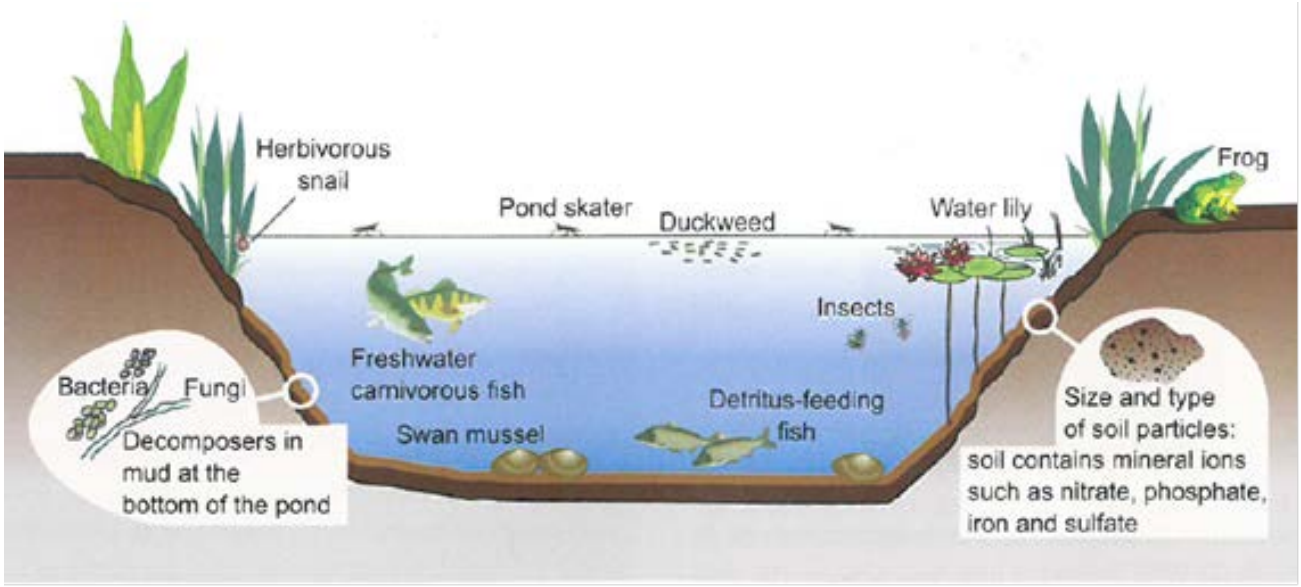
3.4.6 Biodiversity &

3.7.4 Populations in an Ecosystem

Part 1

Name:_____

Reflection on Learning outcomes	☺ or ☹	Target
Define what is meant by the terms population, community, biotic, abiotic, ecosystem and niche		
Explain what is meant by the terms biodiversity, species richness and index of diversity		
Calculate the index of diversity when supplied with relevant information		
Interpret information and draw conclusions from the index of diversity for different habitats		
Explain the techniques of random sampling using quadrats, and systematic sampling using transects and why it is appropriate to use these		
Explain how random sampling can be done to avoid bias		
Describe the different measures of abundance that can be measured		
Explain the technique of mark-release-recapture and when it would be appropriate to use this technique		
Use given data to calculate the size of a population estimated using the mark-release-recapture method		
Explain the assumptions which must be made during mark-release-recapture and why careful consideration must be given to the method used to mark animals		



Outcome:

- Define what is meant by the terms population, community, biotic, abiotic, ecosystem and niche
- Understand the concepts of biodiversity, species richness and index of diversity.

Complete the sort card activity to complete the table below with examples for each definition

Definitions:

Term	Definition	Example
Population	Total number of organisms of one species that occupy the same ecosystem at the same time.	
Community	All the organisms of all species living and interacting together in the same ecosystem at the same time.	
Abiotic Factors	Non-living factors in a particular area	
Biotic Factors	Living factors in a particular area	
Ecosystem	All the Abiotic and Biotic factors in a habitat.	
Niche	Role/position of a species within a habitat	
Biodiversity	The variety of organisms living in an environment	
Carrying capacity	The size of population of a species that an ecosystem can support	
Habitat	Place where an organism lives	

Biodiversity

There are 3 different types of diversity that you need to understand:

Species Diversity: Number of different species and the number of individuals of each species within any one community

Genetic Diversity: Variety of genes possessed by individuals that make up a population of a species

Ecosystem diversity: Range of different habitats from a small local habitat to the whole of the Earth

Example	Term
Coral reef, lake shore, rock pools, your back garden	
A deer lives in wooden areas	
The pH of a seashore is very low, it is acidic	
Daffodils can be white, yellow or orange	
There are approximately 10 million different species of animal and plant life in the amazon rainforest	
The pH of wooden areas is very high, it is alkaline	

Scientist need to be able to **measure the Biodiversity** to check the **"health"** of an ecosystem/habitat/population.

This can be done by **measuring** the **Species richness** or **calculating the Index of Diversity**.

Definition:

Species richness: Number of different species in a particular area at a given time, in a particular community.

What is the issue with using species richness as a measure of biodiversity?

_____

_____

Calculating Index of DIVERSITY – KEY MATHS COMPONENT

Index of Diversity (D): $D = \frac{N(N-1)}{\Sigma\, n(n-1)}$

N means: _____

n means:_____

∑ means: _____

Why do you think the Index of diversity is a better measure of Biodiversity?

_____

Outcome:

- Calculate the index of diversity when supplied with relevant information
- Interpret information and draw conclusions from the index of diversity for different habitats

Follow this method – learn HOW to do this equation

1- **Calculate N.** Add up the total number of individuals in the table eg. 100
2- **Calculate (N-1).** Take 1 away from the value eg. 100-1 = 99
3- **Calculate N (N-1).** Multiply those numbers together eg. 100 X 99 =
This is the top half of the equation (value 1)
4- **Calculate n-1**. Look at the numbers for **each species in the rows**
5- **Calculate n(n-1)**.
6- **Calculate ∑n(n-1)**. Add up the n(n-1) column.
This value is the bottom half of the equation. (Value 2)
7- **Finally divide Value 1 by Value 2**. The answer must be greater than 1.

Habitat 1: Complete to 3 SF.

Species	**Number of individuals (n)**	**n-1**	**n(n-1)**
Hedgerow	600		
Wheat	236		
Ladybird	3		
Total (N)	839		
N (N-1) =		Total	

Habitat __: D= _____

Habitat 2: Complete by applying your knowledge to 3 SF

Species	**Number of individuals (n)**	**n-1**	**n(n-1)**
Hedgerow	126		
Wheat	98		
Ladybird	102		
Total	326		
N (N-1) =		Total	

Habitat __: D= _____

What does this value mean?

The HIGHER the value of D the MORE diverse the habitat. The LOWER the value of D the LESS diverse the habitat.

- Biodiversity reflects how well an ecosystem can survive change in Environmental conditions.
- Stable ecosystems have a high index of diversity
- Stable ecosystems will be less affected by change
- Stable ecosystems are more likely to have at least 1 species that will survive the change in conditions.

What a stable ecosystem, an ecosystem with a high index of diversity, looks like?

- A large variety of different plant and/or animal species.
- No monoculture, all the population sizes are roughly the same
- A large variety of habitats and niches for nesting and feeding
- Large variety of different food sources available

A **low/decrease** in Index of Diversity would result in a **decrease in the factors** listed above.

Using your calculated values for habitat 1 and 2 complete the sentences below then apply your knowledge to the exam question.

Terms**: A B Larger More Less Smaller**

1. Habitat ___ has the highest value and habitat ___ has the lowest value.
2. Habitat ___ has the most stable ecosystem so will be _____ effected by change in the environmental conditions. Has a _____ variety of different plant/animal species, and _____ variety of habitats and niches so a _____ variety of different food sources available.
3. Habitat ___ has the least stable ecosystem so will be _____ effected by change in the environmental conditions. Has a _____ variety of different plant/animal species, and _____ variety of habitats and niches so a _____ variety of different food sources available.

Exam questions:

Q1.(a) What is meant by species diversity?

_____

_____**(1)**

(b) Give **two** pieces of information needed to calculate an index of diversity for a community.

1. _____

2. _____**(2)**

(c) A scientist investigated the effect sewage entering a river had on the distribution of organisms living in the river. Where sewage entered the river, he found a high density of organisms but a low index of diversity. Suggest how sewage entering the river could explain the scientist's findings.

_____

_____

_____

_____ **(2)**

(d) A second scientist repeated the investigation of the first scientist at the same place. The second scientist obtained a high index of diversity. (i) Explain how the second set of results affects the ability of the scientists to make any conclusions about the effect of sewage on the index of diversity.

_____

_____

_____ **(2)**

(ii) Suggest the additional steps that should be taken by the scientists before they are able to make any conclusions about the effect of sewage entering this river.

_____

_____**(1)**

Q2.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.

_____

_____

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_____**(3)**

Q3.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? ☐

(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.

_____

_____

_____

_____**(2)**

Q4. 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.

(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 m^2 (± 2 × SD)		Mean number of species per m^2 (± 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)

(ii) It would not be possible to calculate an index of diversity from the results in the table. Explain why.

_____

_____**(1)**

(iii) 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.

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_____(4)

Key points to use when answering conclusion questions in the exam:

Outcome:

- Explain the techniques of random sampling using quadrats, and systematic sampling using transects and why it is appropriate to use these
- Explain how random sampling can be done to avoid bias
- Describe the different measures of abundance that can be measured
- Explain the technique of mark-release-recapture and when it would be appropriate to use this technique
- Use given data to calculate the size of a population estimated using the mark-release-recapture method
- Explain the assumptions which must be made during mark-release-recapture and why careful consideration must be given to the method used to mark animals

The data above is used to make conclusions about different habitats, it informs ecologists of the stability of ecosystems throughout the world and allows ecologists to track how ecosystems are changing over time. This is quite a difficult task for ecologists though as living organisms are so different and can often move/change with the change of the seasons or an ecosystem can be very large and uniform eg the oceans. To try to make data collected comparable ecologists collect data by sampling.

Definition:

Random Sampling: Reduced human bias, results are representative of whole area

Sampling bias: _____

_____

Chance: _____

_____

How to carry out random sampling:

If the area is **large** and **uniform** with **no clear pattern/species** you would use **random sampling** because it is important that your **results are unbiased** and **representative** of the whole area. **This is an explain question**.

Method:

1. Set up a grid axis using 2 tape measures at right angles to each other,
2. each metre is a marker.
3. Using a random number generator select two numbers at random and use these numbers as co-ordinates.
4. At these co-ordinates place a frame quadrat.
5. Organisms are identified using a key, animals can be counted/collected to give information on abundance, absence or presence of species.
6. Repeat procedure at different times of the day, seasons, month etc.
7. Collect data on % cover using a frame quadrat

Why is it best to carry out random sampling?

It is difficult to eliminate human bias altogether but we can put steps into place which include: (these are also **advantages of carrying out random sampling**)

1. Use a **large sample** size. This will **reduce** the influence **of chance** and anomalies and **allow you to calculate** a **mean** which makes your **results more precise**

2. Analyse the data collected to determine the influence of chance on the data collected. **Carry out statistical tests to make your results more valid**.

3. Use random sampling instead of systematic sampling. **Random sampling reduces human bias** .

How to carry out Systematic Sampling

This is used where there is a **gradual change** in the communities **of plants and animals** takes place e.g. it may be apparent that the species growing in the meadow **gradually change** as you move from a dry part to a wetter part, or from the meadow into the edge of adjoining woodland. **Sampling** is done along a **LINE** that **runs through these changing areas** to identify **change in species** present.

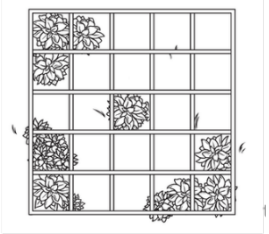
Method:

1. To monitor change along a habitat/area (environmental gradient).
2. Place a line or belt transect across length of area,
3. Quadrat is placed at regular intervals eg every metre.
4. Organisms are identified using a key, animals can be counted/collected to give information on abundance, absence or presence of species.
5. Repeat procedure at different times of the day, seasons, month etc.

How to work out percentage cover when randomly sampling plants.

1. Split quadrat into equal number of squares,
2. Work out % represented by each square by dividing 100% by the number of squares into the quadrat eg 25 squares would be 100/25 = 4% for each square,
3. If a plant covers a whole square = 4%, if the plant covers half the square = 2%, if the plant covers a quarter of the square = 1%.
4. Then add all the squares together to work out the total % cover of the plant within the whole quadrat

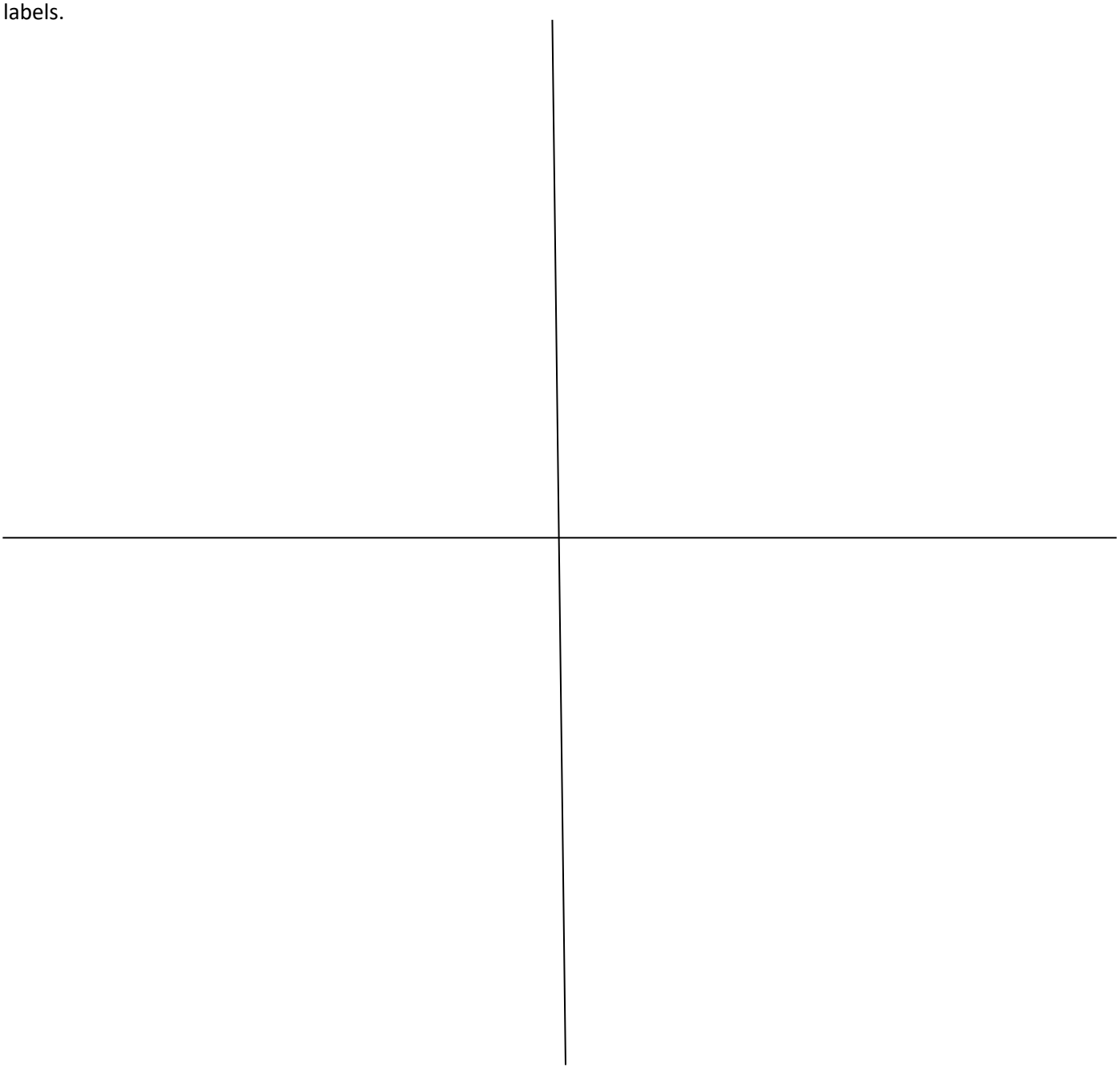
This is one method for working out the abundance of a plant species.



ACFOR scale when randomly sampling plants

Abundant	80-100%
Common	60-80%
Frequent	40-60%
Occasional	20-40%
Rare	0-20%

Draw out the method for Random sampling, systematic sampling, % cover and the ACFOR scale. Remember to add labels.



Mark Release recapture method when randomly sampling animals

Method:

1. Catch a sample of animals and count them
2. Mark each one
3. Release back into habitat
4. Leave for 1-2 days so they can mix
5. Catch a second sample
6. Count the total, and the number which are marked
7. Then use the following equation

$$\text{Total numbers of animals in a population} = \frac{\text{Number in sample 1} \times \text{Number in sample 2}}{\text{Number of marked animals in sample 2}}$$

Worked example: Gypsy moth populations soar every few years in North Eastern deciduous forests, causing great damage to the trees their larvae ear. In order to determine the population of gypsy moths in a forest, 200 were trapped, marked and released. The next night, more moths were collected. Of the 150 that were collected, 15 were already marked. What is the population of gypsy moths in the forest?

Sample size 1: _____

Sample size 2: _____

Marked in 2nd sample: _____

Calculations:

1. In order to determine snail populations, 340 snails were captured tagged and released. Later, 420 snails were captured. Of the 420 snails, 16 were already marked. What is the size of the snail population? Show your working

2. 150 Marlin were captured, tagged and returned to the deep ocean, where they live. Later, when 140 Marlin were captured, 7 of the Marlin has tags. What is the size of the Marlin population? Show your working.

6 assumptions must be correctly followed for the Mark release recapture calculation to be accurate

1. Marked individuals between sample 1 and 2 are proportional
2. Marked individuals from sample 1 distribute evenly
3. No immigration or emigration
4. Few births/death in population
5. Marking not toxic or conspicuous
6. Marking not lost/damaged

Exam questions:

Q1. 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.

_____

_____

_____**(2)**

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

1. _____

_____

2. _____

_____**(2)**

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

_____

_____

_____**(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.

_____

_____

_____**(2)**

Q2.(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.

_____

_____**(1)**

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

_____

_____**(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 m^2
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

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

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.

_____

_____

_____ **(3)**

Q3. Dengue is a serious disease that is caused by a virus. The virus is carried from one person to another by a mosquito, *Aedes aegypti*. One method used to try to reduce transmission of this disease is the Sterile Insect Technique (SIT). This involves releasing large numbers of sterile (infertile) male *A. aegypti* into the habitat. These males have been made infertile by using radiation.

(a) Explain how using the SIT could reduce transmission of dengue.

_____

_____

_____**(2)**

(**b)** Describe how the mark-release-recapture method could be used to determine the population of *A. aegypti* at the start of the investigation.

_____

_____

_____

_____**(3)**

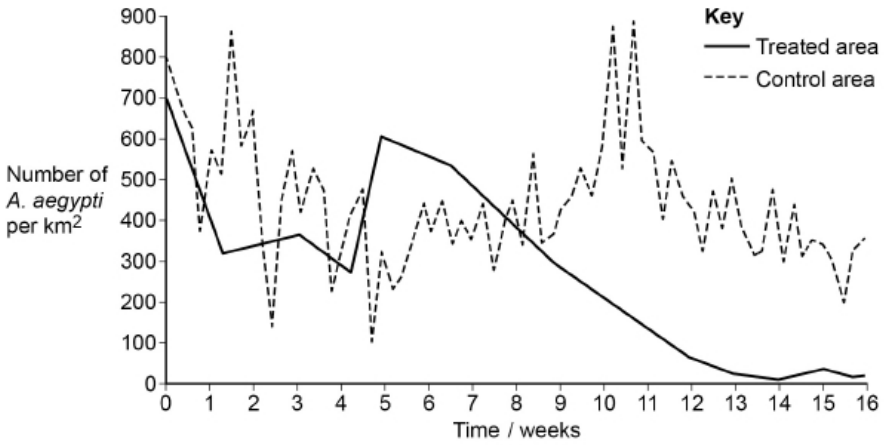
(c) The release of radiation-sterilised *A. aegypti* has not been very successful in controlling the transmission of dengue. Suggest one reason why.

_____

_____ **(1)**

(d) Recently a new method was developed to control *A. aegypti*. Scientists produced transgenic males carrying a 'lethal gene' which kills their offspring before they can reproduce. The scientists released transgenic males every week in one area of a city in Brazil. At regular intervals they determined the number of *A. aegypti* per km^2 in the area where transgenic males were released and in a control area where no transgenic males were released.

The graph shows their results.



Suggest why the scientists released more transgenic males every week.

_____

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_____ **(1)**

(e) The release of transgenic males proved successful in reducing the number of *A. aegypti*.

Describe how the results in the diagram above support this conclusion.

_____

_____

_____

_____**(2)**