**Q1.**

A meadow is an area of grassland with a wide range of plant and animal species.

A student investigated whether cutting some of the plants in a meadow had any effect on the biodiversity of insects in that meadow.

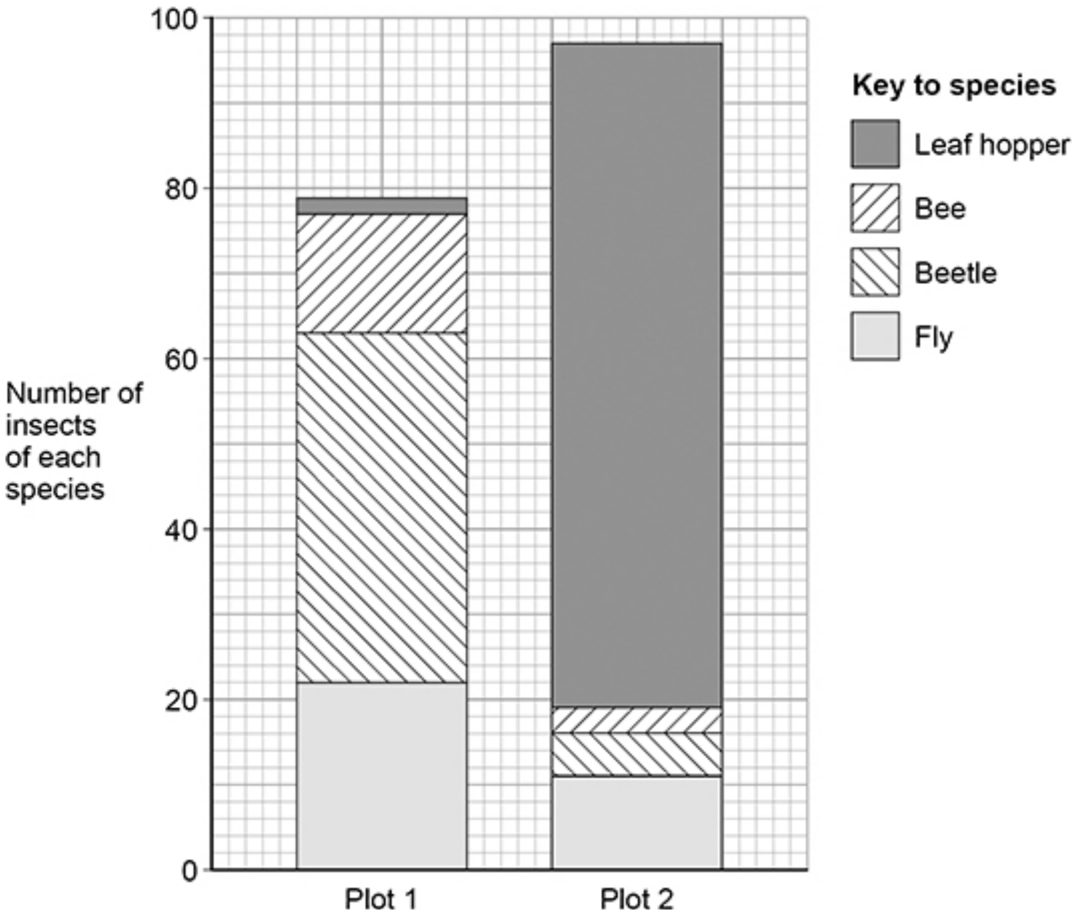
The student created two sample areas, called plots, in the meadow. Each plot measured 10 m × 5 m

The student:

- did not cut plants in **plot 1**
- cut the plants in **plot 2** with a lawn mower once a week.

After 10 weeks, the student captured all of the organisms of four insect species found in each of these plots.

The figure below shows the student's results.




(a) Use the information in the figure above to calculate the index of diversity for the insects captured in **plot 1**.

The formula to calculate the index of diversity ($d$) is

$$d = \frac{N(N-1)}{\Sigma n(n-1)}$$

where *N* is the total number of insects of all species and *n* is the total number of insects of each species.

Give the answer to **2** significant figures and show your working.

*d* = ____________________

**(2)**

(b) The student concluded that cutting plants with a lawn mower increased the species richness of insects in that meadow.

Use information in the diagram above to explain why the student's conclusion is incorrect.

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**(1)**

(c) The student wanted to use the data from **plot 1** to estimate the total number of the beetle species in the meadow.

Suggest how the student should use the data from **plot 1** and other information provided to estimate the total number of the beetle species in the meadow.

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**(4)**
**(Total 7 marks)**

## Q2.

A scientist identified and counted the invertebrate species present in samples taken at two sites in a river. The scientist also measured the rate of water flow at each site.

His results are shown in **Table 1** and **Table 2**.

**Table 1**

| **Invertebrate species** | **Site 1** | **Site 2** |
|---|---|---|
| Anglers' Curse mayfly | 17 | 5 |
| Flat-headed mayfly | 6 | 8 |
| Slate Drake mayfly | 0 | 6 |
| Water beetle | 12 | 13 |
| Midge fly | 13 | 13 |
| Total number caught | 48 | 45 |

**Table 2**

| | **Site 1** | **Site 2** |
|---|---|---|
| Index of diversity | | 4.7 |
| Rate of water flow / cm $s^{-1}$ | 1-14 | 30-60 |

(a) Complete **Table 2** by calculating the index of diversity (d) at **Site 1**.

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

Index of diversity (d) = ______________________

**(1)**

(b) Explain why it is more useful to calculate an index of diversity than to record species richness.

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**(2)**

(c) Suggest how the scientist measured the rate of water flow in the river.

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**(1)**

(d) Use information in **Table 1** and **Table 2** to suggest and explain a reason for the difference in the numbers of Slate Drake mayfly at these sites in this river.

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(2)

(e) It was important that the sampling procedure was standardised when collecting the Slate Drake mayflies from the two sites.

Give **one** way in which the sampling procedure could be standardised.

(1)
(Total 7 marks)

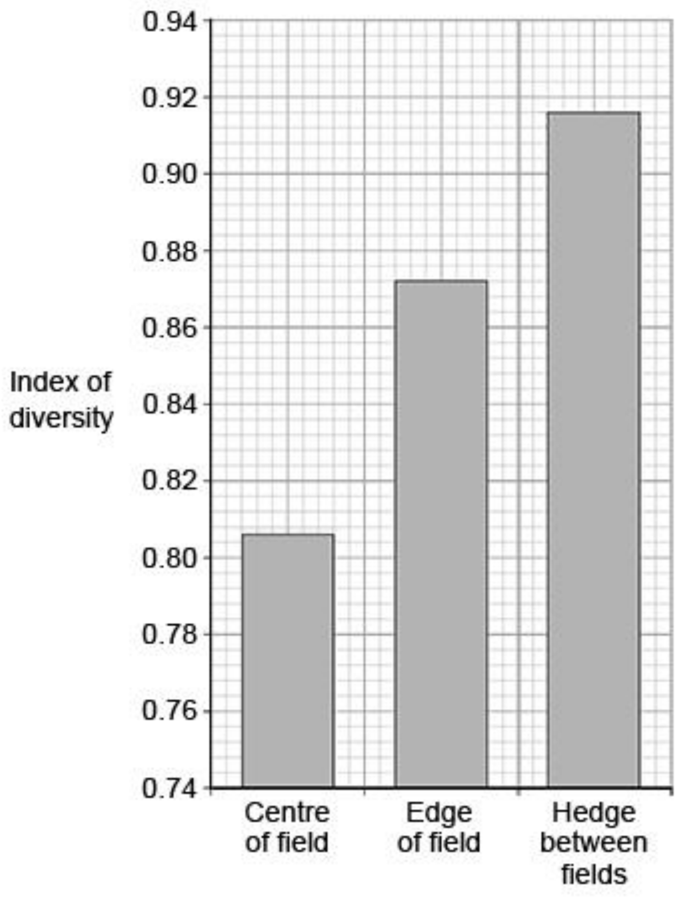
## Q3.

A group of students investigated biodiversity of different areas of farmland.

They collected data in each of these habitats:

- the centre of a field
- the edge of a field
- a hedge between fields.

Their results are shown in the graph.



(a) What data would the students need to collect to calculate their index of diversity in each habitat?

Do **not** include apparatus used for species sampling in your answer.

**(1)**

(b) Give **two** ways the students would have ensured their index of diversity was representative of each habitat.

1

2

**(2)**

(c) Modern farming techniques have led to larger fields and the removal of hedges between fields.

Use the graph above to suggest why biodiversity decreases when farmers use larger fields.

**(1)**

(d) Farmers are now being encouraged to replant hedges on their land.

Suggest and explain **one** advantage and **one** disadvantage to a farmer of replanting hedges on her farmland.

Advantage ___________________________________________

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Disadvantage ___________________________________________

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**(2)**

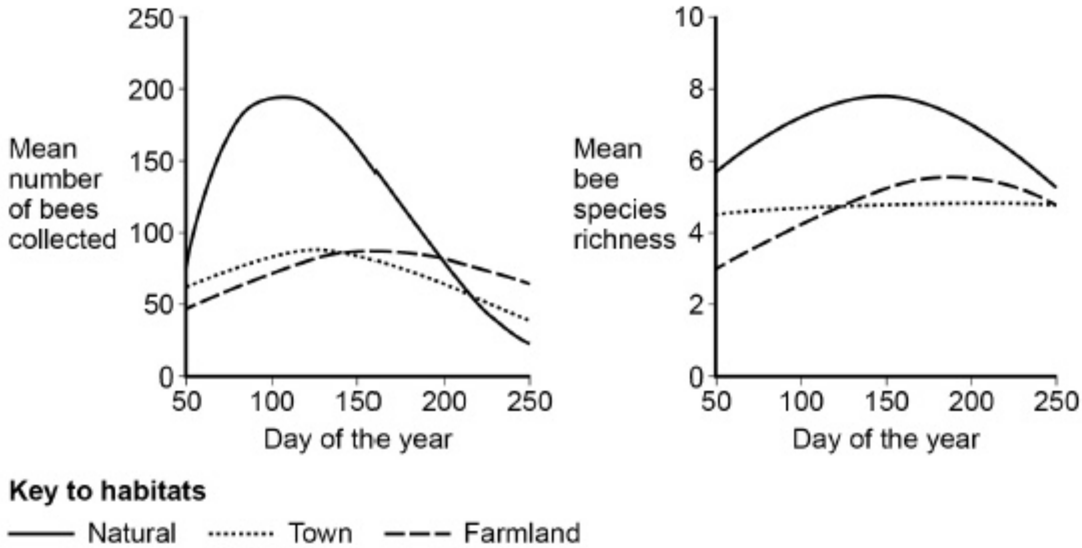
**(Total 6 marks)**

## Q4.

Bees are flying insects that feed on nectar made in flowers. There are many different species of bee.

Scientists investigated how biodiversity of bees varied in three different habitats during a year. They collected bees from eight sites of each habitat four times per year for three years.

The scientists' results are shown below in the graphs in the form they presented them.




(a) What is meant by 'species richness'?

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**(1)**

(b) From the data in the graphs, a student made the following conclusions.

1. The natural habitat is most favourable for bees.
2. The town is the least favourable for bees.

Do the data in the graphs support these conclusions? Explain your answer.

1. The natural habitat is most favourable for bees.

2. The town is the least favourable for bees.

**(4)**

(c) The scientists collected bees using a method that was ethical and allowed them to identify accurately the species to which each belonged.

In each case, suggest **one** consideration the scientists had taken into account to make sure their method

1. was ethical.

2. allowed them to identify accurately the species to which each belonged.

**(2)**

(d) Suggest and explain **two** ways in which the scientists could have improved the method used for data collection in this investigation.

1.

2.

**(2)**

(e) Three of the bee species collected in the farmland areas were *Peponapis pruinosa*, *Andrena chlorogaster* and *Andrena piperi*.

What do these names suggest about the evolutionary relationships between these bee species? Explain your answer.

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**(2)**
**(Total 11 marks)**

## Q5.

(a) Define each of the following terms.

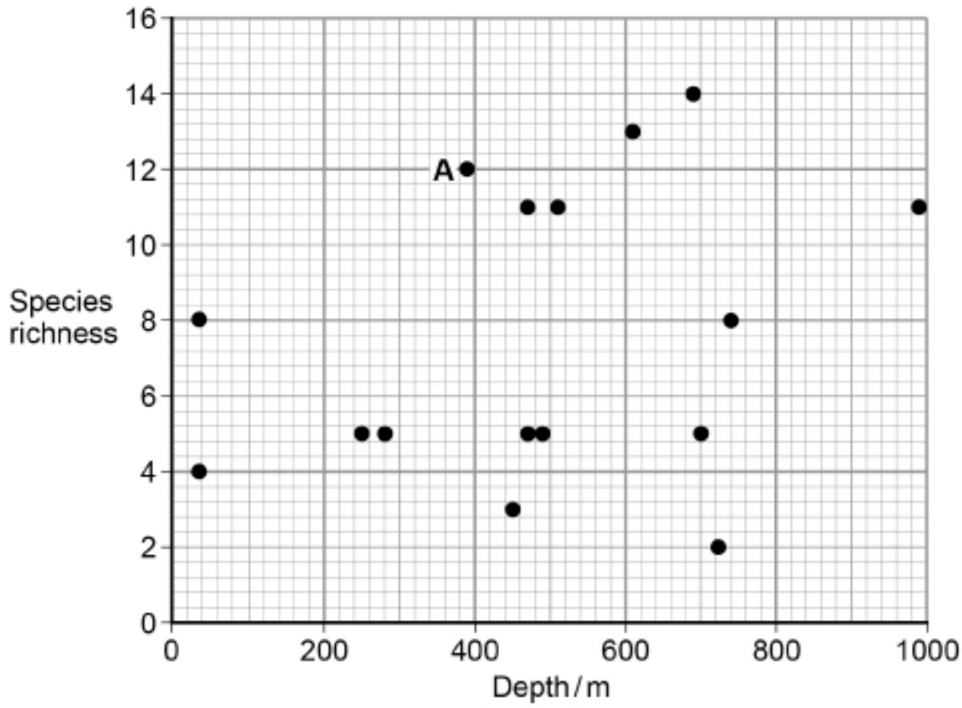
Species ___

Species richness ___

**(2)**

Scientists investigated the species richness of fish caught at various depths in the Pacific Ocean close to the western coast of Chile.

The graph shows the scientists' results. 68% of all the fish caught in this investigation came from sample **A**.




(b) What is the modal value of species richness?

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**(1)**

(c) 68% of all the fish caught in this investigation came from sample **A**.
A student thought this showed that sample **A** had a greater index of diversity than any of the other samples.

It is **not** possible to draw this conclusion from the given data. Give reasons why.

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**(3)**

**(Total 6 marks)**

## Q6.

Ecologists investigated changes in grassland communities on large islands off the coast of Scotland between 1975 and 2010. On each island, they used data from a number of sites to determine the change in mean species richness and the change in mean index of diversity.

(a) **Table 1** shows plant species recorded at one site, on one island, in 1975.

**Table 1**

| Species | Number of individuals |
|---|---|
| *Hydrocotyle vulgaris* | 3 |
| *Plantago maritima* | 19 |
| *Ranunculus acris* | 3 |
| *Hieracium pilosella* | 3 |
| *Calliergon cuspidatum* | 10 |
| *Prunella vulgaris* | 16 |
| *Pseudoscleropodium purum* | 6 |

Calculate the index of diversity for this site using the formula:

$$d = \frac{N(N-1)}{\Sigma n(n-1)}$$

$d$ = ____________

**(2)**

(b) Outline a method the ecologists could have used to determine the plant species richness at one site.

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**(3)**

(c) Some of the ecologists' results are shown in **Table 2**. They carried out a statistical test to find out whether any differences between the 1975 and 2010 means were significant. The values for P that they obtained are also shown in **Table 2**.

**Table 2**

| Island | Change in mean species richness between 1975 and 2010 | Value of P | Change in mean index of diversity between 1975 and 2010 | Value of P |
|---|---|---|---|---|
| **Islay** | +8.89 | ≤0.001 | +0.22 | >0.05 |
| **Colonsay** | +14.70 | ≤0.001 | +2.68 | ≤0.01 |
| **Harris** | −5.13 | ≤0.001 | −2.44 | ≤0.01 |

Do these data show that there were any significant changes in the grassland communities on these islands? Give reasons for your answer.

**(3)**
**(Total 8 marks)**

## Q7.

A student investigated the species richness and index of diversity of insects in three different habitats, a barley field, a wheat field and a hedge.

Her results are shown in the table below.

| | **Number of individuals of each insect species in each habitat** | | |
|---|---|---|---|
| **Insect species** | **Barley field** | **Wheat field** | **Hedge** |
| **a** | 32 | 4 | 34 |
| **b** | 78 | 0 | 12 |
| **c** | 0 | 126 | 22 |
| **d** | 0 | 5 | 12 |
| **e** | 0 | 0 | 8 |
| **f** | 0 | 0 | 42 |
| **g** | 0 | 25 | 13 |
| **h** | 0 | 10 | 12 |
| **i** | 0 | 0 | 12 |
| **j** | 42 | 41 | 0 |
| **Species richness** | | | |
| **Total number of insects (N)** | | | |

(a) Complete the table for species richness and the total number of insects of each habitat.

**(2)**

(b) Calculate the index of diversity of the wheat field.

Use the following formula:

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

where $N$ = total number of organisms

and $n$ = total number of organisms of each species.

**(2)**

(c) The index of diversity of the insects was higher in the hedge than in the barley field.
Suggest why.

**(3)**
**(Total 7 marks)**

## Q8.

The UK government pays farmers to leave grassy strips around the edges of fields of crops. These grassy strips contain a variety of plant species. Leaving the strips is an attempt to encourage biodiversity of animals.

(a) Give **two** reasons why the grassy strips increase the biodiversity of animals.

1.

2.

**(2)**

A group of scientists investigated the effect of grassy strips on the biodiversity of soil animals.

- They divided a field into plots measuring 25 m × 5 m, with a 5-metre-wide grassy strip of land between each plot.
- Each year, they planted wheat in each of the plots.
- In the fifth year, they removed samples of soil from each plot where wheat was growing and from the grassy strips around them.
- They sorted each soil sample by hand for 40 minutes to collect the soil animals within the sample.

(b) The scientists decided to collect animals from the soil samples for 40 minutes.

Suggest how the scientists decided that 40 minutes was an appropriate time.

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**(2)**

(c) The table below shows how the scientists published their results. They calculated mean values and two times the standard deviation (SD) of the mean.

Two standard deviations above and below the mean includes 95.4% of the data.

| **Group of animals** | **Mean number of animals per m² (± 2 × SD)** | | **Mean number of species per m² (± 2 × SD)** | |
|---|---|---|---|---|
| | **Soil under wheat crop** | **Soil under grassy strips** | **Soil under wheat crop** | **Soil under grassy strips** |
| Beetles | 41.2 (± 6.4) | 80.1 (± 10.1) | 10.0 (± 1.6) | 17.3 (± 1.0) |
| Centipedes | 18.4 (± 3.6) | 13.5 (± 1.0) | 1.8 (± 0.3) | 2.1 (± 0.2) |
| Earthworms | 244.5 (± 27.1) | 281.2 (± 39.4) | 3.8 (± 0.3) | 5.1 (± 0.2) |
| Millipedes | 38.4 (± 12.2) | 36.2 (± 2.9) | 3.5 (± 0.3) | 3.2 (± 0.2) |
| Woodlice | 0.0 | 73.9 (± 8.5) | 0.0 | 2.8 (± 0.2) |

It would **not** be possible to calculate an index of diversity from the results in the table.

Explain why.

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**(1)**

(d) A summary of this research was published in a farming magazine. The journalist concluded that creating grassy strips around fields had little effect on the diversity of soil animals.

Do you agree with this conclusion?

Use evidence from the table to justify your answer.

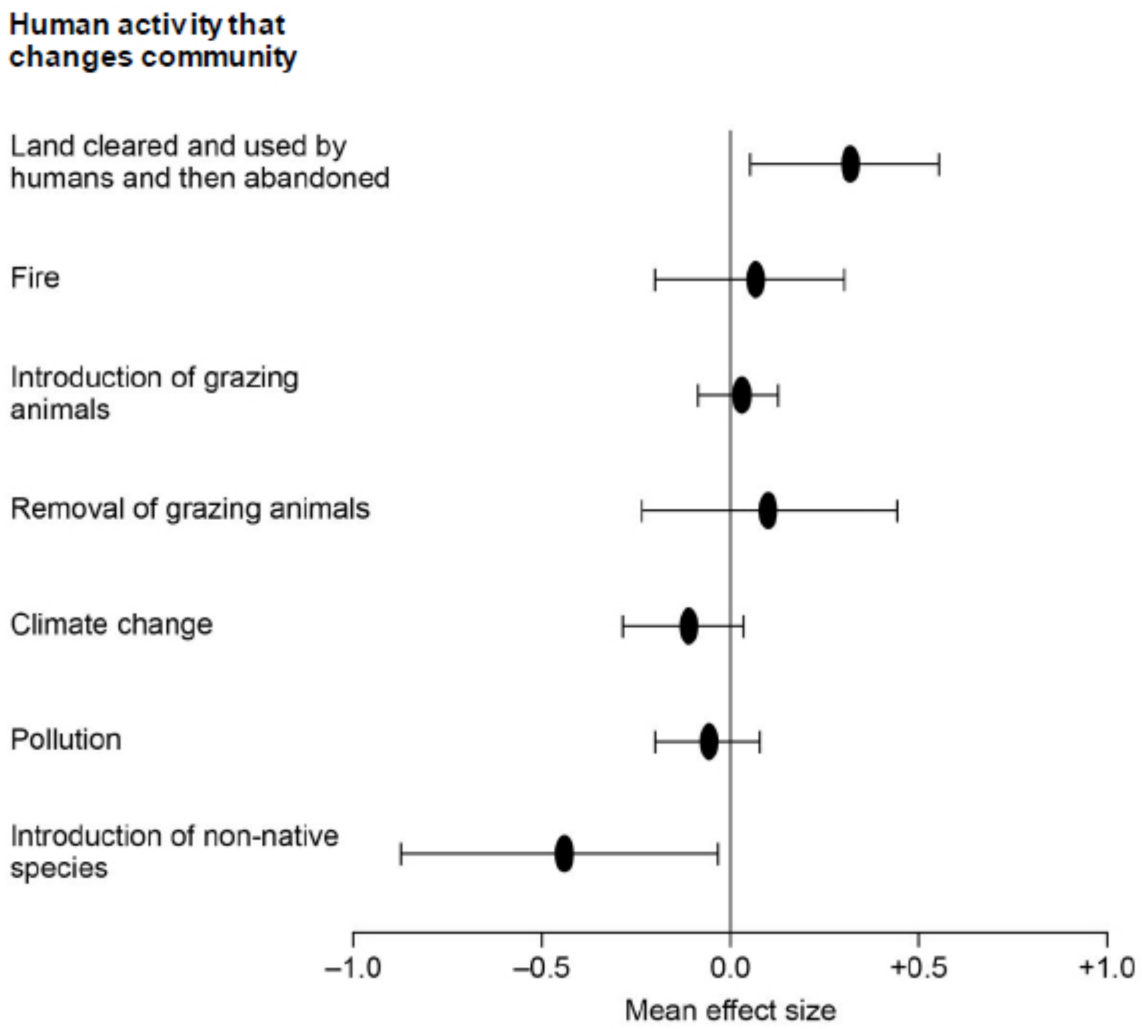
**(4)**
**(Total 9 marks)**

## Q9.

Scientists investigated changes in plant biodiversity in different communities after changes caused by humans. They collected data from many published investigations that recorded changes in species richness of plants over a large number of years.

The scientists used data from each investigation to calculate the effect size. The effect size is a measure of change in species diversity with time. A positive value shows an increase in species richness with time.

The graph below shows the scientists results in the form in which they were published. The horizontal bars represent ±2 standard deviations, which includes 95.4% of the data.




(a) What can you conclude from these data about the effects of human activities on biodiversity?

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**(3)**

(b) Suggest an explanation for the effect size when non-native species were introduced to communities.

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**(2)**

(c) Describe how you would investigate the effect of an invasion by a non-native species of plant (a biotic environmental factor) over many years on the abundance of a native species of plant in a community.

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**(3)**

(d) Effect size is calculated in the following way.

1. Divide the species richness in the last year of an investigation (SR2) by species richness in the first year of the investigation (SR1).
2. Find the natural log ($\log_e$) of the result.
3. Divide this by the time (T) between the first and last year in decades (1 decade = 10 years).

In one community:

- species richness in year 2 (SR2) was 15.3
- species richness in year 1 (SR1) was 18.2
- and the investigation lasted for 29 years.

Use $\log_e$, SR2, SR1 and T to write an equation for 'effect size' and calculate its value for this investigation. On a calculator, the key for $\log_e$ is shown as ln, or $\log_e$.

Effect size = ____________________

**(2)**

**(Total 10 marks)**

**Q10.**

A student investigated the distribution of plants in a heathland.

The table below shows the number of plants he found in a sample area of 1 $m^2$.

| **Species of plant** | **Number counted in 1 $m^2$** |
|---|---|
| Common heather | 2 |
| Red fescue | 14 |
| Vetch | 2 |
| White clover | 8 |

(a) What is the species richness of this sample? ☐

**(1)**

(b) Calculate the index of diversity of this sample. Show your working.

Use the following formula to calculate the index of diversity.

$$d = \frac{N(N-1)}{\Sigma n(n-1)}$$

where $N$ is the total number of organisms of all species
and $n$ is the total number of organisms of each species

Index of diversity = ______________________

**(2)**

(c) Suggest how this student would obtain data to give a more precise value for the index of diversity of this habitat.

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**(2)**

**(Total 5 marks)**

## Q11.

Species richness and an index of diversity can be used to measure biodiversity within a community.

(a) What is the difference between these two measures of biodiversity?

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**(1)**

Scientists investigated the biodiversity of butterflies in a rainforest. Their investigation lasted several months.

The scientists set one canopy trap and one understorey trap at five sites.

- The canopy traps were set among the leaves of the trees 16–27 m above ground level.
- The understorey traps were set under trees at 1.0–1.5 m above ground level.

The scientists recorded the number of each species of butterfly caught in the traps. The table below summarises their results.

| Species of butterfly | Mean number of butterflies | | P value |
|---|---|---|---|
| | In canopy | In understorey | |
| *Prepona laertes* | 15 | 0 | < 0.001 |
| *Archaeoprepona demophon* | 14 | 37 | < 0.001 |
| *Zaretis itys* | 25 | 11 | > 0.05 |
| *Memphis arachne* | 89 | 23 | < 0.001 |
| *Memphis offa* | 21 | 3 | < 0.001 |
| *Memphis xenocles* | 32 | 8 | < 0.001 |

(b) The traps in the canopy were set at 16–27 m above ground level. Suggest why there was such great variation in the height of the traps.

______________________________________________________________________

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**(1)**

(c) By how many times is the species diversity in the canopy greater than in the understorey? Show your working.

Use the following formula to calculate species diversity.

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

where $N$ *is the total number of organisms of all species and* $n$ *is the total number of organisms of each species.*

Answer = ____________________

**(3)**

(d) The scientists carried out a statistical test to see if the difference in the distribution of each species between the canopy and understorey was due to chance. The P values obtained are shown in the table.

Explain what the results of these statistical tests show.

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**(3)**

**(Total 8 marks)**