Answer **all** the questions.

1. Which of the following **best** describes the term *biodiversity*?

A the variety of species
B the number of individuals of each species
C the variety of genes, species and habitats
D the variety of genes within a species

Your answer ☐

[1]

2(a). The cassowary is a large, flightless bird found in the rainforest in parts of Australia. It feeds mainly on fruit. The seeds of the fruit are deposited on the rainforest floor.

(i) The cassowary is known as a *keystone species*. This means it is important for the survival of other species.

Suggest what role the cassowary plays in the survival of other species.

---

[1]

(ii) The cassowary needs to be conserved for ecological reasons.
State **two** other reasons for maintaining biodiversity.

1

2

---

[2]

(b). The mountain gorilla is an endangered species with as few as 880 individuals surviving in the wild. Many of the animals have been 'habituated' to human contact. The health of these animals is monitored and medical assistance is given when necessary. Animals that are not habituated are rarely visited.

(i) Suggest one advantage **and** one disadvantage of keeping some gorilla families that have not been habituated.

---

[2]

(ii) The gorilla population in one area, Virunga, has been regularly monitored (**Table 24.1**). The data have been collected by indirect methods such as collecting dung samples at nest sites.
However, DNA analysis of another gorilla population suggests that estimates made by these indirect

methods may be up to 6% inaccurate.

Year	Population in Virunga
1981	254
1989	320
2003	380
2010	480

Table 24.1

Calculate the mean annual percentage rate of growth of the gorilla population in Virunga between 1981 and 2010.

Show your working.

Answer _____ % **[2]**

(iii) In 1993 the Rio Convention on Biodiversity came into force. In 2010, one conservationist commented that the Rio Convention had had a real effect on the gorilla population.

Use the information above to evaluate the effect that the Rio Convention on Biodiversity has had on the gorillas in Virunga.

---

[3]

3(a). The invertebrate biodiversity of two different peat bog ecosystems was sampled. Values of Simpson's Diversity Index were calculated for both ecosystems. The results are shown in Table 4.1.

Species	**Ecosystem A**			**Ecosystem B**		
	n	*n/N*	$(n/N)^2$	*n*	*n/N*	$(n/N)^2$
G. cottonae	3	0.0361	0.0013	14	0.15	0.0227
G. servulus	1	0.0120	0.0001	12	0.13	0.0166
C. cocksi	4	0.0482	0.0023	20	0.22	0.0462
L. nigrifrons	24	0.2892	0.0836	25	0.27	0.0723
E. cryptarum	33	0.3976	0.1581	22	0.24	0.0560
T. limbata	5	0.0602	0.0036			
S. litorea						
T. rivularis	1	0.0120	0.0001			
S. argus	4	0.0482	0.0023			
Σ =			0.2607			0.2138
1 – Σ =			0.7393			0.7862

Table 4.1

(i) Complete the missing row **in Table 4.1** by adding the correct values for *S. litorea*.

[3]

(ii) What can you conclude about the species evenness and richness of **Ecosystem A** in comparison to **Ecosystem B**?

---

[2]

(iii) Scientists planned to sample the biodiversity in another peat bog ecosystem. They identified three different areas within the ecosystem:

- an area of conifer trees (800 m^2)
- a marshy area with a high water table (2400 m^2)
- a heavily grazed area (3200 m^2)

Suggest the sampling strategy that the scientists should use and comment on the number of samples they should collect.

[3]

(b). The genetic diversity of the moss *Polytrichum commune* was analysed in two peat bog ecosystems.

Scientists measured genetic diversity by studying three gene loci. For each gene locus, they calculated the proportion of heterozygotes in each population. These values were used as a measure of genetic diversity.

The scientists sampled 72 individuals from Population A and 48 individuals from Population B.

The results of the genetic analysis are shown in Table 4.2.

	Number of heterozygous individuals		
	Locus 1	Locus 2	Locus 3
Population A	65	69	60
Population B	42	41	40

Table 4.2

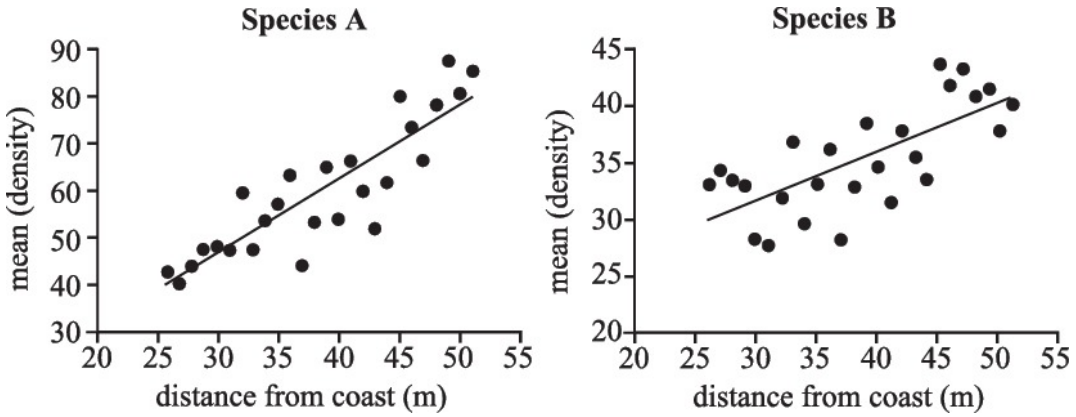
Using the data in Table 4.2, suggest which of the two populations of *P. commune* has the greater genetic diversity.

Explain your conclusion **and** show your working.

---

[2]

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



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

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

Your answer ☐

[1]

5.

(i) The biomass of large fish in the Southern Ocean is a food resource for humans. It is increasingly harvested by powerful, long-distance trawlers. If over-exploited, the Southern Ocean ecosystem may be permanently altered.

- Suggest two measures that an international treaty might impose, to prevent fishing from causing permanent damage to the Southern Ocean.
- Identify the practical difficulties that might prevent your two measures from being effective.

First measure

Difficulty

Second measure

Difficulty

[4]

(ii) Krill can also be harvested as a human food source.
The fishing industry aims to harvest large fish.
Some environmentalists say that krill harvesting should be increased.

Use this information and **Table 21.1** to put forward arguments for and against harvesting krill instead of large fish as a human food source.

[2]

6(a). On a biology field trip, some students carried out a survey of butterfly species in two areas of heathland.

One part of the heathland was used regularly by walkers, while the other had been deliberately fenced off by the National Park Authority in an attempt to promote biodiversity.

Area 1 was the area accessible to walkers.
Area 2 was the fenced off area.

On two different mornings in June the students walked along a transect in each area 4 times, at 30 minute intervals, and recorded every butterfly sighting.

The aim of the survey was to compare the biodiversity of butterfly species in the two areas.

Suggest how the procedure could be improved so that a valid comparison could be made.

---

[3]

(b). The students' results are shown in Table 2.1.

	Area 1	**Area 2**		
Species of butterfly	**Number of individuals (*n*)**	**Number of individuals (*n*)**		
Grayling	2	5		
Large heath	16	10		
Gatekeeper	9	7		
Green hairstreak	3	5		
Silver-studded blue	0	2		
Small heath	8	11		
Simpsons Index	0.7131			

Table 2.1

(i) Identify the area with the higher species **richness** and justify your answer.

Area_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Justification

---

[1]

(ii) Identify the area with the higher species **evenness** and justify your answer.

Area_ _

Justification

---

[1]

(iii) Using the formula below, the students calculated Simpsons Index of Diversity in **Area 1** to be 0.7131.

$D = 1-(\Sigma(n/N)^2)$

Where N is the total number of individuals of all species.

Simpson's Index of Diversity in **Area 2** is greater than in **Area 1**.

Use the formula to show that this is the case.

You may use the blank spaces in Table 2.1 to assist in your calculations.

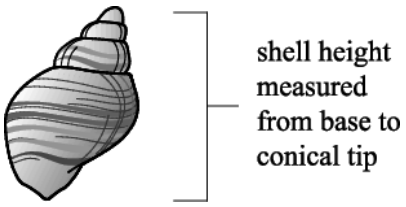
Answer_ _ _ _ _ _ _ _ _ _ _ _ _ _ **[4]**

(c). * The students concluded that “fencing off the area of heathland has increased the biodiversity of butterflies”.

Evaluate the validity of the students' conclusion using all of the information you have been given, including Table 2.1.

[6]

7. The effect of wave action on the height of the shells of the dog whelk *(Nucella lapillus)* was investigated by comparing an exposed shore and a sheltered shore.



- A random sampling technique was used to collect 50 shells from an exposed shore.
- The shell height was measured from the base to the conical tip. The whelk was returned to its location.
- The process was repeated for the sheltered shore.
- All the results were recorded in **Table 3.1**.

Location	Height of shell (mm)										Range	Mean	SD
Sheltered shore	26	28	27	26	28	23	28	23	26	28			
	29	29	29	29	29	28	29	29	29	29			
	30	31	30	29	32	29	30	29	30	32			
	33	35	34	32	35	32	34	32	33	35			
	37	39	38	37	39	35	38	36	37	39	16	31.3	4.1
Exposed shore	15	17	16	15	23	15	23	16	13	15			
	17	24	18	17	17	14	17	18	16	17			
	19	19	20	24	18	20	19	20	18	20			
	23	14	24	14	21	20	23	17	21	23			
	25	25	28	26	25	27	25	28	25	27	15	20.0	4.2

Table 3.1

(a) The t test can be used to determine the significance of the differences between shell height on the exposed shore and the sheltered shore.

(i) Calculate the *t* value for the data using the formula:

$$t = \frac{\left|\bar{x}_1 - \bar{x}_2\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

where, $\left|\bar{x}_1 - \bar{x}_2\right|$ is the difference in mean values of sample 1 and sample 2

s_1^2 and s_2^2 are the squares of the standard deviations of the samples

n_1 and n_2 are the sample sizes.

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

Answer_____ **[2]**

(ii) The null hypothesis is that there is no difference between the means of the two shell populations.

The critical values at 98 degrees of freedom are shown in **Table 3.2**.

Degrees of freedom	***p* = 0.10**	***p* = 0.05**	***p* = 0.01**	***p* = 0.001**
98	1.67	2.00	2.64	3.41

Table 3.2

Using the table of critical values, explain whether the student would be able to accept or reject the null hypothesis as a result of the *t* value you calculated in part **(i)**.

---**[1]**

(b) The students organised the data from **Table 3.1** into classes.

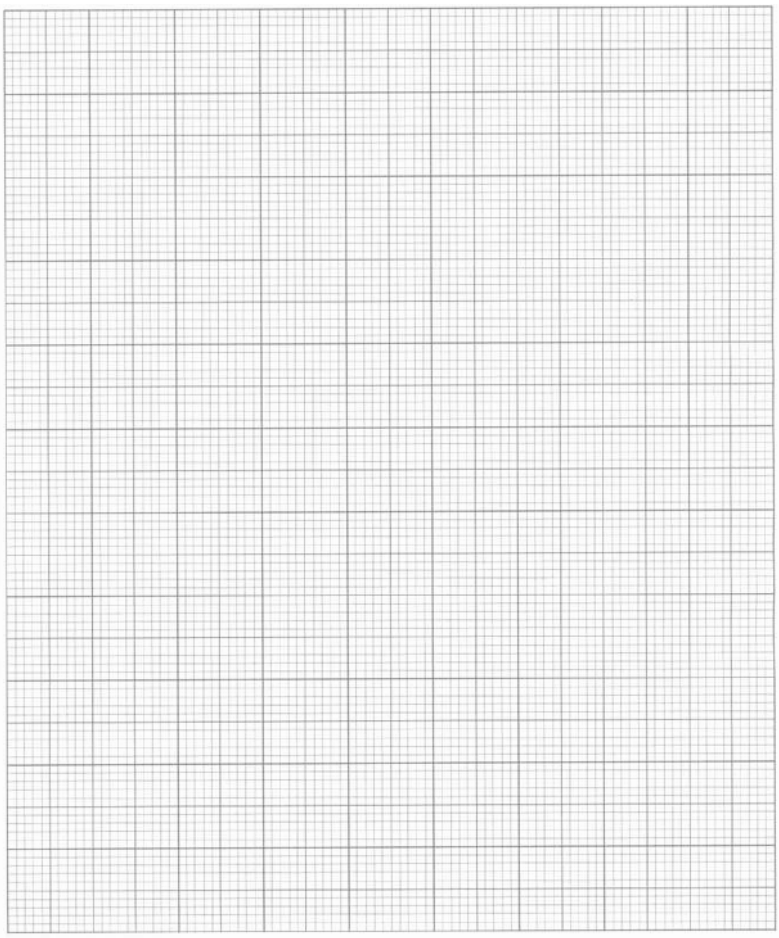
The organised data is shown in **Table 3.3**.

Sheltered shore			**Exposed shore**		
Height (mm)	**Tally**	**Total**	**Height (mm)**	**Tally**	**Total**
23–26	𝍸	5	11–14	𝍸	4

27–30	𝍸 𝍸 𝍸 𝍸 II	22	15–18	𝍸 II	18
31–34	𝍸 𝍸 I	11	19–22	𝍸 𝍸 II	12
35–38	𝍸 IIII	9	23–26	𝍸 𝍸 II	12
39–42	III	3	27–30	IIII	4

Table 3.3

Plot the most suitable graph of the data given in **Table 3.3**.



[4]

(c) Use the data and graph to discuss any correlation between the height of the whelk shell and the type of shore.

Suggest explanations for your findings.

---

[3]

(d) Suggest a limitation of the procedure used to gather the data in this experiment and recommend how you could improve this.

---

[2]

(e) How could the students improve the accuracy of their data?

---

[1]

(f) Discuss the validity of the conclusions you have made during this experiment.

---

[3]

8. Termites such as the species that built the mound in **Fig. 5.1** on the insert can be classed as 'keystone species'.

Use the information given to state one argument that supports this statement and one argument that does not.

---

[2]

Fig. 5.1

9. Two different fields, field **G** and **H**, were sampled for three common species of wildflower.
The results are shown below.

	Number of individuals	
Species	**Field G**	**Field H**
Daisy	300	20
Dandelion	335	49
Buttercup	365	931
Total	1000	1000

Which of the options, **A** to **D**, is correct?

A Field **G** will have a greater Simpson's diversity index.
B Field **H** has greater species evenness.
C Field **H** will have a greater Simpson's diversity index.
D Field **G** has greater species richness.

Your answer

[1]

10. The Sumatran rhinoceros, *Dicerorhinus sumatrensis*, is a rare member of the family Rhinocerotidae. These rhinoceros are now critically endangered, with only six substantial populations in the wild: four in Sumatra, one in Borneo, and one in the Malay Peninsula.

D. sumatrensis lives in rainforests. Their numbers are difficult to determine but they are estimated to number fewer than 100.

(i) Suggest **two** reasons why this species is critically endangered in the wild.

---

[2]

(ii) The remaining populations of *D. sumatrensis* are all small and are scattered in isolated areas. These are factors that might speed up the extinction of the species.

Suggest why.

---

[2]

(iii) Captive breeding programmes with *D. sumatrensis* have been unsuccessful.

Suggest **one** other way in which zoos can contribute to the conservation of the Sumatran rhinoceros.

---

[1]

11(a). *Nymphaea thermarum* is the world's smallest and most endangered water lily. It was first discovered by scientists in central Africa, in 1987. It has not been seen in the wild since 2008 and is only known to exist in a few botanic gardens.

N. thermarum is the only lily that grows in damp mud rather than water.

The site where it was originally discovered has not been directly affected by the activities of humans in the local area.

Suggest why *N. thermarum* is no longer found in the area where it was first discovered.

---

[2]

(b). Botanic gardens collect plant species from around the world to maintain biodiversity.

(i) State two levels at which biodiversity may be considered.

1

2

---

[2]

(ii) State **one** benefit to human health of maintaining plant biodiversity.

---

[1]

(iii) Explain the benefits to agriculture of maintaining plant biodiversity.

---

[3]

(c). When *N. thermarum* was first collected from the wild, it proved very difficult to grow successfully in a botanic garden.

Some scientists thought that successful growing of *N. thermarum* would depend on the availability of water in the soil.

Outline, briefly, a valid investigation that could determine the effect of varying the moisture content of the soil on the growth of *N. thermarum*.

[4]

(d). In 2014, a *N. thermarum* plant was stolen from the Royal Botanical Gardens at Kew.

It is thought that the thief intended to sell the plant to a private collector.

(i) An international agreement exists to restrict the sale of rare species such as *N. thermarum*.

Name this agreement.

[1]

(ii) Other international agreements exist.

Under the terms of one such agreement, some of the money made **legally** from endangered species goes to the country where the species was first discovered in the wild.

Name the agreement that encourages fair sharing of benefits from the legal use of endangered species.

[1]

12. A student wrote the following statement: "The Simpson's Index of Diversity for the area of woodland is very high. This means that the habitat is stable and so the electricity company's application to build a power station is likely to be approved after the Environmental Impact Assessment has been carried out."

Explain the incorrect biology in this answer.

---

[2]

13. In 2007, scientists studied the effect of roe deer on the biodiversity of the habitat at a number of sites, shown on Fig. 3.1.

At each study site, the scientists sampled plants and animals in unfenced areas where roe deer were present and in fenced areas where roe deer could not go.

(i) Explain the importance of sampling in measuring the biodiversity of a habitat.

---

[2]

(ii) Why was it important to take samples in fenced and unfenced areas?

---

[1]

(iii) The scientists needed to measure species richness and species evenness to calculate Simpson's Index of Diversity.

Explain the difference between species richness and species evenness and why both measurements are needed to assess biodiversity.

---

[3]

(iv) In areas where the population of roe deer was high, the Simpson's Index of Diversity was low for shrubs (medium-height plants) and was also low for woodland birds.

Roe deer eat plants. Most woodland birds do not eat plants.

Suggest **one** reason why a large roe deer population might decrease the diversity of woodland birds.

---

[1]

(v) Outline the significance of a low value of Simpson's Index of Diversity.

---

[2]

14(a). Explain why it is sometimes necessary to conserve a plant species, such as *N. thermarum*, outside its natural habitat (*ex situ*).

---

[3]

(b). The Royal Botanic Gardens also manages the Millennium Seed Bank, which aims to store seeds from one quarter of all plant species.

Give **three** advantages of conserving plant species as seeds and **not** as adult plants.

1

2

3

---

[3]

(c). When measuring the biodiversity of a habitat, it is difficult to count every organism. It is therefore necessary to sample a proportion of the habitat. The sampling process must not be biased.

Outline an unbiased sampling method that can be used to measure the biodiversity of plant species in grassland.

---

[4]

(d). Scientists try to estimate the total number of species on Earth.

Suggest **three** reasons why such estimates are not likely to be accurate.

1

2

3

---

[3]

15(a). The elk, *Cervus canadensis*, is a large herbivore.

Fig. 2.1, shows figures relating to the number of elk in Yellowstone National Park in the USA between 1965 and 2002.

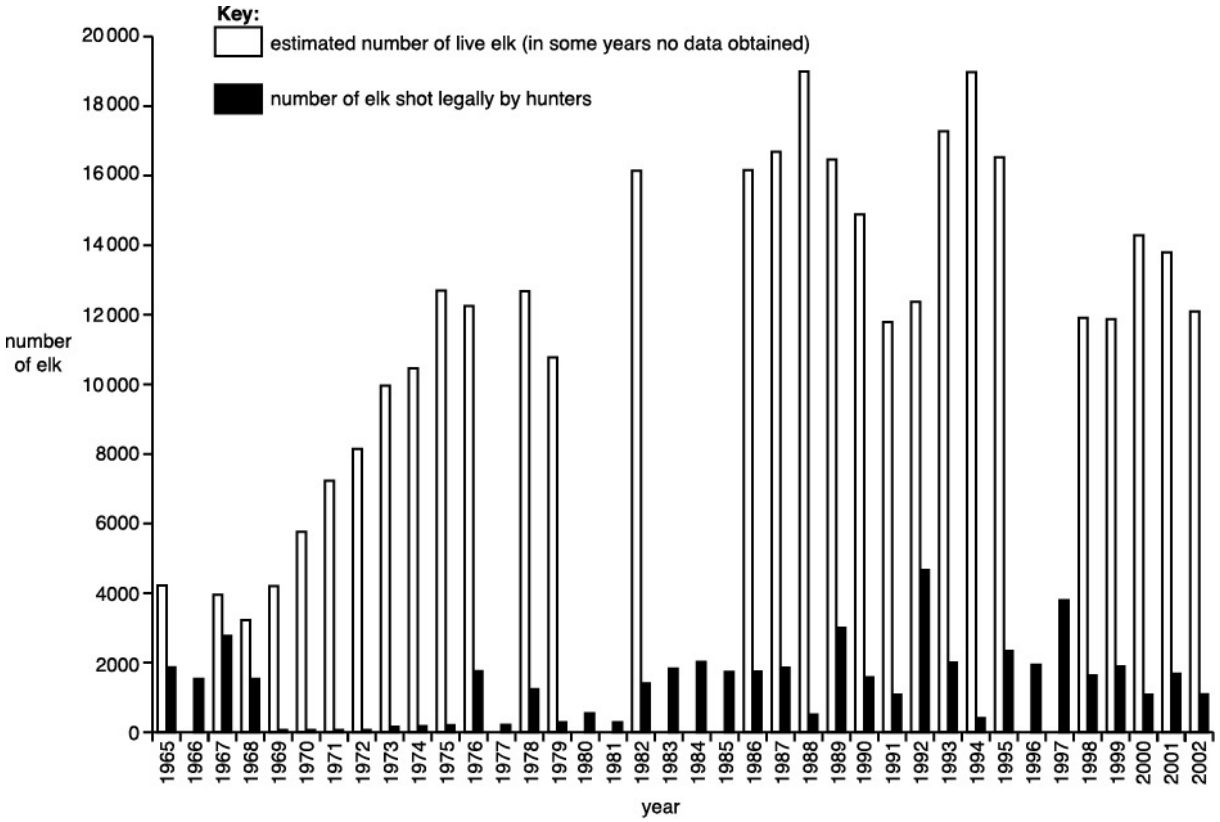


Fig. 2.1

The figures were obtained in two different ways:

- the white bars show estimated numbers of live elk obtained by ecological sampling
- the black bars show numbers of elk that were legally shot by hunters.

In some years no data for live elk were obtained.

(i) Using Fig. 2.1, describe the pattern shown by the data for the estimated number of live elk from 1965 to 2002.

---**[3]**

(ii) The recorded number of elk legally shot by hunters provides accurate data.

Suggest why these data are accurate, but the method used to obtain these data is not a valid way of estimating the number of elk in the population.

---**[2]**

(b). The grey wolf, *Canis lupus*, is a large predator whose diet includes elk.

By 1926, grey wolves had been hunted to extinction in Yellowstone Park. However, this species could still be found in other parts of the world.

In 1995, a population of grey wolves was introduced to Yellowstone Park and their numbers increased.

(i) With reference to Fig. 2.1, discuss the factors that may have affected the size of the elk population:

- before 1995
- after 1995.

In your answer you should provide a balanced account referring to factors before and after 1995.

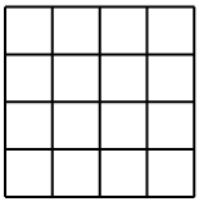
---

[7]

(ii) Explain why the introduction of wolves to Yellowstone Park in 1995 is an example of conservation.

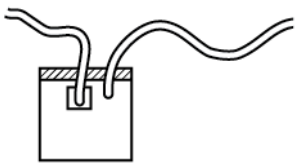
[2]

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



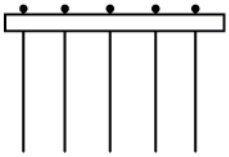
frame quadrant

P



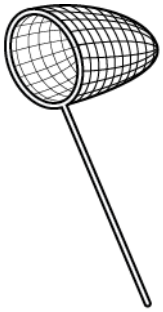
pooter

Q



point quadrant

R



sweep net

S

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

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

Your answer

[1]

17. The following statements describe the benefits of *ex situ* conservation.

1 Conditions can be maintained at the optimum.
2 Many specimens can be conserved in a small space.
3 The health of individuals can be monitored constantly and treatment provided if necessary.

Which of the following, **A** to **D**, identifies the statement(s) that apply to seed banks?

A 1, 2 and 3
B only 1 and 2
C only 2 and 3
D only 1

Your answer ☐

[1]

18(a). *Global biodiversity is in decline.

Human population growth, agriculture and climate change each have an effect upon biodiversity.

Explain how each of these factors contributes to the decline in biodiversity.

[6]

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

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

(i) Beavers are considered to be a keystone species.

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

[2]

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

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

constructed dams

felled trees

built lodges

[3]

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

[1]

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

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

[2]

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

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

argument 1 _____

---

argument 2 _____

---

[4]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	**1**	
2	a	i	seed dispersal	1	
		ii	(named) economic reason (named) aesthetic reason	2	
	b	i	*advantage:* exhibit natural behaviour / less likely to catch disease from humans (1) *disadvantage:* poaching more likely / could be wiped out by disease / more difficult to count (1)	2	Must give one advantage and one disadvantage.
		ii	3.1 (%) (1)(1)	2	**ALLOW** one mark if calculation correct but final figure incorrect e.g. (480 – 254) / 254 × 100 / 29 = **ALLOW** 3% or 3.07%
		iii	*three from* no evidence of causal effect (1) the data may be inaccurate as a result of, indirect methods used / unhabituated animals hard to find (1) annual growth rate higher after 1993 (1) 3.2% (per year) before 1993 against 3.8% after 1993 (1) figures may not be accurate due to collection technique (1)	3	
			Total	**10**	
3	a	i	8 (1) | 0.0964 (1) | 0.0093 (1)	3	
		ii	A has greater richness (1) **ORA** B has greater evenness (1) **ORA**	2	
		iii	stratified **AND** random (within each area) (1) *idea that* the number of samples within each area should be proportional to their size (1) correct suggestion for the number of samples taken within each area (1)	3	**ALLOW** description of stratified e.g. 8 in conifer area, 24 in marshy area, 32 in grazed area

Question			Answer/Indicative content	Marks	Guidance
	b		A because mean proportion of heterozygotes is higher (1) A = 0.898 **AND** B = 0.854 (1)	2	**ALLOW** any correct number of significant figures and percentages
			Total	**10**	
4			C	1	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
5		i	*Measures* fishing quotas (1) mesh size (1) species restriction (1) trawler size / days at sea (1) penalties / sanctions (1) monitoring / surveillance (1) publicity / public education (1) *Difficulties* area too large (1) expense of monitoring (1) monitoring hampered by, weather / seasons (1) false reporting of, catches / trawler size / mesh size / days (1) death of fish caught but not kept (because of restrictions) (1)	4	**The difficulties should relate to the measures proposed.**
		ii	*argument for* comparison of the energy in large fish and krill shows humans would get 100x more kJ / energy from krill than large fish (1) *argument against* would require large change to fishing industry / consumer habits **or** could impact ecosystem at first trophic level (1)	2	**ALLOW** the use of figures to illustrate the data comparison.
			Total	**6**	

<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>a</td><td></td><td>idea of more transects in different parts of area 1 and 2 (1)
(collect at) different, times of day / times of year / weather conditions (1)
method of ensuring that individuals not counted again (1)

(use a method to) capture individuals (1)

(use a method to) correctly identify species (1)</td><td>3</td><td>

ALLOW example of appropriate method, e.g. (butterfly) net
ALLOW e.g. photograph / use of key</td></tr>
<tr><td></td><td>b</td><td>i</td><td>(Area) 2

(because it) has, more / 6, species (1)</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>(Area) 2

idea that the range of n is smaller (1)</td><td>1</td><td>

ALLOW use of figures to exemplify</td></tr>
<tr><td></td><td></td><td>iii</td><td><table>
<tr><th></th><th>Area 1</th><th colspan="3">Area 2</th></tr>
<tr><th>Species of butterfly</th><th>Number of individuals (n)</th><th>Number of individuals (n)</th><th>n/N</th><th>(n/N)^2</th></tr>
<tr><td>Grayling</td><td>2</td><td>5</td><td>0.125</td><td>0.0156</td></tr>
<tr><td>Large heath</td><td>16</td><td>10</td><td>0.250</td><td>0.0625</td></tr>
<tr><td>Gatekeeper</td><td>9</td><td>7</td><td>0.175</td><td>0.0306</td></tr>
<tr><td>Green hairstreak</td><td>3</td><td>5</td><td>0.125</td><td>0.0156</td></tr>
<tr><td>Silver-studded blue</td><td>0</td><td>2</td><td>0.050</td><td>0.0025</td></tr>
<tr><td>Small heath</td><td>8</td><td>11</td><td>0.275</td><td>0.0756</td></tr>
<tr><td></td><td></td><td>N = 40</td><td></td><td>0.2024</td></tr>
<tr><td>Simpsons Index</td><td>0.7131</td><td></td><td></td><td>0.7976</td></tr>
</table>

any successful calculation of (n/N)^2 (1)
(Σ(n/N)^2 =) 0.2024 (1)
(1-Σ(n/N)^2 =) 0.7976 (1)
answer given to 4 significant figures (1)</td><td>4</td><td>Correct answer given to 4 sig. fig. with no working shown = 4 marks

ALLOW correct answer with different sig. figs
ALLOW correct answer with different sig. figs</td></tr>
</table>

Question			Answer/Indicative content	Marks	Guidance
	c		For answers marked by levels of response: Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing. **In summary:** • **The science content determines the level.** • **The communication statement determines the mark within a level.**		

Question	Answer/Indicative content	Marks	Guidance
	Level 3 (5–6 marks) Full and detailed evaluation of the students' conclusion taking into account the validity of the method used **and** the implications of the data collected. Learner demonstrates a holistic judgement of the information including evidence for **and** against the claim. The candidate makes a judgement that there is not enough evidence to support the students' conclusion. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	6	**Indicative scientific points may include…** **Evidence to support the conclusion (that fencing increased biodiversity)** • calculated Simpson's Index of Diversity is higher in fenced area • high Simpson's Index means high biodiversity • greater number of species / higher species richness in fenced area • silver-studded blue only occurs in fenced area.

Question			Answer/Indicative content	Marks	Guidance
			Level 2 (3–4 marks) An evaluation of the students' conclusion taking into account the validity of the method used **and / or** the implications of the data collected. Learner demonstrates a holistic judgement of the information including evidence for **and** against the claim. The candidate makes a judgement in line with the argument they have presented. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** An evaluation of the claim is attempted including discussion of either the validity of the method **or** the implications of the data. The answer includes evidence for **or** against the claim. A definitive judgement may not be present. *A basic structure and some relevant information is provided, although a clear line of reasoning may not be present. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		**Students' conclusion may be overdrawn because…** • difference in Simpson's Index of Diversity between two areas is small (12%) • range of number of individuals is greater in Area 1 (0–16) than Area 2 (2–11) • higher number of individuals of 'Large heath' and 'Gatekeeper' butterflies sighted in Area 1. • do not know length of time Area 2 has been fenced off. • *limitations of method* ◦ samples taken on only two days ◦ samples only taken in one season ◦ no method to prevent recounting ◦ observation at a distance might have led to mis-identification.
			Total	**15**	

Question			Answer/Indicative content	Marks	Guidance
7	a	i	$t = 13.61$ (1)(1)	2	**ALLOW** correct working for 1 mark. $\frac{[31.3 - 20.0]}{\sqrt{\frac{4.1^2}{50} + \frac{4.2^2}{50}}} = \frac{11.3}{\sqrt{\frac{16.81}{50} + \frac{17.64}{50}}} = \frac{11.3}{\sqrt{0.3362 + 0.3528}} = \frac{11.3}{\sqrt{0.689}}$ $= 11.3 / 0.830 = 13.61$
		ii	probability is highly significant, calculated *t* value is greater than the critical value at 0.001 / there is a chance (probability) of below 0.001 that the differences in the shell height seen can be due to chance **and** the null hypothesis can be rejected (1)	1	
	b		histogram correctly plotted for the values (1) two sets of data distinguished by a key or other suitable method to identify them (1) *x* axis labelled 'height (mm)' **and** *y* axis labelled 'number of dog whelks / *Nucella lapillus* / shells / class' (1) makes good use of the graph paper **and** both axes are correctly scaled with ascending equidistant intervals (1)	4	**DO NOT ALLOW** a bar chart or a line graph as neither would represent the data correctly. **ALLOW** a correlation scattergram. **ALLOW** '% of the sample' for the *y* axis if this has been calculated.
	c		three from positive correlation between the height of the whelk shell and the type of the shore (1) correct calculation of the correlation coefficient (1) (histogram / data, indicates that) shore exposure has an impact on height (1) Nucella show adaptation to harsher wave action (1) shells measured may not all be exposed to wave action (1)	3	**ALLOW** correlation is strong or a reference to relationship such as:- taller shell height and sheltered shore or shorter shell height and exposed shore. **ALLOW** little overlap on the histogram bars. **ALLOW** the idea that the differences may be due to direct wave action or adaptation.

Question			Answer/Indicative content	Marks	Guidance
	d		no detail for the random sampling technique was given / *Nucella* from the whole population may not have been sampled (1) **and** use (two) metre tapes to set out a grid and use randomly generated coordinates (1) no measuring instrument specified (1) **and** use vernier callipers with a precision of more than 0.5 mm (1) incorrect identification of *Nucella* / several types of shelled molluscs that are similar to *Nucella* (1) **and** use a sea shore key to correctly identify the whelk (1) classification of the shore as sheltered or exposed was subjective (1) **and** use an approved shore classification (such as Ballantine's) (1)	2	**Limitation and improvement must be linked for 2 marks.**
	e		*one from* increase the number of, *Nucella* used in the data collection / samples (1) replicate / repeat, the entire experiment again (1)	1	**ALLOW** a value given such as increasing number to 100 from each shore. **ALLOW** an understanding of the *idea* that the procedure has only been carried out once for each shore.

Question			Answer/Indicative content	Marks	Guidance
	f		*not valid* a small percentage of N*ucella* sampled and some areas not sampled at all which would lead to skewed data (1) human interpretation of the measurement causes accuracy of the data to be questioned (1) genetic variations or sub species not taken into account (1) *valid* random sampling techniques mean no bias in collection (1) 100 *Nucella* sampled in total (50 in each area) so large sample size (1) precise instructions for consistent measurement of shell height (1)	3	**ALLOW** reverse arguments made. *idea that* conclusion will be distorted
			Total	**16**	
8			*argument for* important, (N or C) recyclers / saprotrophs (1) *argument against* not a predator (1) large in abundance / biomass (so effect on environment not disproportionate) (1)	2	
			Total	**2**	
9			A	1	**Examiner's Comments** Candidates needed to be clear about the definitions of species richness and species evenness in order to answer this question. Option D was a common incorrect suggestion. Some candidates suggested G or H, which were not valid options.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
10		i	loss of, (rainforest) habitat / food source **or** deforestation ☐ hunting / poaching (for horn) ☐ climate change ☐	max 2	**IGNORE** disease **ACCEPT** loss of (rainforest) ecosystem **IGNORE** only lives in rainforest **Examiner's Comments** 'Poaching' or 'hunting' and 'deforestation' were the most common correct reasons given for why the species is critically endangered.
		ii	1 hard to find a mate / may be gender imbalance ☐ 2 (inbreeding leading to) low genetic diversity / small gene pool / genetic bottleneck ☐ 3 cannot / less likely to, cope with / adapt to, (named) environmental change ☐ 4 all wiped out by the same disease ☐ 5 more vulnerable to, predators / poachers ☐ 6 natural disaster could wipe out, one / some, of the small populations ☐	max 2	1 **ACCEPT** few individuals of reproductive maturity 2 **ACCEPT** description 3 **ACCEPT** (population) unable to cope with new selection pressures 4 **DO NOT CREDIT** that they are more susceptible to disease in general **Examiner's Comments** Many candidates stated that less reproduction would occur but did not further develop the idea. A smaller gene pool or less genetic variation was often correctly stated but fewer candidates went on to explain how this would speed up extinction in terms of a lack of ability to adapt to environmental change or all being vulnerable to a particular disease. There was a misconception for some candidates in this question, since they discussed problems for small animals as opposed to small populations.

Question			Answer/Indicative content	Marks	Guidance
		iii	education / awareness ☐ support for / promote, conservation projects / research ☐	max 1	**IGNORE** ref to cloning In the context of educating the general public e.g. information displayed in the zoo or on website / holding education days for schools 'support' could mean: raise money / provide funds / provide technical support / provide expertise / etc. **CREDIT** in the context of an example e.g. sending people to monitor populations in the wild e.g. supporting the setting up of nature reserve **IGNORE** zoo sets up nature reserves **Examiner's Comments** This question proved to be challenging for most candidates who often failed to note from the information in the question that captive breeding programmes with *D. sumatrensis* have been unsuccessful. It was very common to read in their responses that the zoos could re-introduce the rhinos into the wild, rather than correctly referring to zoos providing funding or support for conservation projects or raising public awareness.
			Total	**5**	

Question			Answer/Indicative content	Marks	Guidance
11	a		global warming; *example of consequence of climate change* mud has dried up / mud now too wet / flooding / disease / (new) herbivore / pest;	2	**ACCEPT** climate change **IGNORE** environmental change **ACCEPT** (new) predator / heavy rainfall / drought **IGNORE** refs to temperature for this marking point **IGNORE** competition **Examiner's Comments** Both marks were given, more often than not, in this question. Most candidates cited climate change or global warming and many were able to link this to a specific local event, most commonly the drying up of damp mud.
	b	i	(at the) level / number / range, of species; (at the level of) genetics / genes / gene pool / DNA; (at the level of) habitat / ecosystem;	2 max	**ACCEPT** amount of species / species richness **IGNORE** species evenness **ACCEPT** e.g. range of habitats **IGNORE** area / in a habitat **Examiner's Comments** Performance on this question was surprisingly poor. The question tested AO1 with wording that matched, almost exactly, the second learning outcome in the biodiversity section of the specification. However, many candidates appeared not to understand the question. Common misconceived answers were: local and global, in situ and ex situ, and species richness and species evenness. Serendipitously, 'species richness' did satisfy the requirements of the first marking point.

Question			Answer/Indicative content	Marks	Guidance
		ii	plants are a source of (new), medicines / drugs / treatments;	1	**IGNORE** nutritional / health, benefits **IGNORE** antibiotics **Examiner's Comments** Most scored a mark here for a potential medical use of plants. A few discussed nutrition, or the benefits to health of the aesthetic aspect of nature or the release of oxygen, for no credit.
		iii	*Any three from:* **1** genetic variation / source of (named) useful genes; **2** (used for) genetic engineering; **3** (used for) selective breeding / breeding with, cultivated / crop / AW, varieties; **4** variety might be useful in a changing climate; **5** (habitat for) pollinators **6** (habitat for) agents of biological control; **7** source of a new medicine for livestock;	3 max	**1 ACCEPT** maintaining gene pool / genetic diversity **2 ACCEPT** description of genetic engineering **3 ACCEPT** cross as AW for breed **4 ACCEPT** species as AW for variety **4 ACCEPT** examples of features useful in a different climate, e.g. drought resistance **7 IGNORE** antibiotics **Examiner's Comments** was not done well. Again, the wording of the question matched one of the learning outcomes almost exactly and yet many candidates did not seem to understand the question. Many candidates wrote a lot about the dangers of monoculture and gained the first marking point but few achieved marks beyond that. A minority of candidates discussed selective breeding, genetic engineering or pollination but other marking points were rarely seen.

Question			Answer/Indicative content	Marks	Guidance
	c		**1** grow / AW, (*N. thermarum*) in a range of (soil) water content; **2** leave for / over, same / stated, time; **3** measure height / count number of (viable) individuals; **4** calculate mean (from the results); **5** keep two other named variables constant;	4 max	**1 IGNORE** in presence and absence of water **1 ACCEPT** in context of, seed / cutting / plug etc **2 IGNORE**rate **3 ACCEPT** measure, (dry) mass / width / spread / number of leaves **3 IGNORE** measure growth **4 ACCEPT** perform statistical test (on the results) **4 IGNORE** average but **ACCEPT** mean average **4 DO NOT CREDIT** if there are no measurements to process **5 ACCEPT** (soil) pH / mineral content / type / mass **5 ACCEPT** temperature / CO_2 concentration / light intensity / light duration / light wavelength / number of seeds etc. (if they are being counted) / age / size (if they are being measured) **5 IGNORE** humidity / health / nutrients / species / light availability / soil fertility **Examiner's Comments** differentiated well between candidates. Most were able to outline a valid investigation and achieve 3 or 4 marks. Time references were often too vague for the award of the second marking point and, when measuring the dependent variable, many failed to specify what was being measured beyond the ambiguous term 'growth'. Most candidates were aware that some variable should be controlled, but often their cited variables were too vague, such as 'light availability' or 'nutrients'. Some took a 'field work' approach and were able to get some credit.

Question			Answer/Indicative content	Marks	Guidance
	d	i	Convention on International Trade in Endangered Species / CITES;	1	**ACCEPT** CITES acronym even if incorrect words are given **ACCEPT** cites / Cites **IGNORE** extra information that is not contradictory **Examiner's Comments** Most candidates achieved the mark but some failed to answer entirely.
		ii	Rio Convention/ (Rio) Convention on Bio(logical) Diversity ;	1	**IGNORE** extra information that is not contradictory **Examiner's Comments** was less well known than CITES and had a slightly higher omit rate. Some candidates hedged their bets and wrote CITES for both answers.
			Total	**14**	
12			**1** high, Simpson's Index / biodiversity, means not likely to be, approved / built; *Any **one** from:* **2** damage to biodiversity would be great(er); **3** *idea that* planning decisions are often based on factors other than biodiversity;	2 max	**1 ACCEPT** 'will not be' as AW for 'not likely to be' **2 IGNORE** habitat **2 ACCEPT** rare species might be affected **3 ACCEPT** EIAs also assess (measures to minimise) impact **3 ACCEPT** the area might be an SSSI already **Examiner's Comments** The majority of students achieved the first marking point, but fewer achieved either of the subsequent marks.
			Total	**2**	

Question			Answer/Indicative content	Marks	Guidance
13		i	impossible / difficult, to count every individual; sample provides an estimate; sample representative (of whole area);	2 max	**ACCEPT** *idea that* counting every individual is too time consuming **Examiner's Comments** This question differentiated well. Many candidates attained 1 mark for using the term 'representative', with fewer using 'estimate'. The most frequently seen full mark responses combined 'representative' or 'estimate' with the idea that sampling was more time-efficient. A significant minority of candidates were awarded no marks and of these, most appeared either to be describing *how* sampling should be carried out, or why measuring biodiversity was important.
		ii	to compare (the two areas); (presence or absence of) roe deer is independent variable; *idea of* controlling variables other than roe deer;	1 max	**ACCEPT** one area acts as a control **ACCEPT** to see the effect of the roe deer **Examiner's Comments** The majority of candidates gained 1 mark for expressing the idea of comparing an area where roe deer could go with an area where roe deer could not go. Answers which suggested that the candidate was unaware of the purpose of the fence were not awarded marks.

Question			Answer/Indicative content	Marks	Guidance
		iii	1 (species) richness is number of <u>species</u> (in a habitat); 2 (species) evenness is, abundance / number of <u>individuals</u> of, each / every / all, species (in a habitat); 3 *idea that* both (richness and evenness) are needed to reveal dominance; 4 *idea that* high biodiversity associated with high species richness **and** high species evenness;	3 max	**IGNORE** amount **ACCEPT** 'how many' as AW for 'number' **ACCEPT** evenness is relative, numbers / abundance, of (each) species **IGNORE** number of individuals of, a / the / one, species **Examiner's Comments** Few candidates gained all 3 marks but many gained the first 2. Most candidates could describe species richness and more candidates than in previous sessions were able to offer reasonable definitions of species evenness. Incorrect answers often referred only to one species or to the distribution of species. Marking points 3 and 4 were gained by only a few candidates and this question was a good discriminator. Some candidates simply wrote out the formula for Simpson's Index and were not awarded a mark.

Question			Answer/Indicative content	Marks	Guidance
		iv	plants are, the basis / AW, of (all) food chains; shrubs / plants, are food for, insects / animals, that birds eat; *idea that* shrubs might provide, nesting sites / cover / protection / habitat;	1 max	 **IGNORE** birds eat, shrubs / seeds / fruit **IGNORE** 'fewer insects' without reason for fewer insects **AWARD** in the context of birds, or animals that birds eat **IGNORE** home **Examiner's Comments** This was generally well answered. Candidates either made the connection with food chains or realised that the shrubs might provide some form of habitat for the birds. Common incorrect responses usually fell into two categories. Either candidates suggested that bird ate the shrubs, which was a mis-reading of the question, or candidates suggested that the birds would be frightened by or even preyed upon by the deer.
		v	(habitat) dominated by, one / few / AW, species; ecosystem / habitat, is, unstable / less likely to cope with change;	2	**ACCEPT** high number of one species **IGNORE** area / environment **ACCEPT** in the context of an example of environmental change **ACCEPT** a change in one species with have a large effect on the, ecosystem / habitat / food chain **Examiner's Comments** This question also discriminated well. Some candidates gained both marks, some got only one. Some candidates had the right idea but failed to gain a mark because they used an incorrect ecological term, for example, many candidates seemed to be using the terms 'population' or 'species' to mean 'ecosystem' or 'community', or the terms 'area' or 'environment' to mean 'habitat' or 'ecosystem'.

Question			Answer/Indicative content	Marks	Guidance
			Total	**9**	

Question			Answer/Indicative content	Marks	Guidance
14	a			3 max	**IGNORE** can be in optimum conditions throughout
			1 (natural) <u>habitat / ecosystem</u>, lost due to / destroyed by / under threat from, climate change / (named) human activity;		**1** The essence of this marking point is habitat loss plus reason. Award tick when both these ideas have been seen. **1 ACCEPT** natural disaster / deforestation, as reason for <u>habitat</u> loss
			2 number / population, (in natural habitat) is very low;		**2 IGNORE** reference to, extinct / endangered
			3 *idea that* in the wild, (sexual) reproduction is difficult (if numbers are low); **ora**		**3 ACCEPT** e.g. fertilization can be carried out using a paintbrush
			4 (breeding *ex situ* can) maintain, the <u>gene pool</u> / genetic / allelic, diversity; **ora**		
			5 *idea that* allows <u>protection</u> from, grazers / herbivores / plant collectors / competing species; **ora**		**5 ACCEPT** habitat contains organisms that are a threat **5 ACCEPT** protection from, predators / poachers / hunters
			6 *idea of* <u>protection</u> from, pathogen / parasites / disease; **ora**		**6 ACCEPT** pests **Examiner's Comments** On average, candidates achieved 2 out of 3 for this question. Most commonly candidates identified a danger present in the natural habitat and many were aware that the natural habitat itself was in danger. Some of the latter, however, failed to identify a reason for the habitat destruction or used the less precise term 'environment' as a non-creditworthy alternative to 'habitat'. All other marking points were seen but infrequently. A minority of candidates merely listed reasons for conservation in general rather than focussing their answers on the need for *ex situ*, as opposed to *in situ*, conservation.
	b		1 can be collected with minimal damage to (wild), population / habitat /	3 max	**Mark as prose. Ignore numbered lines.**

Question	Answer/Indicative content	Marks	Guidance
	ecosystem;		
	2 take up little space / larger numbers can be stored; **ora**		**2 ACCEPT** easier to store a large amount
	3 can store great(er), genetic / allelic, diversity; **ora**		
	4 low(er) maintenance / manpower costs / AW; **ora**		**4 CREDIT** 'cheaper' only if supported by an explanation **4 IGNORE** easier to keep unqualified **4 ACCEPT** less labour-intensive **4 DO NOT CREDIT** no maintenance costs
	5 easy / cheaper, to transport / AW; **ora**		
	6 *idea of* remaining <u>viable</u> for long periods; **ora**		**6 CREDIT** description / example – e.g. kept dry so that they do not rot / regular germination and new seed production **6 IGNORE** 'last a long time' unqualified **6 ACCEPT** 'stay, alive / fertile, for a long time'
	7 <u>less</u>, susceptible / vulnerable, to, disease / pests / environmental change; **ora**		**7 ACCEPT** the adult plant might have a disease **7 IGNORE** prevents
	8 *idea that* prevents fertilisation by undesired pollen;		**Examiner's Comments** This question produced marks in the range 1-3 in roughly equal proportions. All marking points were seen, although it was rarer to see reference to less damage to the wild population or the ability to store greater genetic diversity. Many responses discussed seeds being stored for a long time, but without reference to viability the mark was not awarded. A common answer was that in the future, plants could be easily reintroduced back to into the wild; this was not credited because the same could also be said of conserving adult plants.

Question			Answer/Indicative content	Marks	Guidance
	c		**1** (use of) quadrat; **2a** random (sampling); **3a** placing measuring tapes (at right angles) / use grid; **OR** **2b** (use of) <u>transect</u>; **3b** (quadrat / point frame) placed at regular intervals; **4** (use of identification) key; **5** example / detail, of method used to determine <u>abundance</u>; **6** repeat many times / *idea of* considering appropriate number of samples; **7** sample / AW, at different, seasons / times of year;	4 max	**1 ACCEPT** description of a quadrat / point frame **1 IGNORE** quadrant ***AWARD either a or b*** *for both marking points* ***2*** *and* ***3****. Do not mix a and b marks. If both a and b marks are present ignore the lower scoring letter*. **2a ACCEPT** bits of paper in a hat / random number generator **2a DO NOT CREDIT** throw **3a ACCEPT** e.g. bottom left hand corner of quadrat placed at coordinate / two students walk in a straight line from each tape measure **3b ACCEPT** systematic sampling **5 ACCEPT** percentage cover / percentage frequency / number of hits with point frame / ACFOR **5 ACCEPT** strategy for dealing with plants half in or out of quadrat **5 IGNORE** 'count' without further clarification **6 ACCEPT** calculate running mean **6 IGNORE** several / a few **6** If number state must be at least 5 **7 ACCEPT** throughout the year **Examiner's Comments** Most candidates achieved 3 out of the 4 marks on this question, mostly for 'quadrat', 'grid', and 'random sampling'. Those few who discussed using a transect rarely mentioned regular intervals. Many candidates, whose responses were otherwise thorough, failed to mention the need for multiple repeats. All the other

Question			Answer/Indicative content	Marks	Guidance
					marking points were seen, but less frequently. A number of students referred to quadrants, or thought that *throwing* quadrats was a random procedure. Those responses that referred to mark and recapture techniques or net sweeping were not given credit as the question was about plants.
	d		1 reason for not having found all species; 2 may have become extinct, recently / since recording; 3 evolution is on-going / new species are being formed / AW; 4 *idea that* some (species) difficult to distinguish / some species may be reclassified / AW;	3 max	**IGNORE** prompt lines and mark as prose **1 ACCEPT** e.g. some (named) habitats inaccessible / microscopic species missed /low numbers of individuals / habitat unexplored / some habitats rare / species are nocturnal **2 ACCEPT** organisms constantly become extinct **3 ACCEPT** new species are being created **4 ACCEPT** e.g. might mistake several species for one **4 ACCEPT** scientists might disagree about whether it is a species or not. **Examiner's Comments** This was generally well answered, with a good balance of marking points. The first marking point was the most common, but some candidates simply listed alternative reasons for all species not having been discovered and limited themselves to one mark. A number of candidates failed to achieve marking point 3 as they often didn't make it clear that extinction was recent or ongoing. Responses that discussed errors in calculating or estimating, and the difficulties associated with the large numbers involved gained no credit.
			Total	**13**	

Question			Answer/Indicative content	Marks	Guidance
15	a	i	**1** peak in, 1988 / 1994; **2** trend decrease after 1994; **3** ref. decrease and then increase, 1988 to 1994; **4** fluctuations (within pattern); **5** overall increase from 1965 to 2002;	3 max	**IGNORE** ref to population figures **1 ACCEPT** increases until / highest number in, 1988/1994 **4 ACCEPT** 'goes up and down' / oscillates **Examiner's Comments** This question was generally well answered. The majority of candidates were able to identify either or both of the peaks in 1988 and 1994 and some went onto mention the decrease and increase in population between these dates, finishing with the decrease after 1994. It was encouraging to see general statements about the fluctuations in the data and the overall increase from 1965 to 2002. Common errors were to describe trends from 1965 to 1988 or comment on the numbers of shot elk. Other mistakes made were misreading the data or not mentioning any dates at all.

Question			Answer/Indicative content	Marks	Guidance
		ii	*accurate because* *idea that* actual number of elk shot is recorded; *method not valid because idea that* number of elk shot / hunting success, varies independently of population size;	2	**ACCEPT** elks shot are counted / reported **CREDIT** suitable reason e.g. numbers of licences issued / number of hunters set quotas to hunt illegal hunting if weather suitable for hunting only younger / older / diseased / larger, elk killed **IGNORE** length of time spent hunting **Examiner's Comments** Most candidates got the first marking point and understood that the number of elk shot would be recorded and was therefore accurate. However, fewer candidates gained the second marking point about why the method was not valid. The candidates who did get it tended to talk about illegal hunting making the data less valid, as opposed to hunting success being independent of overall population size. A common mistake was to talk about hunting scaring off elk from the area or elk dying from factors other than hunting. Some candidates also confused their answers by talking about ecological sampling in general and not relating it to the question asked.

Question			Answer/Indicative content	Marks	Guidance
	b	i	**1** *idea that population size is determined by* limiting factor(s);	6 max	**IGNORE ref to abiotic / biotic factors throughout**
			Before 1995, population increases due to **2** example of factor that is not limiting population;		**2** e.g. plenty of, enough, food Less / no predation Less / no overcrowding/ enough space less hunting **2 IGNORE** water / nutrients / availability of food
			Before 1995, population levels off because **3** reaches carrying capacity;		
			Before 1995, population becomes limited by ***4*** intraspecific competition for named resource;		**4 CREDIT** description of intraspecific
			5 interspecific competition for named resource;		**5 CREDIT** description of interspecific
			Population can decline at any time/ dips, due to **6** severe weather / natural disaster;		**4 & 5 CREDIT** any suitable limiting factor eg competition for, food / space / mates / overcrowding
			7 decrease before 1995 not due to wolves (as none present);		**6 CREDIT** ref to parasites / disease / drought / floods / fires
			8 decrease after 1995 (probably) due to wolves;		
			9 *idea that* effect of wolves on population may be debatable;		**9** e.g. lack of data in 1996 and 1997 makes it difficult to from conclusions

Question			Answer/Indicative content	Marks	Guidance
		i	QWC;	1	**Award if** **1 mark** awarded from **mps 1 to 6 (limiting factors)** **and** **1 mark** awarded from **mps 7 to 9 (effect of wolves)** **Examiner's Comments** Most students used additional sheets for this question but very few gained additional marks for their extra effort. Mostly they continued with lengthy descriptions and explanations of predator-prey relationships and gained no marks for that. Those candidates who recognised the need to explain the population growth curve and did so in a logical sequence, setting out a section for before 1995 and one for after 1995, gained the most marks for this question. Very few candidates recognised that limiting factors were involved. A good number of candidates recognised that the population increase was due to an abundance of food, enough space, enough mates or less predation or less hunting. Some candidates didn't mention the population at all or mentioned the size of the elk, and not the elk population. General references to population being affected wouldn't gain marks here as it was specifically for a reason linking it to an increase in population. A minority of candidates mentioned the carrying capacity being reached before 1995 but sometimes it was not always awarded due to it being referred to after 1995. When candidates used the proper terms of intraspecific and interspecific competition or described them correctly they often missed the marks by not giving a **named** resource or linking it with population size, rather than a named resource. Many candidates gained the mark for

Question			Answer/Indicative content	Marks	Guidance
					disease affecting population size but sometimes didn't link it with a decrease or dip in population size. The link that any decrease before 1995 was not due to the wolves as none were present was rarely awarded, but the majority of candidates mentioned that after 1995 there was a decrease in elk population and it was likely due to the wolves. This often triggered the QWC mark being awarded. Very occasionally candidates mentioned the idea that the effect of wolves on population may be debatable. There were a number of candidates who wrote about Elm trees or Elk trees and not Elk. In some cases, candidates went into detail of photosynthesis and mineral ions in the soil, showing a complete misunderstanding of the question asked, and relating it to a question asked about Elm trees in a previous paper.

Question			Answer/Indicative content	Marks	Guidance
		ii	*re-introduction of wolves is conservation because* 1 restoring the ecosystem (to its original form) **or** maintains biodiversity; 2 helps the (global) wolf population; 3 active / dynamic / sustainable, management / maintenance; 4 prevents over-population by the elk; 5 prevents over-grazing **or** damage to, habitat / ecosystem;	2 max	**ACCEPT** controls/ increases, biodiversity **ACCEPT** wolves do not become extinct / increase in number 'Actively maintains biodiversity' = **MP1 and 3** **ACCEPT** wolves, limit / control, elk population or lack of wolves causes elk population to grow **ACCEPT** if wolves absent, elk would damage habitat / other species may become extinct **Examiner's Comments** This was generally a well answered question with references to maintaining or increasing biodiversity and the idea of conserving the wolf as a species, gaining two marks. Only a few answers included reference to biological control of the elk population, which if uncontrolled would result in damage to the ecosystem by overgrazing. A lack of key terms (ecosystem / management / maintenance) stopped some candidates from getting both marks and several candidates used the word 'conservation' in their answer, despite it being in the stem of the question. Common mistakes were to focus the whole answer on just increasing biodiversity or helping the wolf population, without making a second point for the other mark, or to give a general definition of conservation without relating it to the question asked.
			Total	**14**	

Question			Answer/Indicative content	Marks	Guidance
16			C ☐	1	
			Total	**1**	
17			B ☐	1	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
18	a		***Please refer to the marking instructions on page 3 of this mark scheme for guidance on how to mark this question. In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ◦ *award the higher mark where the Communication Statement has been met.* ◦ *award the lower mark where aspects of the Communication Statement have been missed.* • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.***		

Question			Answer/Indicative content	Marks	Guidance
			Level 3 (5–6 marks) A good range of explanations are provided. The explanations clearly indicate how the decrease in biodiversity is caused. *The explanations are clearly linked to the factor considered. There is a logical structure and use of scientific terminology is at an appropriate level. All the information presented is relevant and forms a continuous narrative.* **Level 2 (3–4 marks)** Some explanations are provided. The explanations do not always clearly show how the decrease in biodiversity is caused. *The explanations are not always clearly linked correctly to the applicable factor. There is some structure and use of appropriate scientific terminology. The information presented is mostly relevant.* **Level 1 (1–2 marks)** A limited number of explanations are provided. The explanations do not clearly show how the decrease in biodiversity is caused. *There is some structure to the answer. The explanations though basic are linked to the applicable factor.* **0 marks** No response or no response worthy of credit.	Max 6	**Indicative scientific points may include:** Human population growth: • Need for more agricultural land / housing • Destroys habitats • More waste produced • More pollution produced • Damaging ecosystems • Specific example provided Agriculture: • Agricultural land has monoculture / lower biodiversity • Loss of older / wild type strains • Reduced genetic diversity • Subject to disease • Inability to adapt to changing conditions • Altering habitats • Specific example provided such as draining of wetlands reduces habitat diversity • Pesticide use • Use of fertiliser • Nitrate pollution • Eutrophication Climate change: • Warmer / drier climate • Modern strains/species not adapted • Migration may not be possible • Rise in sea level reduces land area • More frequent flooding affects terrestrial ecosystems
	b	i	have significant effect on ecosystem□ many other species rely on activity of beavers□	2	

Question			Answer/Indicative content	Marks	Guidance
		ii	*created dams* flooded areas upstream / reduced flow rate downstream creating still / slow moving water for aquatic species *felled trees* opened up tree canopy allowing light to ground level *built lodges* creates sheltered habitat for insect species / beaver parasites	Max 3	**ALLOW** any other valid point
		iii	ecotourism / education / scientific study water quality improved as silt is held back by dams	Max 1	
	c		species diversity will rise as more species live in the new habitats genetic diversity will increase as species have a wider range of conditions in which to live	2	
	d		loss of farmland due to flooding strength of argument depends on area affected (probably) not a strong argument as relatively small areas affected trees cut down (of concern to foresters) likely to occur only in area near water – so not a strong argument damage to river bank needing costly repairs cost should be shared by all who benefit (including those downstream) so not a strong argument	max 4	
			Total	**18**	