ENVIRONMENTAL SCIENCE

SECTION II

Time—1 hour and 10 minutes

3 Questions

Directions: Answer all three questions, which are weighted equally; the suggested time is about 22 minutes for answering each question. Write all your answers in the Free Response booklet. Where calculations are required, clearly show how you arrived at your answer. Where explanation or discussion is required, support your answers with relevant information and/or specific examples. You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. Researchers interested in sustainability developed three new varieties of genetically modified green beans designed to produce higher yields in arid regions. Four plots (A–D) were set up on a floodplain of a river to grow beans. Plots A, B, and C were each planted with seeds of different types of genetically modified strains of green beans. Plot D was planted with seeds of unmodified green beans. Each plot was given equal amounts of fertilizer, which contains phosphorus and nitrogen, and water and was irrigated using spray irrigation for one hour per day. Throughout the growing season, researchers measured the amount of green beans harvested within each plot. The plots with genetically modified beans had higher crop yields than the plot with unmodified beans.

   (a) **Identify** the control group in this experiment.

   (b) **Identify** the scientific question for the investigation.

   (c) Researchers repeated the experiment by modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification.

   Researchers also monitored the amount of sediment and fertilizer washing into the river from each plot in the original study. The soil temperature was also measured in each plot at the same depth and at the same time each day approximately 0.05 meters below the surface of the soil.

Genetically Modified Green Bean Experimental Results

Plot	Sediment Runoff (mg/L)	Phosphorus Runoff (mg/L)	Nitrogen Runoff (mg/L)	Soil Temperature (°C)
A (Type 1 GMO beans)	2.4	0.11	1.07	18.6
B (Type 2 GMO beans)	2.1	0.02	0.56	18.3
C (Type 3 GMO beans)	0.9	0.04	0.68	18.3
D (Unmodified beans)	3.5	0.15	1.24	17.6

   (d) Based on the data in the table, **identify** the plot with the lowest soil temperature.

   (e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans.

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(f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the table and the experimental design, **explain** whether the researchers' hypothesis was supported or refuted.

Once the experiment was concluded, the researchers burned the plots to remove the crops that had been planted. After a few years, the researchers returned to the plots and observed a variety of plants, insects, and bird species living there.

(g) **Describe** the ecological process that occurred on the plots after the crops were burned.

A survey indicated that one of the plots had twice the plant diversity that the other plots had. Over the next five years, the river occasionally flooded the plots, killing off many of the species that inhabited the plots.

(h) After each flooding event, the plot with twice the plant diversity returned to its prior level of biodiversity more quickly than the other plots did. **Explain** why a community with more plant diversity will recover more quickly from the flooding.

(i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could.

(j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

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Question 1: Design an Investigation — 10 points

(a) **Identify** the control group in this experiment. **1 point**

Accept one of the following:

- Plot D
- Unmodified beans

(b) **Identify** the scientific question for the investigation. **1 point**

Accept one of the following:

- Will genetically modified green beans have higher crop yields than unmodified green beans?
- Is there a difference between the crop yields of genetically modified and unmodified green beans?
- Does genetically modifying green beans affect crop yield?

(c) Researchers repeated the experiment modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification. **1 point**

Accept one of the following:

- With less water, there will be lower crop yield/fewer green beans harvested in all plots.
- The genetically modified beans will remain similar in yield because they are resistant to drought/need less water, but the unmodified beans will decrease in crop yield because they will receive less water.

(d) Based on the data in the table, **identify** the plot with the lowest soil temperature. **1 point**

Accept one of the following:

- Plot D
- The unmodified green beans

(e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans. **1 point**

Accept one of the following:

- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are lower with the genetically modified beans.
- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are higher with the unmodified beans.

(i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could. **1 point**

Accept one of the following:

- The new beetle is a generalist/r-selected species and could more quickly populate the area/outcompete the existing/native beetle species.
- The flooding of the plot caused a natural disruption to the existing community, eliminating species/natural predators and opening niches for the new/invasive beetle.
- Low diversity communities are susceptible to disruption and can't recover allowing the new/nonnative beetle species to invade
- The new beetle is an invasive species that can live outside its normal environment and threaten native species

(j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot. **1 point**

Accept one of the following:

- Remove beetles by trapping/physical removal to reduce their population size.
- Apply a chemical/pesticide to kill beetles.
- Add a predator/parasite/pathogen/biological control that harms beetles.

Total for question 1 10 points

(e) A deposit is estimated to contain 260 million metric tons of gold ore. **Calculate** the number of grams of gold that could be extracted from the deposit. **Show** your work. **1 point**

One point for the correct setup to calculate the number of grams of gold that could be extracted from the gold deposit:

Accept one of the following:

- $260 \text{ million metric tons} \times \frac{5 \text{ grams}}{1 \text{ metric ton}}$
- $260 \times 10^6 \text{ metric tons} \times 5 \text{ grams}$
- $5 \times 260{,}000{,}000$

One point for the correct calculation of the number of grams of gold that could be extracted from the gold deposit: **1 point**

Accept one of the following:

- 1,300,000,000
- 1.3×10^9

Total for part (e) **2 points**

(f) Assuming the price of gold is $62.56 per gram**, calculate** the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. **Show** your work. **1 point**

One point for the correct setup to calculate the value of the gold that could be recovered:

Accept one of the following:

- $\frac{\$62.56}{1 \text{ gram}} \times 1{,}000 \text{ metric tons} \times \frac{5 \text{ grams}}{1 \text{ metric ton}}$
- $\$62.56 \times 1{,}000 \text{ metric tons} \times 5 \text{ grams}$
- $\frac{\$62.56}{\text{g}} \times \frac{5 \text{ g}}{\text{metric ton}} \times 1{,}000$
- $1{,}000 \times 5 \times \$62.56$

One point for the correct calculation of the value of gold that could be recovered: **1 point**

Accept one of the following:

- $312,800
- 312,800 dollars

Total for part (f) **2 points**