

2024



AP[®] Environmental Science

Sample Student Responses and Scoring Commentary Set 1

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Free-Response Question 2

- Scoring Guidelines**
- Student Samples**
- Scoring Commentary**

Question 2: Analyze an Environmental Problem and Propose a Solution **10 points**

(a) Based on the data in the graphs, **identify** the amount of land required to produce 1 kilogram of chicken protein. **1 point**

- 50 m²

(b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle. **1 point**

- Type III

(c) **Explain** why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population. **1 point**

Accept one of the following:

- Darkling beetles reproduce quickly, which allows for a large amount of protein to be produced in a short period of time.
- Darkling beetles have many offspring, which allows for a large amount of protein to be produced in a short period of time.

(d) Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage. **1 point**

Accept one of the following:

- Chicken production has a lower global warming potential than pork production, so it would cause less environmental damage because chicken production releases less greenhouse gas.
- Chicken production has a lower land use than pork production, so it would cause less environmental damage because there would be less deforestation/habitat destruction/soil erosion/fossil fuel use.

(e) Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have. **1 point**

Accept one of the following:

- Beef has a larger impact because methane has a high global warming potential.
 - Beef has a larger impact because methane is a greenhouse gas.
 - Beef requires more land use, which results in loss of forests/habitat/grasslands leading to release of CO₂/reduction in carbon storage.
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- (f)** **Describe** how water quality can be altered by cattle grazing that occurs near a stream or river. **1 point**

Accept one of the following:

- Cattle cause erosion, which increases sedimentation/turbidity in water.
- Cattle feces can add nutrients/nitrogen/phosphorus to waterways.
- Cattle feces may contaminate waterways with bacteria.

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- (g)** **Propose** a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze. **1 point**

Accept one of the following:

- Practice rotational grazing/alternate grazing parcels.
- Eat a diet with less meat/beef.
- Fence/barricade the riparian zone.
- Provide other water sources for the cattle.

-
- (h)** Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion. **1 point**

Accept one of the following:

- Switch crops to perennial plants.
 - Plant crops on terraces.
 - Implement contour plowing/farming.
 - Use no-till farming/cover crops.
-

- (i) **Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion. **1 point**

Accept one of the following:

Solution proposed in (h)	Justification of solution with additional advantage other than the reduction of soil erosion
Switch to perennial plants	<ul style="list-style-type: none"> • Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils.
Plant crops on terraces	<ul style="list-style-type: none"> • Allows areas to be farmed that are otherwise too steep. • Sediments and other contaminants settle out behind the terrace ridge reducing the amount of soil that runs off. • Increases groundwater absorption.
Implement contour plowing/farming	<ul style="list-style-type: none"> • Allows areas to be farmed that are otherwise too steep. • Increases groundwater absorption.
Use no-till farming/cover crops	<ul style="list-style-type: none"> • Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils. • Cover crops can be used as green manure.

- (j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change. **1 point**

Accept one of the following:

- Crop production/yields could decrease because of:
 - Increased drought
 - Increased flooding
 - Increased insect infestation from warmer temperatures
 - Increased temperature
 - Changes in seasonal rain patterns (or temperatures)
 - Expansion of geographic range of invasive pests/species
 - Climate may be outside range of tolerance of crops

Total for question 2 10 points

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1

Question 2

Question 3



Begin your response to each question at the top of a new page. Do not skip lines.

- a) 50 m^2
- b) Type III (S) survivorship curve with a high rate of mortality early in life and low rate of mortality later in life.
- c) As an r-selected species, darkling beetles have a high reproduction rate, producing many offspring in one reproductive cycle. Therefore, the reproductive strategy ensures that there is a sufficient supply of mealworms for the growing human population.
- d) 1 kg of chicken protein would cause less environmental damage than 1 kg of pork to produce because the GWP of producing 1 kg of pork ($\sim 37 \text{ kg CO}_2\text{-eq.}$) is greater than that of 1 kg of chicken ($\sim 27 \text{ kg CO}_2\text{-eq.}$) and the land required to produce 1 kg of pork protein ($\sim 53 \text{ m}^2$) is greater than that required to produce 1 kg of chicken protein (50 m^2):
- e) Beef production has more than a 3x impact on global warming than the next highest animal protein (pork) because cattle produce ^{release} methane, a potent greenhouse gas, along with carbon dioxide produced ~~&~~ during respiration like other animals.
- f) When cattle graze near a stream or river they leave organic waste that enters the water and increases concentration of such limiting nutrients as phosphorus & nitrogen, leading to eutrophication.

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Question 1

Question 2

Question 3



Begin your response to each question at the top of a new page. Do not skip lines.

- g) Cattle can graze in closed enclosures at a specified minimum distance from waterways to ensure that their organic waste does not enter waterways.
- h) ~~No-till agriculture which discourages tilling (turning of the soil before planting crops) helps reduce soil erosion by keeping topsoil intact. An alternate is~~ planting cover crops whose root systems reduce soil erosion by keeping the soil from moving. ~~also~~
- i) Planting cover crops also discourages monocultures by adding diversity to the crops being planted, making the crops ^{in a cycle} more resistant to draining ~~all of~~ the soil of a specific set of nutrients which would occur with monocultures, and less likely to be wiped out by a certain pathogen.
- j) Climate change has led to irregular monsoon patterns along with other climate phenomenon. Therefore in developing countries where farmers still rely on rain as the primary ~~form of~~ source of water & irrigation, inconsistent monsoons can destroy an entire cycle of crops.

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Question 1

Question 2

Question 3

Begin your response to each question at the top of a new page. Do not skip lines.

- A) The amount of land required to produce one kilogram of chicken protein is 50m².
- B) The type of survivorship would be type III. ~~Graph 1~~
- C) The reproductive strategy of a darkling beetle is an advantage because they have lots of ~~eggs~~ larvae. R-selected species have short lifespans and reproduce incredibly frequently and birth a lot of babies, which is an advantage since the species is able to keep up with the demand brought on by the growing human population.
- D) Based on the graphs, producing one kg of pork protein has more harm on the environment, because the global warming potential is greater than the potential for the kilogram of chicken.
- E) It has a different impact than any other animal because of the farms beef is raised on. Farms and cows create the most methane, ~~production~~ in which is a greenhouse gas. As a result, it is a high contributor to climate change or global warming.
- F) Cattle grazing can increase the amount of soil erosion, leading to higher turbidity of the water. As a result, the water can decrease in quality.
- G) One solution
- H) One sustainable agricultural practice would be to rotate crops. ~~Rotating the crops would allow~~
 Rotating the crops would allow

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Question 1

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Question 3



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for less tilling, which increases erosion by stirring up the soil.

~~the~~

i) Another advantage to rotating crops would be maintaining the nutrients in the soil. By not rotating the fields, the soil runs out of nutrients, making it harder to grow and produce crops.

3) Crop production negatively affects climate change through the machinery used to gather it. ~~The~~ CO₂ is a common greenhouse gas and contributor to climate change, which can be produced by ~~the~~ cars, tractors and other motor vehicles.

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- **Important:** Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1

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Begin your response to each question at the top of a new page. Do not skip lines.

- (a) 50 m^2
- (b) Low survivorship, short life span
- (c) Darkling beetles have high reproductive rates so the amount of offsprings they have accounts for their short-life span.
- (d) Producing 1kg of chicken would cause less environmental damage. Producing 1kg of chicken would cause less than 30 kg of CO_2 but 1kg of pork would cause at least 30kg of CO_2 , ~~chicken~~
~~beef~~
- (e) Beef is the only animal that emits Methane. Methane is one of the most harmful gasses contributing to global warming. Beef is the only animal doing so its the most harmful animal. Beef produces the greatest amount of land use and kg CO_2 .
- (f) The chemicals used in cattle grazing can wash into streams or rivers and intoxicate the water. These toxins can affect the aquatic organisms and potentially increase the acidity or salinity.
- (g) Confining cattle grazing to one area instead of having multiple cattle grazing farms. ~~decrease the amount~~
- (h) Crop rotation ~~practice~~ is the use of planting one crop and rotating it during different seasons.
- (i) Reduces ~~the need~~ for the overuse of water.
- (j) Fertilizer is a big help to farming but due to the negative drawback it has, there has been a plan

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Question 1



Question 2



Question 3



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to ban them. If fertilizer is banned ~~farmers~~ farmers will lose money, crops will suffer potentially leading to a food shortage.

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.



Question 2

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

This question focused broadly on the environmental impacts from meat production and other agricultural practices as well as the impacts of climate change on crop production.

In part (a) students were asked to analyze data from a graph to identify the amount of land use required to produce one kilogram of chicken protein [Science Practice 5 Data Analysis and Topic 5.7 Meat Production Methods].

In part (b) students were asked to demonstrate knowledge by identifying the type of survivorship curve exhibited by an r-selected species [Science Practice 1 Concept Explanation and Topics 3.2 K-Selected r-selected Species and 3.3 Survivorship Curves].

In part (c) students were asked to explain why the reproductive strategy of an r-selected species would be an advantage for using the larvae of that species as an alternative protein source to sustain a growing human population [Science Practice 1 Concept Explanation and Topics 3.2 K-Selected r-selected Species, 3.8 Human Population Dynamics, and 5.12 Introduction to Sustainability].

In parts (d) and (e) students were asked to extract data from graphs to explain unique environmental impacts from producing protein from different animals [Science Practice 5 Data Analysis and Topics 5.7 Meat Production Methods and 9.3 The Greenhouse Effect].

In part (f) students were asked to describe how water quality can be altered by cattle grazing near a stream or river [Science Practice 7 Environmental Solutions and Topics 5.7 Meat Production Methods, 8.2 Human Impacts on Ecosystems, and 8.5 Eutrophication].

In part (g) students were asked to propose a solution to reduce negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze [Science Practice 7 Environmental Solutions and Topics 5.7 Meat Production Methods and 5.15 Sustainable Agriculture].

In part (h) students were asked to describe a sustainable agricultural practice used to reduce soil erosion [Science Practice 7 Environmental Solutions and Topic 5.15 Sustainable Agriculture].

In part (i) students were asked to provide an additional benefit of the proposed sustainable agricultural practice, other than the reduction of soil erosion [Science Practice 7 and Topics 4.2 Soil Formation and Erosion and 5.15 Sustainable Agriculture].

In part (j) students were asked to describe how climate change could negatively affect crop production [Science Practice 7 Environmental Solutions and Topic 9.5 Global Climate Change].

Sample: 2A

Score: 8

1 point was earned in part (a) for identifying “50 m².” 1 point was earned in part (b) for identifying “Type III.” 1 point was earned in part (c) for explaining “darkling beetles have a high reproduction rate ... Therefore, the reproductive strategy ensures that there is a sufficient supply of

Question 2 (continued)

mealworms.” No point was earned in part (d). 1 point was earned in part (e) for explaining “Beef production has more than a 3x impact on global warming ... because cattle release methane, a potent greenhouse gas.” 1 point was earned in part (f) for describing “When cattle graze near a stream or river they leave organic waste that ... increases concentration of such limiting nutrients as phosphorus & nitrogen.” 1 point was earned in part (g) for proposing “Cattle can graze in closed enclosures at a specified minimum distance from waterways.” 1 point was earned in part (h) for describing “planting cover crops.” No point was earned in part (i). 1 point was earned in part (j) for describing “Climate change has led to irregular monsoon patterns ... inconsistent monsoons can destroy an entire cycle of crops.”

Sample: 2B**Score: 5**

1 point was earned in part (a) for identifying “50 m².” 1 point was earned in part (b) for identifying “type III.” 1 point was earned in part (c) for explaining “they have lots of larvae. ... reproduce ... frequently ... which is an advantage since the species is able to keep up with the demand.” No point was earned in part (d). 1 point was earned in part (e) for explaining “cows create the most methane, which is a greenhouse gas. As a result, it is a high contribution to climate change.” 1 point was earned in part (f) for describing “Cattle grazing can increase the amount of soil erosion, leading to higher turbidity of the water.” No point was earned in part (g). No point was earned in part (h). No point was earned in part (i). No point was earned in part (j).

Sample: 2C**Score: 2**

1 point was earned in part (a) for identifying “50 m².” No point was earned in part (b). No point was earned in part (c). No point was earned in part (d). 1 point was earned in part (e) for explaining “Beef is the only animal that emits methane. Methane is one of the most harmful gasses contributing to global warming. ... Beef is ... the most harmful.” No point was earned in part (f). No point was earned in part (g). No point was earned in part (h). No point was earned in part (i). No point was earned in part (j).