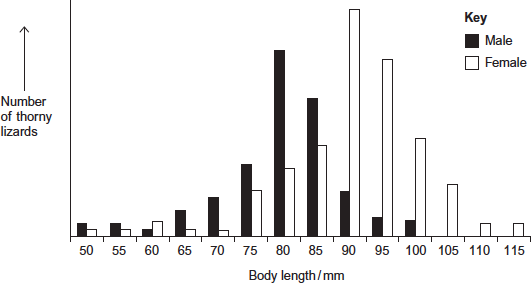
**Q1.**(a)     Ecologists measured the body lengths of male and female thorny lizards living in the same habitat. The ecologists measured the body lengths to the nearest 5 mm.  
The graph shows how they presented their results.



Give **two** differences in the variation in body length of male and female thorny lizards.

1 .....................................................................................................................

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2 .....................................................................................................................

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**(2)**

(b)     Another group of ecologists investigated biodiversity of lizards in a woodland area.

Their results are shown in the table.

|  |  |  |
| --- | --- | --- |
|  | **Lizard species** | **Number of individuals** |
|  | Dominican giant anole | 5 |
|  | Hispaniolan green anole | 11 |
|  | Hispaniolan stout anole | 22 |
|  | Bark anole | 91 |
|  | Hispaniolan grass anole | 13 |
|  | Cope’s galliwasp | 5 |
|  | Cochran’s least gecko | 8 |
|  | Peninsula least gecko | 1 |

The index of diversity can be calculated using the formula



where

*d* = index of diversity  
*N* = total number of organisms of all species  
*n* = total number of organisms of each species

(i)      Use the formula to calculate the index of diversity of lizards in the woodland area.  
Show your working.

Answer = ............................

**(2)**

(ii)     The ecologists also determined the index of diversity of lizards in an oil palm plantation next to the woodland area. They found fewer species of plant in the oil palm plantation. Lizards feed on plants and insects.

Explain why fewer species of plant would lead to fewer species of lizard in the oil palm plantation.

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**(3)**

**(Total 7 marks)**

**Q2.**          Costa Rica is a Central American country. It has a high level of species diversity.

(a)     There are over 12 000 species of plants in Costa Rica. Explain how this has resulted in a high species diversity of animals.

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**(2)**

(b)The number of species present is one way to measure biodiversity. Explain why an index of diversity may be a more useful measure of biodiversity.

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**(2)**

(c)     Crops grown in Costa Rica are sprayed with pesticides. Pesticides are substances that kill pests. Scientists think that pollution of water by pesticides has reduced the number of species of frog.

(i)Frogs lay their eggs in pools of water. These eggs are small. Use this information to explain why frogs’ eggs are very likely to be affected by pesticides in the water.

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**(2)**

(ii)An increase in temperature leads to evaporation of water. Suggest how evaporation may increase the effect of pesticides on frogs’ eggs.

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**(1)**

**(Total 7 marks)**

**Q3.**          Lacewings are insects that feed on aphids and mites, which are crop pests. The numbers of six species of lacewings, **A** to **F**, were counted on samples of apple and strawberry crops. The results are shown in the table.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Crop** | **Number of adults of each species of lacewing** | | | | | | **Diversity index** |
| **A** | **B** | **C** | **D** | **E** | **F** |
| Strawberry | 31 | 0 | 3 | 29 | 17 | 1 | 3.2 |
| Apple | 10 | 1 | 1 | 7 | 0 | 1 |  |

The diversity index (*d*) is calculated from the formula



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

(i)      Calculate the diversity index for lacewing species in the apple crop and write the figure in the table. Show your working.

**(2)**

(ii)      Suggest a reason why the diversity index for the lacewings is different between the two crops.

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**(1)**

**(Total 3 marks)**

**Q4.**          The Solomon Islands are situated in the Pacific Ocean. The nearest large land mass is Australia, which is about 1500 km away. The biggest islands are mountainous, with large areas of tropical forest and a wide range of habitats. Some islands have a very high species diversity, and many species are endemic, that is they occur only in the Solomon Islands.

The table shows the total number of species on the islands in four vertebrate classes and the percentage which are endemic.

|  |  |  |
| --- | --- | --- |
| **Vertebrate class** | **Total number of species** | **Endemic species / %** |
| Mammals Birds Reptiles Amphibians | 53 223 61 17 | 36 20 16 53 |

(a)     How many reptile species are endemic?

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**(1)**

**S** (b)     Suggest an explanation for the high proportion of endemic species on the Solomon Islands.

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**(3)**

**(Total 4 marks)**

**Q5.**          The vegetation on a large heap of waste from an old mine was investigated. The table shows the results of the measurements of certain factors in 1m2 frame quadrats placed on the south-facing slope.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Quadrat** | **Angle of slope / °** | **Vegetation cover / %** | **Moisture content of soil / %** | **pH of soil** |
| 1  2  3  4  5  6 | 45  30  25  12  7  1 | 60  70  68  100  85  100 | 17.2  14.6  20.3  23.5  21.0  21.2 | 5.6  4.2  5.2  7.1  5.4  6.8 |

(a)     Which of the factors measured are abiotic?

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**(1)**

(b)     Describe how the investigators could obtain the value for vegetation cover in each quadrat.

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**(2)**

(c)     The correlation between vegetation cover and soil moisture content was tested statistically. These two factors were found to be positively correlated, and p < 0.05. Explain what this result means.

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**(2)**

**S** (d)     At first the waste heap had no plants growing on it. Some of the first plants to colonise it were small herbaceous plants. Explain **one** way in which colonisation by herbaceous plants could change the physical environment.

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**(2)**

**(Total 7 marks)**

**Q6.** When coal is mined by open-cast mining, the top layer of soil is first scraped off and stored in a large heap. Once mining has finished, the area can be reclaimed. Soil from this store is then spread back over the surface.

Some of the bacteria living in the soil store respire aerobically and some respire anaerobically. **Table 1** shows the numbers of aerobic and anaerobic bacteria found at different depths in a soil store.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Depth / cm** | **Mean number of bacteria per gram of soil (× 107)** | | | |
| Aerobic bacteria | | Anaerobic bacteria | |
| after 1 month | after 6 months | after 1 month | after 6 months |
| 0 | 12.0 | 12.1 | 0.6 | 0.8 |
| 50 | 10.4 | 8.6 | 0.8 | 1.3 |
| 100 | 10.1 | 6.1 | 0.7 | 4.1 |
| 150 | 10.0 | 3.2 | 0.7 | 7.9 |
| 200 | 11.6 | 0.8 | 0.7 | 8.4 |
| 250 | 11.9 | 0.7 | 0.8 | 8.8 |
| 300 | 11.0 | 0.8 | 0.6 | 9.1 |

**Table 1**

(a)     Some of the soil used to determine bacterial numbers was collected from the surface of the soil store. Describe how you would ensure that this soil was collected at random.

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**(2)**

(b)     (i)      Describe how the numbers of aerobic bacteria after 6 months change with depth.

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**(2)**

(ii)     Explain the difference in the numbers of aerobic bacteria at a depth of 300 cm between 1 and 6 months.

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**(2)**

(c)     Explain how the changes in bacterial numbers which take place at 150 cm illustrate the process of succession.

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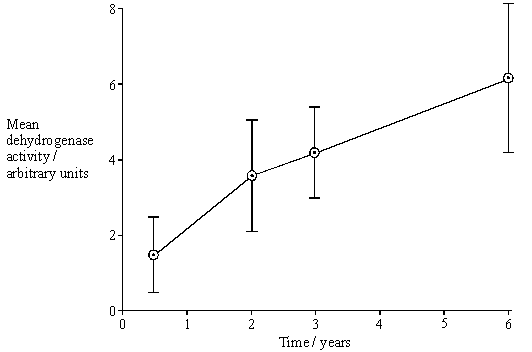
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**(3)**

Dehydrogenase is an enzyme involved in aerobic respiration. Dehydrogenase activity in a soil sample can be used as a measure of the activity of aerobic bacteria. The graph shows the mean dehydrogenase activity of soil samples taken from the same depth in a soil store at different times. The bars on the graph represent two standard errors above and below the mean.



(d)     (i)      From what depth in the soil store would you expect these soil samples to have been taken? Use information from **Table 1** to explain your answer.

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**(2)**

(ii)     How would you expect dehydrogenase activity to vary with depth after 6 months?

Use information from **Table 1** to explain your answer.

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**(3)**

(e)     What do the error bars tell you about the difference between the mean dehydrogenase activity at 6 months and 3 years? Explain your answer in terms of probability and chance.

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**(3)**(f)      **Table 2** shows the dehydrogenase activity and the number of aerobic bacteria present in some soil samples.

|  |  |
| --- | --- |
| **Dehydrogenase activity / arbitrary units** | **Number of aerobic bacteria per gram of soil (× 107)** |
| 13.1 | 12.0 |
| 9.2 | 8.7 |
| 5.5 | 6.5 |
| 3.0 | 4.6 |
| 2.2 | 2.7 |
| 0.4 | 0.6 |

**Table 2**

A sample of soil was found to have dehydrogenase activity of 8.7 arbitrary units. Explain how you would use the data in **Table 2** to predict the likely number of aerobic bacteria in 1 g of this soil sample.

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**(3)**

**(Total 20 marks)**

**Q7.**          A hedgerow is a line of shrubs and trees bordering a field, together with the herbaceous plants at their base. In the last 50 years farmers have removed many hedgerows.

(a)     Explain **two** advantages for a farmer of removing hedgerows.

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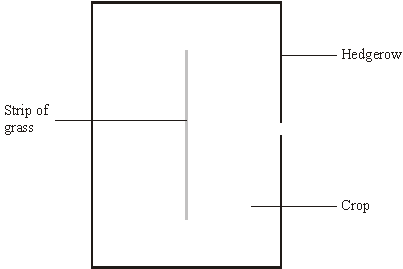
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**(2)**

(b)     In recent years some hedgerows have been replanted. Ground beetles, which are unable to fly, are predators of crop pests. The beetles overwinter in the shelter of grasses at the base of the hedgerow. In some large fields, a permanent strip of grass is left as shown in the diagram.



Suggest and explain the advantage of leaving the strip of grass in the middle of the field.

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**(2)**

(c)Apart from providing a habitat for predators of crop pests, give **two** biological benefits of replanting hedgerows.

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2 ...................................................................................................................

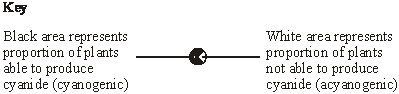
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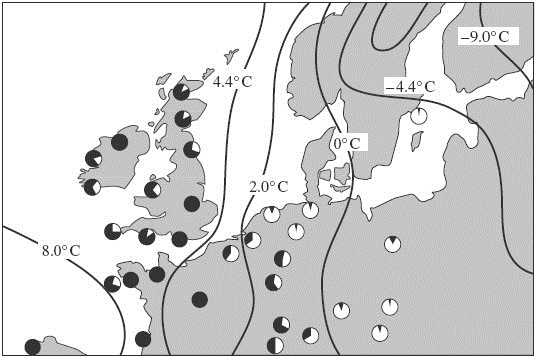
**(2)**

**(Total 6 marks)**

**Q8.**          **S**       Clover plants have leaves all through the year. Some clover plants have leaves that produce poisonous hydrogen cyanide gas when damaged. These cyanogenic plants are less likely to be eaten by snails. However, the leaves of these plants can be damaged by frost, resulting in the production of enough hydrogen cyanide to kill the plants. Acyanogenic plants do not produce hydrogen cyanide. This characteristic is genetically controlled.

The map shows the proportions of the two types of plant in populations of clover from different areas in Europe. It also shows isotherms, lines joining places with the same mean January temperature.





(a)     Explain how different proportions of cyanogenic plants may have evolved in populations in different parts of Europe.

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**(4)**

(b)     Differences in cyanide production may affect the total number of clover plants growing in different areas. Describe how you would use quadrats in an investigation to determine whether or not there is a difference in the number of clover plants in two large areas of equal size.

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**(4)**

**(Total 8 marks)**

**Q9.**         The table shows the numbers of adult butterflies in two areas of the same tropical forest. In the logged area some trees had been cut down for timber. In the virgin forest no trees had been cut down. The two areas were the same size.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Logged forest** | | **Virgin forest** | |
| **Butterfly species** | **Number** | ***n*(*n*–1)** | **Number** | ***n*(*n*–1)** |
| *Eurema tiluba* | 72 | 5112 | 19 | 342 |
| *Cirrochroa emalea* | 43 | 1806 | 132 | 17292 |
| *Partenos sylvia* | 58 | 3306 | 14 | 182 |
| *Neopithecops zalmora* | 6 | 30 | 79 | 6162 |
| *Jamides para* | 37 | 1332 | 38 | 1406 |
| Total | 216 | 11586 | 282 | 25384 |

(a)     Describe a method for finding the number of one of the species of butterfly in the virgin forest.

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**(2)**

(b)     The index of diversity of a forest can be calculated using the equation



Calculate the index of diversity for the virgin forest. Show your working.

Answer ......................................

**(2)**

(c)     What does the table show about the effects of logging on the butterfly populations?

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**(2)**

**(Total 6 marks)**

**Q10.**          Mayflies are insects which lay their eggs in streams and rivers. The nymphs which hatch from the eggs live in the water for several years.

Mayfly nymphs were collected by disturbing the gravel of a stream bed. A net placed immediately downstream caught any animals which were washed out of the gravel. Eight samples were collected from shallow, fast-flowing parts of the stream and eight from deeper, slow-flowing parts. Nymphs from two different families of mayfly were found. The results are given in the table.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Family Caenidae** | | **Family Baetidae** | |
|  |  | **Shallow water** | **Deep water** | **Shallow water** | **Deep water** |
|  | **Mean number of nymphs** | 2.38 | 12.88 | 24.50 | 6.00 |
|  | **Standard deviation** | 1.51 | 7.92 | 6.72 | 1.51 |

(a)     Describe how you would have collected the samples in order to ensure they were representative of the habitats being investigated and could be compared with each other.

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**(3)**

(b)     Which **one** of the four samples showed the greatest variation within the sample? Give evidence from the table for your answer.

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**(1)**

(c)     The two families of mayfly nymph occupy different ecological niches.

(i)      What is meant by the term *ecological niche*?

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**(1)**

(ii)     Describe the evidence in the table which suggests that the two families of mayflies occupy different ecological niches.

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**(1)**

(iii)     Explain the advantage to these two families of mayflies of occupying different ecological niches.

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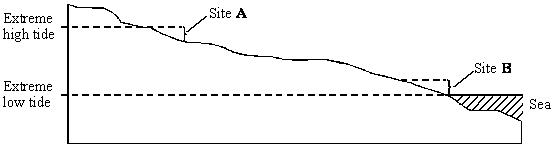
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**(2)**

**(Total 8 marks)**

**Q11.** Parts of the sea shore form a very hostile environment for living organisms. Twice each day the incoming and outgoing tides alternately cover the organisms on the sea shore with water and then leave them exposed. The force of the waves could also dislodge any organisms that were not firmly attached.

The diagram shows a section through a rocky shore. Two sites were studied: site **A** was on the upper shore and site **B** on the lower shore.



The table shows the seaweeds that were found growing at sites **A** and **B**.

|  |  |  |  |
| --- | --- | --- | --- |
| **Site A: upper shore** | **Mean number per m2** | **Site B: lower shore** | **Mean number per m2** |
| *Ascophyllum nodosum Fucus spiralis Fucus vesiculosus Pelvetia canaliculata* | 2 10 4 6 | *Corallina officinalis Fucus serratus Laminaria digitata Laminaria hyperborea Laminaria saccharina Laurencia pinnatifida Palmaria palmata* | 31 8 15 3 6 18 6 |
| Index of diversity |  | Index of diversity | 4.77 |

(a)     (i)      Use the formula 

where       **d** = index of diversity  
**N** = total number of organisms of all species  
**n** = total number of organisms of a particular species

to calculate the index of diversity for the seaweeds growing at site **A**.  
Show your working.

Index of diversity at site **A** = ......................................

**(2)**

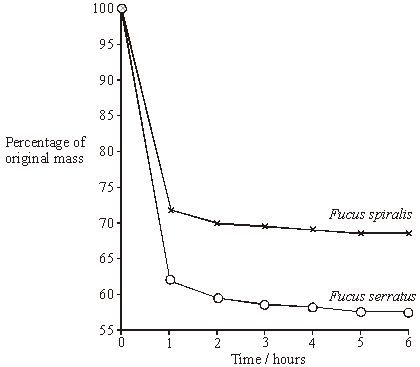
(ii)     Give **one** advantage of calculating the index of diversity rather than just recording the number of species present.

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**(1)**

(b)     Availability of water is one abiotic factor which determines the distribution of seaweeds. The graph shows loss in mass due to water evaporation for two of the seaweed species. The two seaweeds belong to the same genus but one was found only on the upper shore and the other only on the lower shore.



Explain how the results shown in the graph relate to the distribution of these two seaweeds on the sea shore.

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**(3)**

**(Total 6 marks)**

**Q12.**          Deforestation often involves clearing large areas of forest for use as agricultural land.

(a)     Deforestation reduces the diversity index of an area cleared in this way. Explain why.

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**(2)**

(b)     Because the forest soil is often nutrient-poor, nitrogen-containing fertilisers may be applied to ensure good crop yields. Use your knowledge of the nitrogen cycle to explain the potential benefit of applying a fertiliser containing ammonium nitrate rather than one containing potassium nitrate.

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**(3)**

**(Total 5 marks)**

**Q13.**          (a)     What information is required to calculate an index of diversity for a particular community?

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**(1)**

(b)     Farmers clear tropical forest and grow crops instead. Explain how this causes the diversity of insects in the area to decrease.

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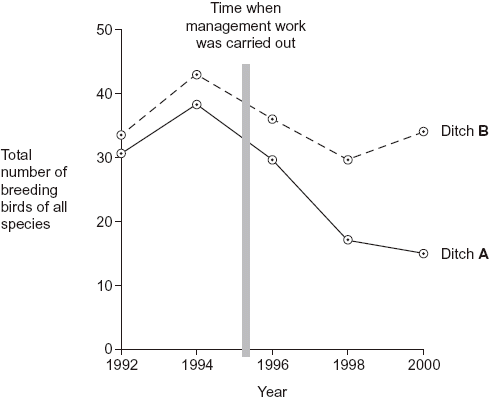
**(3)**

Farmers manage the ditches that drain water from their fields. If they do not, the ditches will become blocked by plants. Biologists investigated the effects of two different ways of managing ditches on farmland birds.

•        Ditch **A** was cleared of plants on both banks

•        Ditch **B** was cleared of plants on one bank.

The graph shows the number of breeding birds of all species along the two ditches, before and after management.



(c)     (i)      The points on the graph have been joined with straight lines rather than with a smooth curve. Explain why they have been joined with straight lines.

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**(1)**

(ii)     It would have been useful to have had a control ditch in this investigation. Explain why.

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**(1)**

(d)     A farmer who wanted to increase the diversity of birds on his land read about this investigation.

He concluded that clearing the plants from one bank would not decrease diversity as much as clearing the plants from both banks. Evaluate this conclusion.

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**(3)**

**(Total 9 marks)**

**Q14.**          Biologists studied the process of succession in an area of wasteland over a period of ten years. They calculated the index of diversity of the area every year. After three years, the index of diversity was 1.6. After ten years, it had risen to 4.3.

(a)     What information concerning the organisms present in the area is suggested by the increase in the index of diversity?

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**(2)**

(b)     The increase in the index of diversity is one indication that a biological succession is taking place in the area. Describe those features of a succession that would bring about an increase in the index of diversity.

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**(3)**

**(Total 5 marks)**

**Q15.**          (a)     Heath is a community of plants and animals. A student investigated the species diversity of plants in this community. The table shows her results.

|  |  |
| --- | --- |
| **Plant species** | **Number of plants per m2** |
| Heath rush | 1 |
| Bilberry | 1 |
| Sheep’s sorrel | 5 |
| Ling | 2 |
| Bell heather | 1 |
| Heath bedstraw | 8 |
| Mat-grass | 11 |

(i)      The index of diversity can be calculated from the formula

*d* = 

where

*d* = index of diversity

*N* = total number of organisms of all species

*n* = total number of organisms of each species.

Use this formula to calculate the index of diversity for the plants on the heath.

Show your working.

Answer ............................................

**(2)**

(ii)     Explain why it may be more useful to calculate the index of diversity than to record only the number of species present.

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**(2)**

(b)     The demand for increased food production has led to areas of heath being used to grow wheat. Explain the effect of this on

(i)      the species diversity of plants

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**(2)**

(ii)     the species diversity of animals.

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**(2)**

**(Total 8 marks)**

**Q16.**          Scientists investigated the species of insects found in a wood and in a nearby wheat field. The scientists collected insects by placing traps at sites chosen at random both in the wood and in the wheat field.

The table shows the data collected in the wood and in the wheat field.

|  |  |  |
| --- | --- | --- |
| **Species of insect** | **Number of organisms of each species** | |
| **Wood** | **Wheat field** |
| Bird-cherry oat aphid | 0 | 216 |
| Beech aphid | 563 | 0 |
| Large white butterfly | 20 | 0 |
| Lacewing | 12 | 3 |
| 7-spot ladybird | 36 | 0 |
| 2-spot ladybird | 9 | 1 |
| Total number of organisms of all species | 640 | 220 |

(a)     The scientists collected insects at sites chosen at random. Explain the importance of the sites being chosen at random.

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**(1)**

(b)     (i)      Use the formula



to calculate the index of diversity for the insects caught in the wood, where

*d* = index of diversity*N* = total number of organisms of all species*n* = total number of organisms of each species

Show your working.

                               Answer ...................................................................

**(2)**

(ii)     Without carrying out any further calculations, estimate whether the index of diversity for the wheat field would be higher or lower than the index of diversity for the wood.

Explain how you arrived at your answer.

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**(2)**

(c)     A journalist concluded that this investigation showed that farming reduces species diversity.  
Evaluate this conclusion.

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**(2)**

(d)     Farmers were offered grants by the government to plant hedges around their fields.  
Explain the effect planting hedges could have on the index of diversity for animals.

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**(2)**

**(Total 9 marks)**

**Q17.**Farmland previously used for growing crops was left for 30 years and developed into woodland. During this period, ecologists recorded an increase in the diversity of birds in the area.

(a)     Name the process that resulted in the development of woodland from farmland.

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**(1)**

(b)     Explain the increase in the diversity of birds as the woodland developed.

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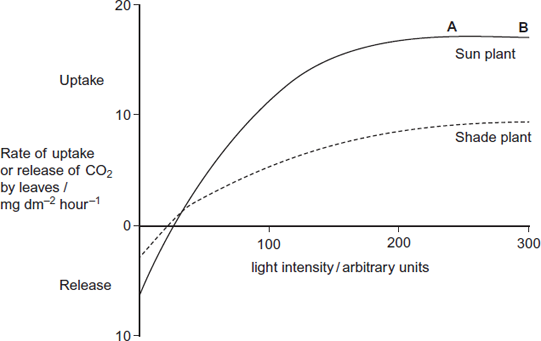
*(Extra space)* .................................................................................................

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**(3)**

(c)     The ecologists also investigated photosynthesis in two species of plant found in the woodland. One of the species was adapted to growing in bright sunlight (sun plant) and the other was adapted to growing in the shade (shade plant). The ecologists’ results are shown in the figure below.



(i)      Give **two** factors which could be limiting the rate of photosynthesis in the sun plant between points **A** and **B** on the figure.

1..............................................................................................................

2.............................................................................................................

**(1)**

(ii)     Explain why CO2 uptake is a measure of net productivity.

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*(Extra space)* ........................................................................................

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**(1)**

(iii)    Use the information in the figure to explain how the shade plant is better adapted than the sun plant to growing at low light intensities.

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*(Extra space)* ........................................................................................

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**(2)**

**(Total 8 marks)**

**Q18.**(a)     A student investigated the diversity of plants at several sites on a golf course. At each site she took a large number of random samples.

(i)      Explain the importance of taking a large number of samples at each site.

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**(1)**

(ii)     Explain the importance of taking samples at random.

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**(1)**

The student collected data from one part of the golf course and calculated an index of diversity.

The table shows her data.

|  |  |  |
| --- | --- | --- |
|  | **Species** | **Number of plants per m2** |
|  | Sheep’s fescue | 11 |
|  | Creeping buttercup | 6 |
|  | Clover | 5 |
|  | Dandelion | 2 |
|  | Sheep’s sorrel | 1 |
|  | Lady’s bedstraw | 7 |
|  | Stemless thistle | 4 |

The index of diversity can be calculated from the formula



where

*d*  =  index of diversity  
*N*  = total number of organisms of all species  
*n*  =  total number of organisms of each species

(b)     Use the formula to calculate the index of diversity for the plants on this part of the golf course. Show your working.

                                             Answer .....................................................

**(2)**

(c)     The golf course was surrounded by undeveloped grassland from which it had been produced.  
The golf course had

•        some areas of very short grass which was cut frequently

•        some areas of longer grass which was cut less frequently

•        some areas of long grass and shrubs which were never cut.

The index of diversity for the insects on the golf course was higher than that for the surrounding undeveloped grassland.

Explain the effect of developing this golf course on the index of diversity of insects.

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*(Extra space)* .................................................................................................

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**(3)**

**(Total 7 marks)**

**Q19.**(a)    There are ethical and economic arguments for maintaining biodiversity.

(i)      Suggest **one** ethical argument for maintaining biodiversity.

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**(1)**

(ii)     Suggest **one** economic argument for maintaining biodiversity.

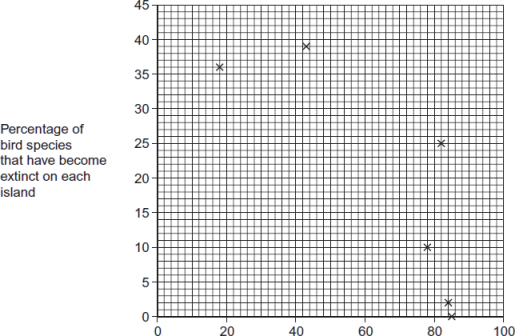
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**(1)**

Ecologists calculated the percentage of bird species that have become extinct on six islands in the last one hundred years. They also calculated the percentage of original forest area remaining on each island after the same time period. The graph shows their results.



Percentage of original forest area   
remaining on each island

(b)     Explain the relationship between the percentage of original forest area remaining and the percentage of bird species that have become extinct.

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**(2)**

(c)     What **two** measurements would the ecologists have needed to obtain to calculate the index of diversity of birds on each island?

1......................................................................................................................

2......................................................................................................................

**(2)**

(d)     The ecologists noted that the species of birds surviving on the coldest islands had a larger body size than those surviving on warmer islands.

Explain how a larger body size is an adaptation to a colder climate

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**(2)**

**(Total 8 marks)**

**Q20.**The Amazonian forest today contains a very high diversity of bird species.

•        Over the last 2 000 000 years, long periods of dry climate caused this forest to separate into a number of smaller forests.

•        Different plant communities developed in each of these smaller forests.

•        Each time the climate became wetter again, the smaller forests grew in size and merged to reform the Amazonian forest.

(a)     Use the information provided to explain how a very high diversity of bird species has developed in the Amazonian forest.

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*(Extra space)*..................................................................................................

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**(5)**

(b)     Speciation is far less frequent in the reformed Amazonian forest. Suggest one reason for this.

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**(1)**

**(Total 6 marks)**

**Q21.**(a)     What is a *species?*

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**(2)**

(b)     Scientists investigated the diversity of plants in a small area within a forest. The table shows their results.

|  |  |  |
| --- | --- | --- |
|  | **Plant species** | **Number of individuals** |
|  | Himalayan raspberry | 20 |
|  | Heartwing sorrel | 15 |
|  | Shala tree | 9 |
|  | Tussock grass | 10 |
|  | Red cedar | 4 |
|  | Asan tree | 6 |
|  | Spanish needle | 8 |
|  | Feverfew | 8 |

The index of diversity can be calculated by the formula



where

*d* = index of diversity  
*N* = total number of organisms of all species  
*n* = total number of organisms of each species

(i)      Use the formula to calculate the index of diversity of plants in the forest. Show your working.

Answer .....................................

**(2)**

(ii)     The forest was cleared to make more land available for agriculture.

After the forest was cleared the species diversity of insects in the area decreased. Explain why.

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(Extra space).........................................................................................

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**(3)**

**(Total 7 marks)**

**Q22.**(a)     What **two** measurements are needed to calculate an index of diversity?

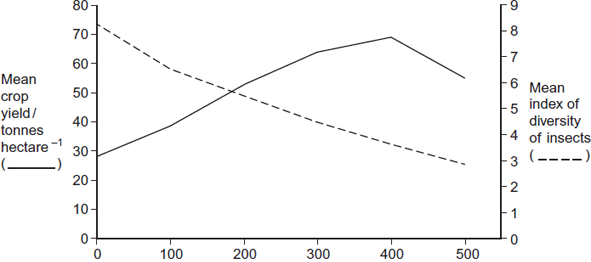
1 .....................................................................................................................

2 .....................................................................................................................

**(2)**

(b)     A herbicide is a chemical used to kill weeds. Ecologists investigated the effect of a herbicide on crop yield and the diversity of insects. They sprayed different fields with the same volume of different concentrations of the herbicide. At harvest, the ecologists determined the mean crop yield and the mean index of diversity of insects for fields that had received the same concentration of the herbicide.

The figure below shows their results.

  
Concentration of herbicide sprayed on field / mg dm−3

(i)      Some fields acted as controls. They were sprayed with a solution that did not contain the herbicide. Explain the purpose of these control fields.

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**(1)**

(ii)     Suggest an explanation for the relationship between the concentration of herbicide and the mean crop yield.

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**(2)**

(iii)     Explain the relationship between the concentration of herbicide and the mean index of diversity of insects.

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*(Extra space)* ........................................................................................

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**(3)**

**(Total 8 marks)**

**Q23.**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 m2.

|  |  |  |
| --- | --- | --- |
|  | **Species of plant** | **Number counted in 1 m2** |
|  | 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* = 

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)**

**Q24.**Ecologists investigated the size of an insect population on a small island. They used a mark-release-recapture method. To mark the insects they used a fluorescent powder. This powder glows bright red when exposed to ultraviolet (UV) light.

(a)     The ecologists captured insects from a number of sites on the island. Suggest how they decided where to take their samples.

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**(2)**

(b)     Give **two** assumptions made when using the mark-release-recapture method.

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2 .....................................................................................................................

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**(2)**

(c)     Suggest the advantage of using the fluorescent powder in this experiment.

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**(2)**

The ecologists did **not** release any of the insects they captured 1–5 days after release of the marked insects.

The table below shows the ecologists’ results.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Days after  release** | **Number of marked  insects remaining in population** | **Number of insects captured** | **Number of  captured insects  that were marked** |
|  | 1 | 1508 | 524 | 78 |
|  | 2 | 1430 | 421 | 30 |
|  | 3 | 1400 | 418 | 18 |
|  | 4 | 1382 | 284 | 2 |
|  | 5 | 1380 | 232 | 9 |

(d)     Calculate the number of insects on this island 1 day after release of the marked insects.

Show your working.

Answer = ...................................

**(2)**

(e)     The ecologists expected to obtain the same result from their calculations of the number of insects on this island on each day during the period 1–5 days after release. In fact, their estimated number increased after day 1.

During the same period, the number of insects they caught decreased.

The method used by the ecologists might have caused these changes.

Use the information provided to suggest **one** way in which the method used by the ecologists might have caused the increase in their estimates of the size of the insect population.

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**(2)**

**(Total 10 marks)**

**Q25.**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* = 

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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**(Extra space)** ................................................................................................

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**(3)**

**(Total 8 marks)**

**M1.**(a)     1.      Females are (generally) longer / larger / bigger / up to 115(mm) / males are (generally) shorter / smaller / up to 100(mm);

*Ignore: tall*

*Accept: females have a larger / 90 modal / peak / most common value and males have a smaller / 80 modal / peak / most common value*

*Accept mean length of females greater / mean length of males shorter*

*Reject: use of mean in relation to 80 mm or 90 mm*

*Reject: Most of the females are 90 mm long / most of the males are 80 mm long*

2.      Females show a greater range / variation / males show a narrower range / variation.

*Accept: correct use of figures from the graph: the range of males is 50 to 100 and of females is 50 to 115 / the spread is 50 for males and 65 for females*

**2**

(b)     (i)      **2.6** to **2.7** = 2 marks;

          Incorrect answer but evidence of a numerator of **24180 OR 156** **×** **155** or denominator of **9014** = 1 mark;

**2**

(ii)     (Fewer plant species) − no mark

1.      (So) few(er) habitats / niches;

*Ignore habitat size*

***Q*** *Neutral: fewer homes*

2.      (So) lower diversity of insects / fewer insect species / fewer insect types;

***Q*** *Neutral: fewer insects*

*Accept less variety of insects*

3.      (So) fewer food sources / less variety of food.

***Q*** *Neutral: less food*

*Ignore references to pesticides, farmers’ actions, competition between lizards and evolution*

**3**

**[7]**

**M2.**          (a)     Greater variety / different foods;

More habitats / niches;

*Answers only referring to ‘more food’ should not be credited but allow ‘more food sources’.*

**2**

(b)     Also measures number of individuals in a species / different proportions of species;

Some species may be present in low / high numbers;

*First marking point can only be awarded if there is a reference to species.*

**2**

(c)     (i)     Large surface area to volume (ratio) / permeable / thin (outer layer); Correct reference to diffusion;

*Accept (Eggs) cannot move (out of water) for 1 mark*

**2**

(ii)     Concentration (of pesticide) is increased;

**1**

**[7]**

**M3.**          (i)      for correct use of sigma;  
numerator = 380 and denominator = 132;

**2**

2.87 to 2.9 gains 2 marks

*(do not allow 2.8 or denominator = 135)*

(ii)      more types of prey found on strawberries;

**1**

**[3]**

**M4.**          (a)     10

*(reject: 9.76)*

**1**

(b)     isolation (on islands);  
variety of habitats / conditions different from origin / other islands;  
differing pathways of natural selection;  
leading to organisms too different to interbreed.

**3 max**

**[4]**

**M5.**          (a)     angle, moisture and pH

*(all required)*

**1**

(b)     system for subdividing quadrat into, e.g. many squares;  
method of estimating cover in small squares, e.g. counting those where cover over 50%, or cover at points (of intersection);

*(not just ‘count squares with vegetation’ unless very small)*

**2**

(c)     increasing vegetation cover is related to increasing moisture content

*(allow ‘affects‘ moisture content or vice versa, not ‘causes);*

correlation is significant / not due to chance / can reject null hypothesis  
/ only 1 in 20 / 5% probability that the correlation is due to chance;

**2**

(d)     factor; and linked effect e.g.  
wind-blown particles trapped;  
accumulation of soil;  
OR  
accumulation of organic / dead / decomposed matter / humus;  
increase in mineral ions / improved water retention / improved  
soil structure;  
OR  
nitrogen fixation;  
increased nitrate concentration / improved soil fertility;

**2 max**

**[7]**

**M6.**          (a)     Tapes / string / axes laid out at right angles / grid area;  
Method of obtaining random co-ordinates;  
*Do not allow “Use random number generator”*

**2**

(b)     (i)      Decrease then remain constant;  
From 200 cm / over 150 cm;

**2**

(ii)     Oxygen decreasing because soil becomes more compacted / not  
replaced;  
Decrease in oxygen leads to fewer aerobes surviving;

**2**

(c)     Anaerobic bacteria replace aerobic as oxygen decreased by aerobic bacteria;  
Remove competition;  
Aerobic bacteria no longer able to survive in these conditions;

**3**

(d)     (i)      Near the surface / in top 50 cm;  
Table shows decrease with time at greater depths;

**2**

(ii)     Decrease;  
Fewer aerobic bacteria with depth;  
Oxygen concentration decreases / less oxygen at depth;

**3**

(e)     Probability greater than 95% / 0.95;  
Results are not due to chance / results are significant;  
Because bars do not overlap;

**3**

(f)      Plot as graph;  
Draw line of best fit;  
Read off appropriate value;

**3**

**[20]**

**M7.**          (a)     source of pests / animals, and effect on crop;  
source of weeds / no longer taking nutrients, hence competition /   
reduced yield; creation of larger fields / leaving room,  
hence more efficient use of machinery / grow more crops;  
hedgerows have to be maintained, so removal saves time / money;

**2 max**

(b)     allows beetles to remain / survive / over winter in the middle of the  
field / strip of grass;  
effect on distribution, e.g. do not normally reach the centre of the field  
/ can reach all parts;

**2**

(c)     increases biodiversity;  
source of food for animals;  
habitat / nest for animals;  
reduce need for insecticides / attracts insects away from crop;  
windbreaks / prevent erosion / run-off / leaching;  
migratory corridors;

**2 max**

**[6]**

**M8.**          (a)     colder / below 0°C (January) areas, cyanogenic plants die in this cold / acyanogenic survive;  
non-cyanogenic allele / gene passed on more often / its frequency increases;  
warmer (January) areas cyanogenic plants at advantage,  
because of less herbivore selection pressure / feeding;  
so cyanogenic survive more often to pass on cyanogenic allele / gene.

**4 max**

(b)     large (and equal) number of quadrats in each area;  
*(reject several)*random sampling method, described;  
*(accept described ‘systematic’ method)*percentage cover / point hits per quadrat / count plants;  
mean / average value for each area;  
statistics test to see if differences significant.

**4 max**

**[8]**

**M9.**          (a)     suitable method of capture;  
mark individuals and release;  
count percentage recaptured / use Lincoln index / equation;

**2 max**

(b)     

*(accept 3.1 / 3.122)*

**2**

(c)     decrease in total numbers of butterflies;  
*(reject population)*change in proportion of species / example(s);  
increase in diversity in logged forest / calculation(4.01);

**2 max**

**[6]**

**M10.**          (a)     Samples collected at random;  
Method for choosing random sites – random  
coordinates / position from tables / calculator / other suitable  
means;

Other named factor constant e.g.:

Same size of net / same width of opening of net / use of one  
quadrat / Quadrats of same size / of stated size / same area  
disturbed / collect each   
Sample for same time;

**3**

(b)     *Caenidae* in deep water – because highest standard  
deviation / ‘S.D.= 7.92’

**1**

(c)     (i)      An organism’s role / in the ecosystem / community;  
[ALLOW refs. To trophic levels / named]

*(IGNORE refs. To habitat)*

**1**

(ii)     *Caenidae* found mainly in deep water AND *Baetidae* in  
shallow water / one family mainly in deep water AND the  
other in shallow water;

**1**

(iii)     Reduces competition for named factor – e.g. food / shelter / O2 ;  
To ensure both types survive / otherwise better adapted   
type displaces other type;  
OR  
Ref. to ‘Competitive exclusion principle’ = 2 marks

**max 2**

**[8]**

**M11.**          (a)     (i)      EITHER:     Correct answer: 3.45 / 3.44 / 3.4            = 2 marks  
OR:            Understanding of ∑n(n-1) / use of  
                   134 / (2 + 90 + 12 + 30)  
                   + wrong answer                                      = 1 mark

**max 2**

(ii)     Takes account of number of individuals / abundance /   
population size (as well as number of species);

**1**

(b)     The species at A /  *F.spiralis* loses less water /   
loses water less rapidly / loses less mass;

The species at A / *F.spiralis* better adapted to / can survive where   
exposed for longer / to drier conditions;

The species at A / *F.spiralis* avoids competition For named aspect  
– e.g. light / substratum / space / CO2;

*ACCEPT converse argument re. F. serratus*

**3**

**[6]**

**M12.**          (a)     deforestation removes many habitats / niches fewer species / fewer types of organisms;

*(do not credit just fewer organisms);*

**2**

(b)     1. nitrate ions in fertiliser available / absorbed immediately;  
2. ammonium converted to nitrate by nitrifying bacteria   
3. fertiliser would provide only the initial release of nitrate / potassium nitrate;

**3**

**[5]**

**M13.**          (a)     Number of a / each (species);

*Accept answers expressed differently providing they convey this information.*

*Ignore extra information if it does not contradict answer.*

**1**

(b)     1.      Lower diversity of plants / few species of plants / less variety  
of plants / few plant layers;

2.      Few sources / types of food / feeding sites; / few habitats / niches;

3.      Fewer (species of) herbivore so few (species of) carnivores;

**3**

(c)     (i)      Cannot predict / do not know intermediate values;

**1**

(ii)     To see what would happen / compare with no management work / to see if numbers fell anyway / To show that it was not a factor;

*Management as a term not required. Allow explanations.*

**1**

(d)     1.      Total number of birds along ditch B / ditch with one side cleared greater than along ditch A / ditch with both sides cleared;

2.      But only gives data for all birds / does not give data for species / data not about diversity;

3.      Single ditch / single occasion / not repeated / no control;

*Principles:*

*Correct from evidence*

*Total number not diversity*

*Flaws in technique*

**3**

**[9]**

**M14.**          (a)     Increase in number of species;

Increase in numbers of some species;

**2**

(b)     Initial environment hostile / few organisms adapted;

These organisms change the environment / suitable example;

More niches / more habitats;

Allowing other organisms to become established;

**max. 3**

**[5]**

**M15.**          (a)     (i)      Two marks for correct answer of 4.3;

***Q*** *An answer of 4 scores 1 mark*

One mark for incorrect answer that clearly shows understanding of ∑n(n – 1) / 188 as denominator;

**2**

(ii)     Measures number of individuals (of each species) and number of species;

***Q*** *First marking point can only be awarded if there is a reference to species.*

Some species only present in small numbers;

**2**

(b)     (i)      Reduced as one crop / species grown / other species removed;

Use of herbicides / weeding / ploughing / wheat (better) competitor for named factor e.g. light / nutrients;

**2**

(ii)     (Reduced) as less variety of food sources;

(Reduced) as fewer habitats / niches;

***Q*** *Answers only referring to ‘less food’ should not be credited*

**2**

**[8]**

**M16.**          (a)     Removes bias;

**1**

(b)     (i)     1.      1.28 / 1.29 / 1.285 / 1.3

*1. Ignore more than 3dp*

2.      Answer incorrect but shows clear understanding of Σ

*2. Σ = 318250. Allow mark if denominator written out. Incorrect denominator but evidence of understanding gains mark*

**2**

(ii)     Diversity index would be lower (NO MARK)

*Assume wheat field if site unspecified*

1.      Fewer species / Beech aphid / Large white butterfly / 7-spot ladybird absent / only three species / species diversity lower / mostly one species / mostly bird-cherry aphid;

*1. Allow species richness in context of few species*

2.      Fewer plant species;

*2. Allow one type of food source if clearly plant*

**2**

(c)     For:

1.      Data support the claim / evidence supports claim;

*1. Ignore reference to correlation / causation*

Against:

2.      Only wheat field / only comparing with wood / one type of habitat / only insects considered;

**2 max**

(d)     1.      Greater variety of plants;

2.      Another habitat / more habitats / places to live / niches / another food source / more food types;

*2. Answers referring to ‘more food’ should not be credited. Allow  reference to either animal or plant as foods*

**2**

**[9]**

**M17.**(a)     Succession;

*Ignore any word in front of succession e.g. secondary / ecological succession.*

*Neutral ‘forestation’.*

**1**

(b)     1.      Greater variety / diversity of plants / insects / more plant / insect species;

*Neutral: more plants.*

2.      More food sources / more varieties of food;

*Neutral: more food / more / greater food source (singular).*

3.      Greater variety / more habitats / niches;

*Accept: more nesting sites.*

***Q*** *Neutral: more homes / shelters.*

**3**

(c)     (i)      Temperature and carbon dioxide;

*Neutral: water, chlorophyll.*

**1**

(ii)     Shows (gross) photosynthesis / productivity minus respiration / more carbon dioxide used in photosynthesis than produced in respiration;

*Correct answers are often shown as: net productivity = (gross) photosynthesis – (minus) respiration.*

**1**

(iii)    1.      (Shade plant) has lower (rate of) respiration / respiratory losses / less CO2 released at 0 light intensity / in dark;

*Accept use of figures.*

*Accept: lower compensation point.*

2.      Greater (net) productivity / less sugars / glucose used / more sugars / glucose available;

*Neutral: any references to rate of photosynthesis.*

**2**

**[8]**

**M18.**(a)     (i)      Produces a more reliable mean / average / makes sure sample was representative / reduce effect of extreme values / identify anomalies;

*Ignore references to chance*

**1**

(ii)     Removes bias;

**1**

(b)     Two marks for correct answer of 5.8;

One mark for incorrect answer that clearly shows denominator as 216;

**2**

(c)     1.      Increase in variety of plants / shrubs / grass;

2.      More habitats / niches;

3.      Greater variety of food sources / more food sources;

*Answers only referring to 'more food' should not be credited*

**3**

**[7]**

**M19.**(a)     (i)      (We should maintain biodiversity to)

*Prevent extinction / loss of populations / reduction in populations / loss of habitats / save organisms for future generations (idea of);*

*Neutral: references to ‘playing God’ / animal rights*

**1**

(ii)     A suitable example of how some species may be important financially e.g.

1.      medical / pharmaceutical uses;

2.      commercial products / example given;

3.      tourism;

4.      agriculture;

5.      saving local forest communities;

**1 max**

(b)     1.      Fewer plant species / decrease in plant diversity;

*Accept: converse arguments for islands with a high percentage of forest remaining*

*1. Neutral: fewer plants*

2.      Fewer habitats nesting sites / niches / food sources / varieties / less protection from predators / hunters / environment;

*2. Neutral: fewer homes*

*2. Neutral: less food*

**2**

(c)     1.      Number of (individuals / birds of) each species;

*1. Neutral: number of species*

2.      Total number of individuals / birds of all species;

*2. Accept: ‘total number of birds’ as given context for ‘all species’ in the investigation*

**2**

(d)     1.      (Larger birds have) a low(er) SA:VOL;

*Neutral: reference to fat / feathers*

2.      (So) less heat loss / more heat retained;

*MP2 is independent of MP1*

**2**

**[8]**

**M20.**(a)     1.      No interbreeding / gene pools are separate / geographic(al) isolation;

*Accept: all marks if answer written in context of producing increased diversity of plants*

*1 Do not award this mark in context of new species being formed and then not interbreeding*

*1 Accept reproductive isolation as an alternative to no interbreeding*

2.      Mutation;

*2 Accept: genetic variation*

3.      Different selection pressures / different foods / niches / habitats;

*3 Accept: different environment / biotic / abiotic conditions or named condition*

*3 Neutral: different climates*

4.      Adapted organisms survive and breed / differential reproductive success;

5.      Change / increase in allele frequency / frequencies;

**5**

(b)     Similar / same environmental / abiotic / biotic factors / similar / same selection pressures / no isolation / gene flow can occur (within a species);

*Accept: same environment*

**1**

**[6]**

**M21.**(a)     1.      Group of similar organisms / organisms with similar features / organisms with same genes / chromosomes;

*1. Accept: same number of chromosomes*

*1. Accept: smallest taxonomic group*

*1. Reject: genetically identical. Only allow 1 max if mentioned*

*1.* ***Q*** *Neutral: similar genes / chromosomes*

2.      Reproduce / produce offspring;

*2. Accept: breed / mate*

3.      That are fertile;

*3. Neutral: that are ‘viable’*

*‘Produce fertile offspring’ = 2 marks*

**2 max**

(b)     (i)      Correct answer of 6.97 to 7 = 2 marks;

One mark for 6320 as numerator or 906 as denominator;

**2**

(ii)     1.      Decrease in variety of plants / fewer plant species;

*1. Accept: reference to monoculture or description*

*1. Neutral: fewer plants*

2.      Fewer habitats / niches;

*2. Neutral: fewer homes / less shelter*

3.      Decrease in variety of food / fewer food sources;

*3. Neutral: less food*

*3. Accept: less variety of prey*

**3**

**[7]**

**M22.**(a)     1.      Number of (individuals of) each species;

*Accept: ‘population’ for ‘number’*

2.      Total number of individuals / number of species;

*Accept: ‘species richness’*

*MP2 allows for other types of diversity index*

**2**

(b)     (i)      (Shows) results are due to the herbicide / are not due to another factor / (to) compare the effect of using and not using the herbicide / shows the effect of adding the herbicide;

*Neutral: allows a comparison*

*Neutral: ensures results are due to the independent variable*

*Reject: ‘insecticide’*

*Accept: ‘pesticide’*

**1**

(ii)     1.      (More) weeds killed **so** more crops / plants survive / higher yield / less competition;

2.      High concentrations (of herbicide) harm / damage / kill / are toxic to crops / plants;

*Accept: ‘pesticide’*

*Neutral: ‘insecticide’*

*Accept: use of figures (eg 400+)*

**2**

(iii)    1.      Reduced plant diversity / fewer plant species / fewer varieties of plant;

*Accept: ‘weed’ for ‘plant’*

*Neutral: fewer plants*

*Accept: only one crop species remains*

2.      Fewer habitats / niches;

***Q*** *Neutral: fewer homes / shelters*

3.      Fewer food sources / varieties of food;

*Neutral: less food*

**3**

**[8]**

**M23.**(a)      4:

**1**

(b)     2.68(6).

*If answer incorrect:  
Σn(n-1) = 242 = 1 mark*

*N(N-1) = 650 = 1 mark*

**2**

(c)     1.      Take more samples and find mean;

2.      Method for randomised samples described.

*Allow larger area = 1 mark*

**2**

**[5]**

**M24.**(a)     1.      Draw grid over (map of) area;

2.      Select squares / coordinates at random.

**2**

(b)     1.      No emigration / immigration;

2.      No losses to predation;

3.      Marking does not affect survival;

4.      Birth rate and death rate equal;

5.      (In this case) all belong to one population.

**2 max**

(c)     1.      Only glows brightly with UV, so doesn’t make insects more visible;

2.      So doesn’t affect / increase predation;

***OR***

1.      Glows brightly with UV marking visible;

2.      So makes it easy to pick out labelled insects.

**2**

(d)     10 130.

Tolerance of ±1

 *= 1 marks*

**2**

(e)     1.      Scientists removed large numbers of insects (which were not returned) from same area / same population;

2.      Affecting ratio of marked to unmarked.

**2**

**[10]**

**M25.**(a)     Species richness measures only number of (different) species / does not measure number of individuals.

**1**

(b)     Trees vary in height.

**1**

(c)     1.      Index for canopy is 3.73;

2.      Index for understorey is 3.30;

3.      Index in canopy is 1.13 times bigger;

*If either or both indices incorrect, allow correct calculation from student’s values.*

**3**

(d)     1.      For *Zaretis itys*, difference in distribution is probably due to chance / probability of being due to chance is more than 5%;

2.      For all species other than *Zaretis itys*, difference in distribution is (highly) unlikely to be due to chance;

3.      Because P < 0.001 which is highly significant / is much lower than 5%.

**3**

**[8]**

**E1.**(a)     About a third obtained both marks and half one mark. The commonest correct observation was that female lizards are longer. Fewer students noted that there is a greater range of lengths amongst females. Many students had trouble expressing themselves clearly. Some said that most females were 90 mm long and most males 80 mm. This is not correct, these are modal values. Others stated that males were mainly shorter than females below 100 mm.

(b)     (i)      75% obtained both marks for the calculation.

(ii)     The problem for many students in this part was that they wrote about factors affecting the number of lizards, not the number of species as required in the stem of the question. This meant that large numbers wrote about less food in the plantation, rather than fewer food sources, and failed to gain credit. The question required students to think about fewer food sources for both lizards and the insects they feed on. Only just over a tenth of students noted that there would be a lower diversity of insects in the plantation. This, together with fewer species of plants, would limit the range of food sources available and thus the number of species of lizard that could live there. It was pleasing to see that many students obtained a mark for stating there were fewer habitats or niches in the plantation.

**E2.**          (a)     This proved to be a very effective discriminator with almost equal numbers of candidates scoring two, one or zero marks. A significant number of candidates referred to ‘more food’ rather than a greater variety of foods. Vague terms such as ‘more shelter’ were not accepted as an alternative to more habitats.

(b)     Very few candidates obtained both marks in this question. However, almost half the candidates gained one mark for indicating that the index of diversity measures the number of species and the number of individuals. Better candidates used this information to explain that an index of diversity would be more useful where some species were only present in low or high numbers.

(c)     (i)      This proved a very demanding question with two thirds of candidates scoring zero. Despite the cue that ‘these eggs are small’ relatively few candidates correctly linked this to a large surface area to volume ratio. Only a small percentage of these candidates then referred to diffusion. It was very disappointing to see responses describing pesticides moving by osmosis.

(ii)     The majority of candidates appreciated that evaporation of water would increase the concentration of the pesticide.

**E3.**          (i)      Most candidates calculated the diversity index correctly and obtained both marks. A significant few understood how to use the equation but failed to apply the right mathematical approach; multiplying a number by the value zero was often performed incorrectly.

(ii)      Only rarely was a valid reason given for the difference in diversity index. Many candidates incorrectly believe that the quantity of available food, rather than the type of food, determines species diversity.

**E4.**          (a)     A surprisingly high proportion of candidates failed to calculate the percentage correctly, and those who did often did not round off their answer, thus suggesting that a fraction of a species existed.

(b)     Few candidates showed appreciation of the role of isolation in the production of new species that would be unique to the Solomon Islands. Most focused on one aspect only. For example, some described adaptation to the range of habitats without discussing speciation. Others pointed out the problems of interbreeding without considering how the endemic species might have arisen in the first place.

**E5.**          (a)     The majority of candidates showed that they were aware of what is meant by an abiotic factor and many correctly identified all three.

(b)     Candidates showed little evidence of having actually carried out fieldwork. Several misread the question and simply gave the standard answer relating to the random positioning of quadrats. Few could give a reasonable description of how to obtain a measure of the percentage cover. Better answers suggested subdividing the large quadrat into smaller squares, or counting whether vegetation was present at a large number of points. Several candidates merely subdivided the quadrat into 10 small squares, and candidates then recorded presence or absence of vegetation, which clearly could only at best give a value to the nearest 10%.

(c)     Most candidates were aware that the correlation was unlikely to be due to chance, and several expanded their answer to point out there was only a 1 in 20 probability of its being a chance result. Some, however, stated that the result showed that moisture in the soil caused the increase in vegetation, or vice versa.

(d)     Most could suggest some factor that might change, such as increase in humus, but few gave a clear explanation of how the physical environment would be changed as a consequence.

**E6.**          (a)     Most candidates clearly appreciated that the samples would best be obtained by using random numbers to determine co-ordinates, although they were not always specific as to how these numbers would be generated. There were, however, frequent references to “throwing” a quadrat, a technique which does not give rise to a genuinely random distribution.

(b)     In part (i), candidates revealed considerable difficulty in recognising the trend of a decrease followed by stabilisation from a depth of around 200 cm. The most frequent response was to ignore the change in gradient and refer simply to the population falling. Where a genuine attempt was made to offer an explanation for the difference in numbers in part (ii), answers were usually correctly related to the decreasing concentration of oxygen available for respiration.

(c)     There was obvious confusion in the minds of some between the concepts of ecological succession and natural selection. While some of those who made this distinction produced excellent answers, others lost their way in rambling anthropomorphic accounts of bacteria “not finding conditions to their liking” or being “happier” with conditions at other depths. There were also many general references to “bacteria”. These lacked the necessary precision to gain significant credit.

(d)     Part (i) was generally well answered and there were many accounts based on correct references to the surface layers being the only ones where numbers of aerobic bacteria increased. Part (ii) also produced some sound responses although candidates were inclined to embellish their answers with irrelevant detail relating to the anticipated change with time. Once again, a failure to gain marks most commonly stemmed from imprecise use of the word “bacteria”. In both parts (c) and (d) there was a need to refer them as being either aerobic or anaerobic.

(e)     There was encouraging evidence of a good understanding of standard error and many candidates were able to show some appreciation of this demanding concept. However, answers were seldom targeted at explaining what the error bars revealed about the difference in activity at the times given. In spite of the wording of the last sentence of the question, the terms probability and chance were seldom incorporated into the explanation.

(f)      The most frequent approach to this part of the question was to produce a mass of figures supporting a complex but inappropriate calculation. With these data the best approach was to construct a graph and draw a line of best fit. The likely number of bacteria could then have been established by reading off the appropriate value from the curve.

**E7.**          (a)     Many candidates failed to explain the advantages of removing hedgerows in sufficient detail, many just stating that this leaves ‘more space’ with no further qualification. Good candidates included detail about the effect on the crop, or the cost of labour in maintaining hedgerows.

(b)     Although most candidates scored at least one mark, many did not refer back to the stem of the question. Some suggested that it might be easier for the farmer to destroy the beetles if they were all in one place, or that the strip of grass might become a source of humus. Relatively few candidates explained that the strip of grass would allow the beetles easier access to pests throughout the crop.

(c)     Most candidates scored well on this question, with the most popular responses describing the effect of hedgerows in preventing erosion, or promoting biodiversity.

**E8.**          Many good answers were seen to both parts of this question. The topics covered were obviously familiar to many candidates. Where marks were not gained, it was usually because of omissions rather than errors. The full range of marks was seen and the question discriminated well.

(a)     Almost all of the candidates obtained a mark for noting that cyanogenic plants might die in areas with very low mean January temperatures. Many went on to obtain a second mark for identifying the positive advantage that cyanogenic plants have in warmer areas, because they deter herbivores. Only the better candidates wrote about the impact of these different selection pressures on allele frequencies in different clover populations. It was encouraging to note that ‘rote answers’, unrelated to this example were absent. Some weaker candidates did fail to score marks because they wrote in general terms about factors affecting natural selection and evolution but with no reference to the specific factors given in this example.

(b)     The vast majority of candidates were familiar with the use of quadrats. Many were also able to describe a suitable method for placing these at random locations in the study areas. Some candidates suggested the use of transects and this suggestion was rejected; unless they suggested the use of very large numbers of transects along randomly chosen lines. Many candidates scored one mark for suggesting the use of large numbers of quadrats. A surprising number failed to get this mark, either because they made no reference to sample size, or because they wrote vaguely about ‘several’ quadrats being used. The majority of candidates obtained a mark for what a quadrat might be used to measure. A large number of candidates made reference to the use of statistics but often that was all they said. The examiners were looking for the use of a statistical test to determine whether or not there was a significant difference in the number of clover plants in the two areas.

**E9.**          (a)     Surprisingly few candidates suggested a suitable method of trapping butterflies, but many could suggest mark, release and recapture as a method of estimating the population and gained one mark. Few candidates could then go on to explain how the data collected would be used to estimate a population.

(b)     This calculation was done well by many candidates, although some did a lot of extra work and did not use the information given. A minority of candidates could not even begin to attempt the calculation.

(c)     This question discriminated well. Better candidates calculated the index of diversity and correctly stated that diversity increased with logging. Weaker candidates could explain the effects on one or more species of butterfly, but they often missed the mark for stating that the number of butterflies decreased because they incorrectly used the term species (fewer species of butterflies) or population (the butterfly population decreases).

**E10.**          (a)     In this section, candidates often concentrated on either the method of achieving randomness in the sampling or on how other variables might have been controlled: both aspects were required for a complete answer.

(b)     Most realised that mayfly nymphs belonging to the family Caenidae and living in the deep water showed the greatest variation as this sample had the highest standard deviation. Some were less specific.

(c)     A simple definition in terms of an organism’s role in the ecosystem or community was required to explain the meaning of the term *ecological niche*. Some candidates’ answers could equally well have been applied to the term ‘habitat’. However, there were few problems in recognising that one family of mayfly nymphs living mainly in deep water and the other in shallow water indicated that they occupied different ecological niches. Also, most candidates appreciated that the occupancy of different niches would result in reduced competition for some environmental resource (food being the most common correct suggestion), although some should have thought more carefully about the given situation before suggesting competition for ‘light’ of for ‘mates’ (the two groups of mayflies were from different families). Some confused *intraspecific* and *interspecific* competition – only the latter being applicable here.

**E11.**          (a)     Most candidates were able to substitute the data in the formula and calculate the index of diversity correctly. There were occasional arithmetical errors. Many appreciated that the numbers of individuals had been used in the calculation of the index of diversity, or pointed out that the influence of rare species would be minimised. Weaker candidates frequently thought the index of diversity was good for comparing two areas (although why this should be an advance on just comparing the numbers of species present was not made apparent).

(b)     Some candidates were confused and seemed to regard the results as having been derived *in situ* on the shore rather than being produced using a balance in a laboratory. Many confused cause and effect and ignored information provided earlier in the question, insisting that *Fucus spiralis* must have been located on the lower shore as it lost less water due to having been exposed for a shorter time. Those who did realise that *Fucus spiralis* in fact lost less water because it was better adapted to life on the upper shore, very rarely went on to suggest that living in this location (seemingly rather hostile) would result in reduced competition between it and the other species.

**E12.**          (a)     Nearly all candidates knew that habitats would be lost, and a good number also knew that this would reduce the number of species in the area.

(b)     Better candidates realised that both potassium nitrate and ammonium nitrate would release nitrate ions into the soil immediately, and that the ammonium ions in ammonium nitrate could be nitrified by nitrifying bacteria to provide a secondary release of nitrates. Many candidates, however, just did not apply their knowledge to the problem and merely recited chunks of the nitrogen cycle, with some confusion between nitrifying and nitrogen-fixing bacteria.

**E13.**          (a)     Those candidates who could explain with sufficient clarity that it was necessary to determine the number of each species present were able to gain credit. A surprising number of candidates knew that an equation was involved and could quote it with some degree of accuracy. Many revealed, however, little knowledge of what the various terms represented.

(b)     Part (a) should have indicated to candidates that the thrust of this question was species diversity. Unfortunately the term diversity triggered many candidates to respond in terms of selection, genetic bottlenecks or the founder effect. The approach to this question was further influenced by a poor understanding of the concept of a species with many candidates apparently of the impression that all insects are members of the same species. Better candidates however approached the question in an appropriate way, and although they did not always appear to appreciate that clearing forest and planting crops would lower the plant diversity and hence the variety of available food, they were able to make worthwhile comments.

(c)     In part (i), many candidates showed an unfamiliarity with the idea that joining points on a graph with straight lines indicated uncertainty over the reliability of intermediate points. Answers to part (ii) were rather better with most candidates clearly understanding the nature of controls even if they enjoyed less success in explaining why a control would be necessary in the investigation described.

(d)     The best candidates understood the requirements of a question requiring evaluation and were able to link the changes in breeding birds shown on the graph with species diversity. They also indicated that the data referred to total number of birds and not diversity and point out the shortcomings at arriving at conclusions based on limited data. Those who did not gain significant credit, not infrequently failed to read the axes with sufficient care or did not appreciate why the points had been joined with straight lines. Evaluate was occasionally regarded as having the same meaning as Explain. Explanations gained little if any credit.

**E14.**          Candidates were not always selective in choosing the material to answer this question. They sometimes wrote at length about succession in part (a) (which concerned diversity), and then found they had nothing new to say in part (b), which did concern succession.

(a)     Good candidates were able to state, clearly and unequivocally, that an increase in the index of diversity means that the number of species has increased, as has the number of individuals within each species. Weaker candidates sometimes wrote all they knew about succession here or sometimes just wrote about “an increase in the organisms“, failing to distinguish between new species and existing species.

(b)     Most candidates were able to describe the role of pioneer species in colonising a harsh environment and the ways in which they might change this environment. Better candidates then went on to say that these changes allowed new species to become established with the creation of new habitats for still other species. However, too many could not resist following the development right through to the climax and describing the nature of this condition. Clearly, given the question, this was not necessary and could have wasted valuable time for some candidates.

**E15.**          (a)     (i)      Most candidates correctly carried out the calculation and obtained both marks. Approximately 10% of candidates obtained a principle method mark but calculated an incorrect answer.

(ii)     Very few candidates obtained both marks in this question. Approximately a third of candidates gained one mark for indicating that the index of diversity measures the number of species and the number of individuals. However, only the very best candidates used this information that an index of diversity would be more useful when some species were only present in small numbers.

(b)     (i)      Most candidates gained one mark for explaining that removing other plant species or growing a single crop would reduce the species diversity of plants. However, very few candidates gained a second mark for explaining how these plant species would be decreased e.g. by the use of chemicals or by competition from the crop plant.

(ii)     A majority of candidates gained one mark for appreciating that a decrease in plant species would provide fewer habitats for animals. Better candidates gained a second mark for referring to a decrease in the variety of food sources available. However, many candidates simply stated there would be ‘less food’ which was not credited.

**E16.**          (a)     This question was generally answered well, with the better students able to explain the importance of random collection in the context of the investigation rather than simply turning out the phrase ‘avoiding bias’.

(b)     (i)       Most students understood the summation process even though they made mistakes in another part of the calculation. A significant number of answers went up to 5 or 6 decimal places which, although not penalised, should be avoided. The mathematical requirements of the specification do state the ‘use of an appropriate number of significant figures’. A significant number of students use the space available as rough working rather than for setting out the logic by which they arrived at the answer. A tangled mass of numbers did not always allow the examiners to credit incorrect responses for an understanding of underlying principles.

(ii)     Most students made reasonable attempts at this section. Most correct references were to the reduction in species number and to the predominance of the bird-cherry aphid. Incorrect references were made to totals of all organisms and totals of all species. Weaker students assumed that the fewer organisms in total, the lower the biodiversity. Some wrote, incorrectly, about genetic diversity.

(c)      Instead of evaluating the conclusion given, a significant number of students wrote their own conclusions about the effects of farming on the environment and the mechanisms by which these were brought about. Answers were often vague and did not refer to the data provided.

(d)     Generally answered well; almost all students offered responses, often with good explanations relating to increasing variety of habitats and food sources.

**E17.**(a)    Over 95% of students correctly named the process as succession. Speciation was the most common incorrect response.

(b)     Most students obtained at least one mark, usually for stating that more habitats would be available. Many of these students also referred to a greater variety of food sources although a significant minority simply stated there would be more food, which was not credited. Approximately a third of students gained all three marks by also indicating that as the woodland developed there would be an increase in the variety of plants.

(c)    (i)      50% of students correctly gave temperature and carbon dioxide as the two limiting factors. Most who did not referred to water rather than temperature. However, humidity, mineral ions / nutrients, oxygen, pH, light intensity and chlorophyll were also given as limiting factors. Only rarely were two incorrect factors selected.

(ii)     Most students referred to the uptake of carbon dioxide in photosynthesis and its release during respiration but did not fully explain net productivity. Some students got the use / production of carbon dioxide in photosynthesis / respiration the wrong way round. Almost a third of students did gain this mark, almost invariably by stating that net productivity = gross productivity minus respiration.

(iii)    This question was not answered well. Very few students were able to use the information in **Figure 2** to explain how the shade plant is better adapted to gain both marks. The lower rate of respiration was recognised but the lower release of carbon dioxide was usually described at low light intensities rather than at 0 or in the dark. The idea of greater productivity in the shade plant was less frequently described. Most answers related to photosynthesis and many students gained no marks. As in part (ii), the uptake and release of carbon dioxide was sometimes wrongly assigned to respiration and / or photosynthesis. The surface area of the leaves, amount of chlorophyll and number of stomata were also incorrectly used as part of some students’ explanations.

**E18.**(a)     (i)      Slightly more than half the students obtained this mark, often for mentioning the idea of identifying anomalies or that the sample would be representative of the population. Answers failing to gain credit often lacked sufficient detail with responses such as 'to make the results reliable' or 'to calculate an average' being commonplace.

(ii)     Almost 95% of students gained this mark by mentioning the removal of bias.

(b)     Two thirds of students correctly carried out the calculation and obtained both marks. Approximately 5% of students obtained a principle method mark having calculated an incorrect answer.

(c)     This question proved to be a fairly effective discriminator. Surprisingly, a significant minority of students suggested that there would be a decrease in the variety of insects on the golf course despite the stem of the question indicating that diversity would be higher. However, most students did mention an increase in habitats for one mark. Many also appreciated there would be an increase in the variety of food sources although references to 'more food' were not credited. Only the very best students mentioned an increase in the variety of plants.

**E19.**(a)     (i)      40% of students gave one ethical argument for maintaining biodiversity that was of A-level standard. This was the idea of preventing extinction or loss of habitats. References to animal rights, or ‘playing God’ were classed as neutral.

(ii)     Just under half of students gave one economic argument for maintaining biodiversity. The most common responses that gained credit referred to medicine, tourism or agriculture.

(b)     This proved to be a good discriminator. Nearly two-thirds of students gained at least one mark usually for the answer ‘fewer habitats’. Very few students mentioned that a lower percentage of the original forest meant that fewer plant species would be present. The ability to express the idea of ‘fewer food sources’ discriminated well. This was often conveyed in weaker responses as ‘less food’, which was not credited.

(c)     85% of students scored at least one mark. This was usually for ‘number of each species’. It should be noted that the specification requires students to be able to calculate one specific index of diversity. The ‘number of species’ is not required to calculate this index of diversity. Consequently, this response was classed as neutral

(d)     70% of students scored full marks. Students who did not typically referred to surface area only, a *larger* SA:VOL, a *smaller* VOL:SA, fat or feathers.

**E20.**(a)     This question was the most effective discriminator on the entire paper. The best answers used all the information provided to describe how geographic isolation could cause a very high diversity of bird species. At the other extreme, speciation was ignored and a description of succession was given. Most answers did attempt to explain speciation but often did not make sufficient use of the information provided to gain high marks. Usually these accounts only gained the marks for geographic isolation and for describing differential reproductive success. Poor use of terminology was also clearly evident in these weaker responses. References to different selection pressures and changes in allele frequency were often only mentioned in better responses.

(b)     Surprisingly, almost fifty percent of students failed to gain this mark. Common incorrect response referred to a climax community being formed, or mutations not occurring. Students gaining this mark often mentioned no ‘isolationߣ or ‘a similar environmentߣ.

**E21.**This question was targeted at grade E. It is again surprising that all parts proved to be good discriminators.

(a)     Two-thirds of students gained full marks. This was usually for mentioning that organisms of the same species can produce fertile offspring. However, some students failed to gain the mark for replacing the word ‘fertile’ with ‘viable’.

(b)     (i)      Seventy percent of students correctly calculated the index of diversity within the range of 6.97 to 7. Of the other thirty percent, most gained one mark for calculating a correct numerator or denominator.

(ii)     Nearly all students gained at least one mark, typically for ‘fewer habitats’. Similarly, reference to pesticides or machinery decreasing species diversity was common. Compared with the previous series, it was pleasing to see a greater percentage of students refer to ‘less food sources’ or ‘less variety of food’, rather than simply ‘less food’. Relatively few students linked clearing the forest to a reduction in the number of plant species.

**E22.**Parts (a), (b)(ii) and (b)(iii) proved to be good discriminators.

(a)     70% of students scored full marks. Those who scored one mark often gave both alternatives of the second mark point. Weaker responses often lacked clarity; for example, ‘number of individuals’ and ‘different species within a population’. Students who failed to score often thought that the ‘size of the area’ and ‘standard deviation values’ are needed to calculate an index of diversity. It should be noted that although the specification requires students to be able to calculate one specific index of diversity, the mark scheme was amended so that other types of index of diversity could be credited.

(b)    (i)      Most students were aware that the purpose of the control fields was to ensure that the results are due to the herbicide, or not due to another factor. Those who failed to score typically gave stock How Science Works responses, which could apply to any investigation. These usually referred to comparing groups or results, ensuring that the results were due to the independent variable, or simply that these fields acted as controls. Students should be reminded of the need to relate their answers to the specific investigation or context outlined.

(ii)     Half of students scored one mark and this was usually for appreciating that the herbicide killed more weeds, which led to less competition. However, the ability to explain the effect of high concentrations of herbicide, in terms of damage to the crop, proved to be a good discriminator. Unfortunately, many students did not read information in the introduction carefully enough. They thought that the herbicide killed insects, which meant that fewer crops were eaten. The weakest responses usually went no further than to describe the graph.

(iii)    Just under half of students scored at least two marks. This was usually for ‘fewer habitats’ and ‘fewer food sources’. It was only the best responses that referred to ‘fewer plant species’ being present. Similarly, the ability to express these ideas discriminated well. Weaker responses often referred to ‘less food’ and ‘less plants’, which were not credited. As mentioned in part (i), some students wrongly thought that the herbicide killed insects, which directly led to a decrease in their index of diversity.