oxygen does not alter (1)</li> <li>because (with leghaemoglobin) there is no cooperative binding (1)</li> <li>(leghaemoglobin) binds to one molecule (of oxygen) (1)</li> </ul> | <p><b>Accept</b> converse for haemoglobin</p> <p><b>Accept</b> converse for haemoglobin</p> <p><b>Accept</b> converse for haemoglobin</p> <p><b>Accept</b> shape change to subunits / conformation change</p> <p><b>Accept</b> (leghaemoglobin / myoglobin) has only one oxygen binding site</p> <p><b>Accept</b> haemoglobin has four binding sites / binds to four molecules of oxygen</p> | (3)  |

| Question Number | Answer | Additional Guidance | Mark |
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|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                      |     |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 8(c)(ii) | <p>An explanation that makes reference to three of the following points:</p> <ul style="list-style-type: none"> <li>• (waterlogged soil has) little / low / less / no oxygen (1)</li> <li>• (leghaemoglobin) provides oxygen for <b>respiration</b> (1)</li> <li>• which enables active uptake of mineral ions / named mineral ion (1)</li> <li>• such as (calcium) to make calcium pectate / (nitrate) to make amino acids / (magnesium) to make chlorophyll (1)</li> </ul> | <p><b>Accept</b> binds to / stores oxygen for respiration</p> <p><b>Accept</b> other correct active processes e.g. synthesis of amino acids / protein synthesis / mitosis</p> <p><b>Accept</b> other correct examples of minerals with functions</p> | (3) |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|

| Question | Answer | Additional Guidance | Mark |
|----------|--------|---------------------|------|
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|       |        |  |     |
|-------|--------|--|-----|
| 7 (a) | 50 (1) |  | (1) |
|-------|--------|--|-----|

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                   | Additional Guidance                                          | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------|
| 7 (b)           | <p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> <li>because food attracts mouse into trap (1)</li> <li>because {small entrance / size of trap} allows {small animals / mice} to enter trap / larger animals cannot enter trap (1)</li> <li>because door slides down when the mouse {approaches the food / walks on board} (1)</li> </ul> | Accept the entrance is big enough for mice to enter the trap | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional Guidance | Mark |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 7 (c)           | <p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> <li>mice have large surface area to volume ratio (1)</li> <li>(therefore) {lose a lot of heat / lose heat quickly} (1)</li> <li>heat generated by {metabolism / respiration} (1)</li> <li>insufficient food to {maintain (high) metabolic rate / release enough energy} (1)</li> <li>no bedding {for insulation / to prevent heat loss} (1)</li> </ul> |                     | (4)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|
| 7 (d)           | <p>An answer that makes reference to five of the following:</p> <p><b>Inaccurate because</b></p> <ul style="list-style-type: none"> <li>{births / deaths} may occur (1)</li> <li>migration may occur (1)</li> <li>marking may affect survival (1)</li> <li>mice may lose bands (1)</li> <li>food encourages capture / trap discourages capture (1)</li> </ul> <p><b>Accurate because</b></p> <ul style="list-style-type: none"> <li>{time / a week} is long enough for random dispersal (1)</li> <li>a lot of traps were set / sample size large (1)</li> <li>traps were randomly placed (avoids bias) (1)</li> </ul> | Accept that some animals are more or less likely than others to enter trap | (5)  |

| Number  | Answer                                                                                                                                                                                                                                                   | Additional Guidance                                                      | Mark |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------|
| 7(a)(i) | A description that includes three of the following: <ul style="list-style-type: none"> <li>• moved {across membrane / into cell / into root} by carrier proteins (1)</li> <li>• against a concentration gradient (1)</li> <li>• using ATP (1)</li> </ul> | Ignore channel proteins<br><br>Accept from a low to a high concentration | (3)  |

| Question Number | Answer                                                                                                                                                                 | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                             | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(a)(ii)        | A description that includes the following <ul style="list-style-type: none"> <li>• suitable mineral ion named (1)</li> <li>• appropriate function given (1)</li> </ul> | eg<br><b>nitrate / (ammonium)</b> – formation of amino acids / proteins / enzymes / nucleic acids / nucleotides / DNA / RNA / chlorophyll<br><b>phosphate</b> – formation of nucleotides / nucleic acids / DNA / RNA / ATP / ADP / amino acids<br><b>calcium</b> – formation of middle lamella / calcium pectate<br><b>magnesium</b> – formation of chlorophyll<br><br>Accept other correct mineral ions with correct functions | (2)  |

| Question Number | Answer                                                                                                                   | Additional Guidance                                                                                                            | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------|
| 7(b)(i)         | there is no difference in the (mean) height of { <i>Galium verum</i> / Lady's bedstraw} growing in meadows and dunes (1) | Accept no significant difference in the (mean) height of { <i>Galium verum</i> / Lady's bedstraw} growing in meadows and dunes | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                | Additional Guidance                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(b)(ii)        | An answer that includes the following: <ul style="list-style-type: none"> <li>• use of random numbers to select sampling site (1)</li> <li>• use of (frame or point) quadrat (to define sampling area) in meadow and dune (1)</li> <li>• measurement of {height / length} of {<i>Galium verum</i> / Lady's bedstraw} (1)</li> <li>• large sample size or use of running mean (1)</li> <li>• attempt to control relevant named variable (1)</li> </ul> | Accept description of setting up grid and using co-ordinates for random sampling<br><br>Accept closest plant to point selected in meadow and dune<br><br>eg at least 10 plants in each place<br><br>eg shading / slope / grazing / trampling / time of year / use of herbicide<br><br>Ignore soil type / pH / temperature / time of day | (5)  |

| Question Number | Answer                                                                                                                                                                                                 | Additional Guidance                                                                                                             | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|------|
| 7(b)(iii)       | An explanation that includes the following <ul style="list-style-type: none"> <li>• t-test (1)</li> <li>• (because it) tests for the difference between the means of two sets of values (1)</li> </ul> | Accept other suitable test eg Mann Whitney U test<br><br>Accept it tests for a (significant) difference between two sample sets | (2)  |

Total for Question 7 = 13 marks

| Number  | Answer                                                                                  | Additional Guidance                                                                                                                | Mark |
|---------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(a)(i) | there is no <b>difference</b> in the (mean) area of leaves growing in sun and shade (1) | Accept there is no <b>difference</b> in the (mean) area of leaves growing {in the two areas / at the <b>two</b> light intensities} | (1)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Additional Guidance                                                                                                                                                                                                                                                                                                                      | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(a)(ii)        | <p>An answer that includes four of the following:</p> <ul style="list-style-type: none"> <li>random selection of plants to be studied (1)</li> <li>measure leaf <b>area</b> of {hedge woundwort / <i>Stachys sylvatica</i>} (1)</li> <li>method of measurement described eg using squared paper (1)</li> <li>suggested method of control of which leaf to measure (1)</li> <li>(select leaves in) light and shade (1)</li> <li>{control / monitor} other relevant named factor (1)</li> </ul> | <p>Accept other suitable method eg {photocopy or trace and weigh / use of computer programme / measure length and width and multiply by a factor}</p> <p>eg lowest leaf on each plant</p> <p>Accept measurement of light intensity</p> <p>eg soil type, water {content / availability}, pH, mineral content, slope, aspect, same day</p> | (4)  |

| Question Number | Answer                                                                                                     | Additional Guidance                                                                                                                                                                                                                                                          | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(b)(i)         | <ul style="list-style-type: none"> <li>calculation of 2SD (1)</li> <li>calculation of range (1)</li> </ul> | <p><math>2 \times 9.62 = 19.24 \text{ (cm}^2\text{)}</math></p> <p><b>8.31 to 46.79</b> (cm<sup>2</sup>)    Accept 38.48</p> <p>Correct answer with no working gains full marks</p> <p>Correct calculation of value for shade (28.7 to 82.3/ range of 53.6) gives 1 mark</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                      | Additional Guidance                                                                                                                                                                                         | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(b)(ii)        | <ul style="list-style-type: none"> <li>calculation of difference between 2 means (1)</li> <li>substitution of values into denominator (1)</li> <li>correct value of <i>t</i> (1)</li> </ul> | <p>27.95 (ignore minus)</p> <p>Accept intermediate values 4.63 / 8.98 / <math>\sqrt{13.61}</math> / 3.69</p> <p>7.57 / 7.58 / 7.6 (ignore minus)</p> <p>Correct answer with no working gains full marks</p> | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                       | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 7(b)(iii)       | <p>An answer that includes three of the following:</p> <ul style="list-style-type: none"> <li>calculated value is more than the critical value of <b>2.02 / 2.71</b> (1)</li> <li>therefore reject the null hypothesis / <math>H_0</math> (1)</li> <li>there is a <b>significant</b> difference between the leaf area in sun and shade plants (1)</li> </ul> | <p><b>Allow ecf from part ii</b></p> <p>Accept <math>7.6 &gt; 2.02</math><br/> <b>Do not accept</b> minus <math>7.6 &lt; 2.02 / 2.71</math><br/>           Accept value circled in table</p> <p>Accept leaves of shade plants have a significantly bigger area<br/>           Accept there is a less than {0.05 / 5%} probability that the difference in leaf area is due to chance</p> | (3)  |

**(Total for Question 7 = 13 marks)**

|                                            | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark                     |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| :<br>s then<br>}<br>pecies<br>ites} /<br>s | <p>e.g. temperature / wind speed / humidity / rain / previous weather/ sunlight</p> <p>e.g. number of sweeps / size of nets / may not catch all species / some not caught / sampling was not random / subjective / relies on judgement when all are collected / bias / should grid areas / some not seen / some may fly away</p> <p>e.g. some butterflies not present at different times / hatch at different times / migrate at different times / should look at other months</p> <p>e.g. lots of fields needed / may be other differences between fields / sizes of fields / may differ / needs more repeats over more years</p> <p>IGNORE ethical issues</p> | (1)<br>(1)<br>(1)<br>(3) |
|                                            | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark                     |
| :<br>is<br>it /                            | <p>ACCEPT converse statement</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | (1)<br>(2)               |

|                                                                                        | Additional Guidance                                                           | Mark                     |
|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------|
| :78)                                                                                   | <p>(1)</p> <p>(1)</p> <p>Correct answer with no working gains full marks</p>  | (1)<br>(1)               |
|                                                                                        | Additional Guidance                                                           | Mark                     |
| ne following:<br>less / more varieties<br><br>g areas /<br><br>nsecticide / fertiliser | <p>ACCEPT converse statements</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> | (1)<br>(1)<br>(1)<br>(1) |

| Number  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Mark |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 4(a)(i) | <p>A description that includes five of the following:</p> <ul style="list-style-type: none"> <li>find mass of woodlice (1)</li> <li>{description / diagram} of respirometer (1)</li> <li>with {sodium hydroxide / potassium hydroxide / soda lime} (to absorb carbon dioxide) (1)</li> <li>measure distance moved by liquid in stated time (1)</li> <li>method of control of temperature (1)</li> <li>method of finding volume of oxygen used (1)</li> <li>method of calculation of rate (1)</li> </ul> | <p>Allow same / stated mass</p> <p>Accept description of basic respirometer or detail of method eg way of keeping woodlice away from soda lime</p> <p>Allow time to move fixed distance</p> <p>Accept thermostatically controlled waterbath<br/>Accept control tube described (to compensate for changes in temperature / air pressure)</p> <p>Accept volume of air needed to reset liquid to original position if syringe used / use of <math>\pi r^2 d</math></p> <p>Accept volume of oxygen used divided by time divided by mass<br/>Accept units ie <math>\text{mm}^3 \text{min}^{-1} \text{g}^{-1}</math><br/>Accept finding the gradient on a graph</p> | (5)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Additional Guidance                                                                                                                               | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 4(a)(ii)        | <p>An answer that includes the following:</p> <p><b>One from</b><br/>Safety</p> <ul style="list-style-type: none"> <li>soda lime is corrosive, so wear gloves / goggles (1)</li> <li>{allergy to woodlice / they may have bacteria on them} so wear gloves (1)</li> <li>glassware may break, so wear gloves (1)</li> </ul> <p><b>And one from</b><br/>Ethics</p> <ul style="list-style-type: none"> <li>avoid harm to woodlice by {handling carefully / handling with a paintbrush / handling with a teaspoon / returning to garden} (1)</li> <li>woodlice may be harmed by soda lime, so make sure they are separated from it eg {gauze / small bag} (1)</li> <li>woodlice might use all the oxygen in the respirometer so refresh the air (1)</li> </ul> | <p>Accept harmful / toxic / irritant</p> <p>Accept avoid reducing population by returning woodlice to garden (once investigation is over) (1)</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                         | Additional Guidance                                          | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------|
| 4(b)(i)         | <p>A explanation that includes the following:</p> <p>Test</p> <ul style="list-style-type: none"> <li>chi squared (1)</li> </ul> <p>Reason</p> <ul style="list-style-type: none"> <li>{used to compare observed and expected frequencies / we are investigating the distribution of a single categoric variable} (1)</li> </ul> | <p>Accept to compare observed and expected data / values</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                 | Additional Guidance                                                                                | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|------|
| 4(b)(ii)        | <p>An explanation that includes the following:</p> <ul style="list-style-type: none"> <li>(woodlice prefer dark conditions as) more likely to be {humid / damp} so woodlice less likely to lose water (1)</li> <li>(woodlice prefer) damp so can absorb oxygen (more) effectively (when gills are damp) (1)</li> </ul> | <p>Accept less likely to be eaten by predators</p> <p>Accept gas exchange for absorbing oxygen</p> | (2)  |



| Question Number  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional Guidance                                        | Mark |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------|
| <b>4(b)(iii)</b> | <p>A description that includes three of the following:</p> <ul style="list-style-type: none"> <li>• set up choice chamber in advance (1)</li> <li>• leave woodlice for longer than 5 minutes (1)</li> <li>• ensure all woodlice are the same species (1)</li> <li>• use more woodlice (than 5 / 20) (1)</li> <li>• {take a photograph and analyse that to count numbers / statement of how to deal with woodlice on boundary} (1)</li> </ul> | Accept clean chamber between trials to remove scent trails | (3)  |

**(Total for Question 4 = 14 marks)**

| Number | Answer                                                                                                                                 | Additional Guidance | Mark |
|--------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------|------|
| 8(a)   | There is no correlation between the (mean) abundance of {celandine plants / <i>Ficaria verna</i> } and the distance from the path. (1) | Accept these plants | (1)  |

| Question Number | Answer                                                                                                                                                                                               | Additional Guidance                                                                                                                                             | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(b)(i)         | <ul style="list-style-type: none"> <li>calculation of <math>\sum d^2</math> (1)</li> <li>calculation of intermediate step (1)</li> <li>calculation of <math>r_s</math> to <b>3 sf</b> (1)</li> </ul> | <p>example of calculation</p> $\sum d^2 = 236$ $\frac{6 \sum d^2}{n(n^2 - 1)} = 1.967$ $r_s = (-) 0.967$ <p>correct answer with no working gains full marks</p> | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                         | Additional Guidance                                                                                                                                                                                                                                                                        | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(b)(ii)        | <p>An answer that includes the following:</p> <ul style="list-style-type: none"> <li>critical value is 0.700 (1)</li> <li>calculated value (0.967) is greater than the critical value, therefore reject the null hypothesis (1)</li> <li>there is a <b>significant</b> (negative) correlation between distance from the path and abundance of celandine plants. (1)</li> </ul> | <p>Accept correct value indicated in table<br/>Accept 0.833</p> <p>Allow ecf from 8bi for wrong calculated value<br/>Do not allow minus 0.967 &lt; critical value</p> <p>Accept observed correlation between abundance of celandine plants and distance from path is not due to chance</p> | (3)  |

| Question Number | Answer                                                                               | Additional Guidance                                                                                                               | Mark |
|-----------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|------|
| 8(c)(i)         | <ul style="list-style-type: none"> <li>suitable abiotic factor chosen (1)</li> </ul> | <p>eg<br/>light intensity / humidity / temperature / soil pH / soil humus content / soil mineral content / soil water content</p> | (1)  |

| Question Number | Answer                                                                                                                                                                                                          | Additional Guidance                                                                                                                                                                                                                                                                                                        | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(c)(ii)        | <p>A description that includes the following points</p> <ul style="list-style-type: none"> <li>use of correct {equipment / method} (1)</li> <li>standardisation (1)</li> <li>location of samples (1)</li> </ul> | <p>eg use of probe / meter if appropriate.<br/>eg collection of soil sample, weighing, heating and reweighing</p> <p>eg sample at known depth / meter at known / same height above soil surface<br/>Ignore time of day / year</p> <p>eg sample at every position on the transect / at 1m intervals / smaller intervals</p> | (3)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                       | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 8(c)(iii)       | <p>An explanation that includes the following:</p> <ul style="list-style-type: none"> <li>comment on how factor will vary <u>as distance from path increases</u> (1)</li> <li>correct explanation for why this factor will vary (1)</li> <li>comment on how this affects plant physiology (1)</li> <li>explanation of how this affects growth (1)</li> </ul> | <p>{light intensity / temperature / pH} will decrease<br/>         {humidity / soil humus content} will increase<br/>         Accept {soil water / mineral content} will increase or decrease</p> <p>eg {light / temperature / humidity} affected by shading from trees<br/>         soil humus increased due to decomposing leaf litter<br/>         soil minerals increase due to decomposing leaf litter or decrease as trees / (mycorrhizal) fungi take up more<br/>         soil pH decreased by decomposing leaf litter<br/>         soil water increased as less evaporation due to shading / more humus or decreased as trees take up more water.</p> <p>eg light – reference to light dependent reactions of photosynthesis<br/>         temperature / pH – reference to enzyme-controlled reactions<br/>         humidity – reference to transpiration<br/>         water - reference to photolysis / mineral uptake / turgor pressure<br/>         minerals / humus – reference to uptake of nitrates etc</p> <p>eg less photosynthesis, so less glucose / amino acids for growth<br/>         slower <u>named</u> enzyme-controlled reaction for growth<br/>         more minerals, so more amino acids / chlorophyll etc for growth</p> | (3)  |

(Total for Question 8 = 14 marks)



| Number          | Answer                                                                                                                                                                                                                                                                                                                                                                            | Additional Guidance                                                                                                                                                                           | Mark       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>11(a)(i)</b> | <p>An answer including one of the following:</p> <p>{rainfall / availability of water / soil water} (1)</p> <p>OR</p> <p>frequency of {mowing lawn / grazing} / use of herbicide / trampling (1)</p> <p>OR</p> <p>time of year data was collected (1)</p> <p>OR</p> <p>{geographical location / altitude} of data collection sites (1)</p> <p>OR</p> <p>disease in plants (1)</p> | <p>Accept hours of {sunlight / cloud cover}</p> <p>Accept different number of participants involved</p> <p>Accept daylength</p> <p>Different gardens may have been surveyed in both years</p> | <b>(1)</b> |

| Question Number  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                       | Mark       |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>11(a)(ii)</b> | <p>An answer including five of the following:</p> <p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• large amount of data collected (1)</li> <li>• method is simple so easy to follow (1)</li> <li>• random sampling, so lack of bias (1)</li> </ul> <p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• area surveyed may not be exactly one m<sup>2</sup> (1)</li> <li>• area surveyed may not be chosen randomly (1)</li> <li>• {plants / flowers} may be identified incorrectly (1)</li> <li>• flowers may be counted incorrectly (1)</li> <li>• we are not told the area surveyed in 2019 (1)</li> <li>• time of year may vary (1)</li> </ul> | <p><b>At least one strength and one weakness for full marks</b></p> <p>Accept easy to count flowers / easier to count flowers than plants</p> <p>Accept one m<sup>2</sup> is {a very small / too small an} area</p> <p>Accept not all parts of UK might be covered</p> <p>Accept area surveyed may be different in the two years</p> <p>Accept not all data collected on the same day</p> | <b>(5)</b> |

| Question Number | Answer                                                                                                                                                                                                                                                                       | Additional Guidance                                                                                               | Mark       |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|------------|
| <b>11(b)(i)</b> | <p>A calculation including the following steps</p> <ul style="list-style-type: none"> <li>• calculation of <math>N(N-1)</math> (1)</li> <li>• calculation of {correct values for <math>n(n-1)</math> / denominator} (1)</li> <li>• calculation of final value (1)</li> </ul> | <p>1190</p> <p>Accept 110, 56, 182, 2 / 350</p> <p>3.4</p> <p>Correct answer with no working gains full marks</p> | <b>(3)</b> |

| Question Number  | Answer                                                                                                                                                                                                                                 | Additional Guidance                                           | Mark       |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|------------|
| <b>11(b)(ii)</b> | <p>A description including the following</p> <ul style="list-style-type: none"> <li>• {record / count} all species of plants (including grasses) (1)</li> <li>• {record / count} number of plants not number of flowers (1)</li> </ul> | <p>Accept {larger range of / more} plant species recorded</p> | <b>(2)</b> |



| Question Number | Answer                                                                                 | Additional Guidance                                                                                                                                                                                                                                                                                                                                                                                                          | Mark |
|-----------------|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>11(c)(i)</b> | <ul style="list-style-type: none"> <li>calculation of intermediate step (1)</li> </ul> | <p>Example calculation</p> <p>eg <math>\frac{41\,912}{38\,885} = 1.0778 / 1.078</math>      (ratio of nectar sugar 2019 to 2020)</p> <p>OR <math>\frac{38\,885}{41\,912} = 0.9278 / 0.928</math></p> <p>OR <math>\frac{41\,912}{3.8} = 11\,029.47</math>    (nectar sugar needed to support one bee)</p><br><p>3.5                                  3.53 gets 1 mark</p> <p>Correct answer with no working gains 2 marks</p> | (2)  |

| Question Number | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Additional Guidance                                                                                                                                                                                                                                                                                 | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 11(c)(ii)       | <p>An explanation including four of the following:</p> <ul style="list-style-type: none"> <li>S - (there will be a) decrease in population of bees due to lack of {food / nectar} (1)</li> <li>S - (data suggests) bee population decreases by 7.9% (1)</li> <li>S - (fewer bees so) reduced pollination of (wildflower) plants results in less {seed / offspring} produced (1)</li> <li>L - (reduced pollination of wildflower plants) so population of (wildflower) plants declines in future years (1)</li> <li>L - population of (wildflower) plants decline in future years could lead to further decline of bee populations (1)</li> <li>S / L - (fewer bees so) reduced pollination of {crop plants / named crop plant} results in decreased yield (1)</li> <li>L - description of effect on predators if fewer {bees / other pollinators} (1)</li> </ul> | <p><b>At least one short term and one long term effect for full marks</b></p> <p>Accept other pollinators for bees</p> <p>Accept ecf for correctly calculated % decrease from wrong value for 11ci</p> <p>Accept {reduced genetic diversity / smaller gene pool} as an alternative to bp 4 or 5</p> | (4)  |

**(Total for Question 11 = 17 marks)**



| Question Number | Answer                                                                                                                                                                                          | Additional guidance                                                                                                                                                                                                                                             | Mark       |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>5(b)(i)</b>  | <ul style="list-style-type: none"> <li>Calculation of <math>N(N-1)</math> (1)</li> <li>Calculation of <math>\sum n(n-1)</math> (1)</li> <li>Calculation of Index of biodiversity (1)</li> </ul> | <p>Example of calculation:<br/>130 x 129</p> <p>3580</p> <p>4.68</p> <p>130 x 129 <b>OR</b> 16770 <b>OR</b><br/>130 (130-1) <b>(one mark)</b></p> <p>3580 <b>(one mark)</b></p> <p>4.68 <b>(3 marks)</b></p> <p><b>Correct answer gains all three marks</b></p> | <b>(3)</b> |

| Question Number | Answer                                                                                                                                                                           | Additional guidance                                                                                                                      | Mark       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>5(b)(ii)</b> | <p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> <li>takes population numbers into account / takes account of abundance (1)</li> </ul> | <p><b>Accept</b> species evenness</p> <p><b>Accept</b> populations may change / the number of individuals of each species may change</p> | <b>(1)</b> |

| Question Number  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Additional guidance                                                                                                                                                                                                       | Mark       |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>5(b)(iii)</b> | <p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> <li>there are many food chains / food webs are complex (1)</li> <li>because there are alternative food sources (1)</li> <li>there are different predators (1)</li> <li>range of niches / many habitats (1)</li> <li>there is {high genetic diversity / many alleles / large gene pool} <b>and</b> some {survive / have advantageous alleles} (1)</li> </ul> | <p><b>Ignore</b> lots of food</p> <p><b>Accept</b> many food sources / different prey /</p> <p><b>Accept</b> different niches</p> <p><b>Accept</b> many alleles <b>and</b> some (advantageous) alleles) are passed on</p> | <b>(2)</b> |

**(Total for Question 5= 12 marks)**