Past-paper walk-through

Global Climate Change ▪ 9.5

eXercise

Questions in this set

- 2026 Q1
- 2025 Set 2 Q1
- 2024 Set 1 Q2
- 2019 Q1
- 2018 Q3
- 2016 Q4
- 2015 Q1
- 2014 Q4

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 1

2026 ▪ Q1

The following information applies to parts A, B, C, D, and E.

Climate change can affect both terrestrial and marine organisms. Researchers studying the effect of climate change on bird distribution mapped elevation zones at which five bird species lived within a tropical mountain range. Birds are distributed in part according to climate-related adaptations. Researchers modeled where the birds would most likely live in the future based on climate change predictions.

The results of this study are shown in the following diagram. Each unique shape in the diagram represents a different bird species, labeled A through E. Current distribution is shown on the left side of the figure, and predicted future distribution is shown on the right.

Bird Species Distribution

Question 1

[Diagram: a pyramid-shaped chart titled “Bird Species Distribution,” split into a “Current Distribution” half (left) and “Predicted Future Distribution” half (right), divided by a vertical center line. The pyramid is divided into four horizontal elevation bands, from top (narrowest) to bottom (widest): “High Elevations,” “Mid-High Elevations,” “Mid-Low Elevations,” and “Low Elevations,” separated by dashed lines. Each band shows bird-shape icons above the letters A, B, C, D, E (Current side) and A, B, C, D, E (Predicted Future side), indicating which species is present at that elevation. A legend defines a black bird silhouette = “Species present at elevation” and a gray bird silhouette = “Extinct species.”
Current Distribution:

- High Elevations: Species A and Species C present.
- Mid-High Elevations: Species A present.

Question 1

- Mid-Low Elevations: Species B and Species D present.
- Low Elevations: Species B, Species C, Species D, and Species E present.

Predicted Future Distribution:

- High Elevations: Species A present; Species E shown extinct (gray icon).
- Mid-High Elevations: Species B and Species D present.
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Question 1

The following information applies to parts F, G, and H.
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- Tank 1: 27°C and no sediment
- Tank 2: 32°C and no sediment

Question 1

- Tank 3: 37°C and no sediment

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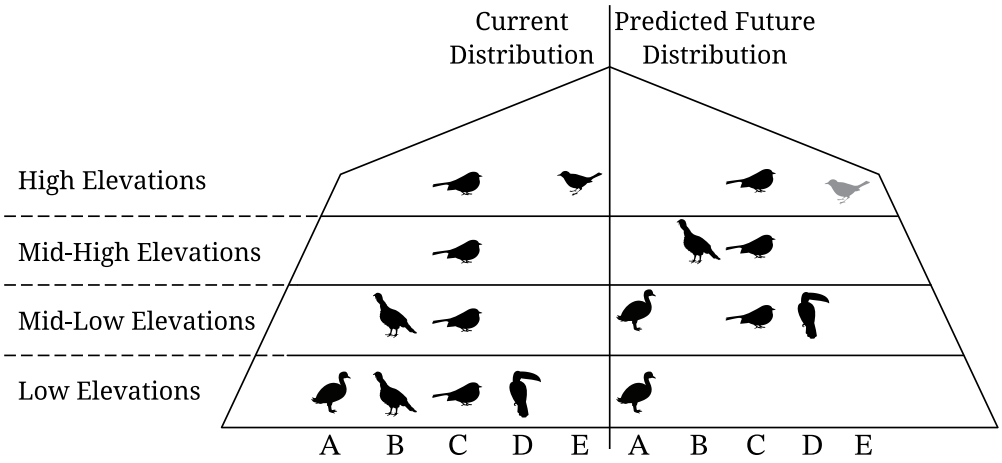
- Tank 1: 27°C and no sediment
- Tank 2: 27°C and moderate sediment
- Tank 3: 27°C and high sediment

1. Respond to parts A, B, C, D, E, F, G, H, I, and J.

(a) Based on the information in the diagram, **identify** the elevation zone that has the highest species richness for the current distribution.

Question 1


Current Distribution
Predicted Future Distribution
High Elevations
Mid-High Elevations
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A B C D E
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2026 ▪ Q1

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Question 1

- Mid-High Elevations: Species B and Species D present.
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Question 1

1. Respond to parts A, B, C, D, E, F, G, H, I, and J.

(b) Describe a climate condition at high elevations that is different than it is at low elevations.

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(c) A predator at low elevations currently feeds on Species C and D. Based on the information in the diagram, **describe** what could happen to the predator species in the future in response to the predicted changes in the prey community.

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(d) Species C is considered a generalist, while Species E is considered a specialist. **Explain** why Species C and E are predicted to respond differently to climate change.

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(e) Based on the information in the diagram, **explain** why the bird community at low elevations in the future would be less likely to recover from natural disruptions than the current low-elevation bird community.

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1. Respond to parts A, B, C, D, E, F, G, H, I, and J.

(f) Identify the independent variable in Experiment 1.

Question 1

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1. Respond to parts A, B, C, D, E, F, G, H, I, and J.

(g) Identify a likely scientific question for Experiment 1.

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(h) In Experiment 2 the temperature of the tanks was held constant, while the amount of sediment was varied. **Explain** how this modification could affect the results of this experiment.

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(i) Changes in climate also affect Arctic ecosystems. One impact of climate change is the loss of ice and snow in polar regions. **Describe** a positive feedback loop that results from the loss of ice and snow in polar regions.

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Climate change can affect both terrestrial and marine organisms. Researchers studying the effect of climate change on bird distribution mapped elevation zones at which five bird species lived within a tropical mountain range. Birds are distributed in part according to climate-related adaptations. Researchers modeled where the birds would most likely live in the future based on climate change predictions.

The results of this study are shown in the following diagram. Each unique shape in the diagram represents a different bird species, labeled A through E. Current distribution is shown on the left side of the figure, and predicted future distribution is shown on the right.

Bird Species Distribution

[Diagram: a pyramid-shaped chart titled "Bird Species Distribution," split into a "Current Distribution" half (left) and "Predicted Future Distribution" half (right), divided by a vertical center line. The pyramid is divided into four horizontal elevation bands, from top (narrowest)

Question 1

to bottom (widest): “High Elevations,” “Mid-High Elevations,” “Mid-Low Elevations,” and “Low Elevations,” separated by dashed lines. Each band shows bird-shape icons above the letters A, B, C, D, E (Current side) and A, B, C, D, E (Predicted Future side), indicating which species is present at that elevation. A legend defines a black bird silhouette = “Species present at elevation” and a gray bird silhouette = “Extinct species.”
Current Distribution:

- High Elevations: Species A and Species C present.
- Mid-High Elevations: Species A present.
- Mid-Low Elevations: Species B and Species D present.
- Low Elevations: Species B, Species C, Species D, and Species E present.

Predicted Future Distribution:

- High Elevations: Species A present; Species E shown extinct (gray icon).

Question 1

- Mid-High Elevations: Species B and Species D present.
- Mid-Low Elevations: Species A, Species C, and Species D present.
- Low Elevations: Species A present.]

The following information applies to parts F, G, and H.
Some organisms such as birds can move in response to environmental changes, while other organisms such as corals cannot. Researchers studying the effect of climate change on marine organisms conducted two experiments involving photosynthetic algae that have a symbiotic relationship with corals.
In Experiment 1, the researchers placed photosynthetic algal colonies living in corals in three different saltwater tanks. The temperature of Tank 1 was set to 27°C, the average temperature at which most corals live. Water circulation in each tank mimicked natural ocean currents. After 30 days, the researchers counted the number of bleached corals. The tank setups are shown in the following list.

Question 1

- Tank 1: 27°C and no sediment
- Tank 2: 32°C and no sediment
- Tank 3: 37°C and no sediment

In Experiment 2, the researchers used the same photosynthetic algae living in corals but modified the conditions of the tanks as shown in the following list. Water circulation kept the sediment in the tanks suspended. After 30 days, the researchers counted the number of bleached corals.

- Tank 1: 27°C and no sediment
- Tank 2: 27°C and moderate sediment
- Tank 3: 27°C and high sediment

Question 1

1. Respond to parts A, B, C, D, E, F, G, H, I, and J.

(j) Describe one problem that Arctic species, such as polar bears or ringed seals, face because of warming in polar regions.

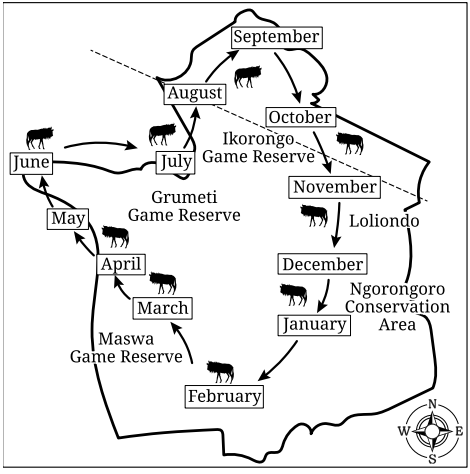
Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(a) Based on the data in the graph, **identify** the number of Common Tern breeding pairs in 1995.

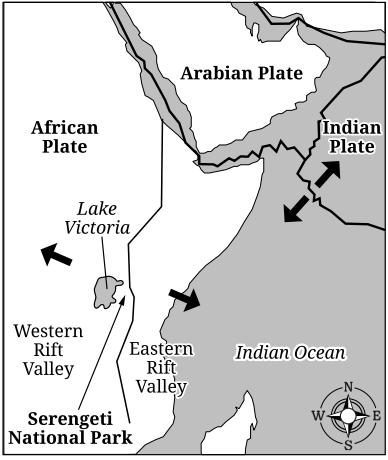
Question 1


September
August
October
Ikorongo
Game Reserve
June
July
November
Grumeti
Game Reserve
Loliondo
May
April
December
March
Ngorongoro
Conservation
Area
January
Maswa
Game Reserve
February
N
W
E
S

Question 1

Year	Increase in Sea Level (m)	Location A	Location B	Location C	Location D
1	0.05	1	5	3	4
2	0.08	2	4	3	6
3	0.10	6	7	5	5
4	0.12	5	7	7	7
5	0.15	7	8	9	8

Question 1


Arabian Plate
African Plate
Indian Plate
Lake Victoria
Western Rift Valley
Eastern Rift Valley
Indian Ocean
Serengeti National Park
N
W
E
S

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(b) Based on the data in the graph, **describe** the trend in the number of Common Tern breeding pairs from 1995 to 2008.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(c) A group of students hypothesized that sea level rise will lead to an increase in Common Tern populations. **Describe** one way that the data in the graph refute this hypothesis.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(d) Explain how climate change can lead to sea level rise.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(e)(i) Wading birds are a group of large-bodied birds that inhabit coastal wetlands all over the world. Researchers monitored the number of wading bird species at four coastal locations experiencing rising sea levels over a 5-year period. The data are shown in the following table.

Sea Level Rise and Number of Wading Bird Species at Four Coastal Locations

Year	Increase in Sea Level (m)	Location A	Location B	Location C	Location D
1	0.05	1	5	3	4
2	0.08	2	4	3	6
3	0.10	6	7	5	5
4	0.12	5	7	7	7
5	0.15	7	8	9	8

Question 1

i. **Identify** a hypothesis that researchers are likely investigating in the wading bird study.

(e)(ii) ii. **Identify** the dependent variable in this study.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(f) One year after the completion of the study of wading bird species described in Part E, locations A and B experienced an increase in the concentration of PCBs, known to be a persistent organic pollutant, running off into the water.

If the researchers repeated their study, **explain** how this environmental change could affect the results of the study.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(g) Describe a regulating ecosystem service that can be provided by wetlands.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(h) Since 1990, there has been an increase in urbanization around the coastal wetlands that wading bird communities inhabit. Most of these bird species eat fish and locate prey visually while walking through shallow water. An increase in sediment was discovered in a wetland located near an urban area.

Explain how increased sediment might lead to a change in the size of the wading bird populations.

Question 1

2025 Set 2 ▪ Q1

Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(i) Describe an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development.

Solution 1

(a)

Mark scheme

- 1400. This is the number of Common Tern breeding pairs read directly from the graph in 1995. 1 point for identifying 1400 (or a value clearly consistent with reading the graph at 1995).

Solution 1

(b)

Mark scheme

- The number of breeding pairs varies year to year but shows an overall decrease from 1995 to 2008 (equivalently: the number of breeding pairs decreases over this period). 1 point for correctly describing the overall downward trend.

Solution 1

(c)

Mark scheme

- The data refute the hypothesis because they show the opposite relationship: the data suggest that a rise in sea level is associated with a decrease in the number of breeding pairs, i.e. as sea level rises, fewer breeding pairs will likely lead to smaller populations (not the increase the students hypothesized). 1 point for describing this inverse relationship.

Solution 1

(d)

Mark scheme

- Climate change leads to sea level rise because increasing global temperatures cause melting of glaciers/land-based ice sheets, which adds water to the oceans, and/or because increasing global temperatures cause thermal expansion of ocean water. 1 point for either mechanism.

Solution 1

(e)(i)

Mark scheme

- A reasonable hypothesis for the wading bird study: if sea level rises, wading bird diversity/species richness will decrease (or will increase; or sea level rise will/will not affect wading bird diversity/species richness; or wading bird diversity/species richness is correlated with sea level rise). 1 point for stating a testable if/then (or correlational) hypothesis relating sea level rise to wading bird species richness/diversity.

Solution 1

(e)(ii)

Mark scheme

- The dependent variable is the number of wading bird species (species richness of wading birds) at each location. 1 point for identifying species richness/number of wading bird species as the measured (dependent) variable.

Solution 1

(f)

Mark scheme

- If PCB concentration increased at locations A and B, repeating the study would likely show a decrease in wading birds, because PCBs (a persistent organic pollutant) biomagnify/concentrate in higher trophic levels, can bioaccumulate in fatty tissue, are toxic and can kill or sicken birds when ingested, and/or cause eggshell thinning, developmental deformities, or reproductive problems. 1 point for any one valid PCB mechanism linked to a decline in wading birds.

Solution 1

(g)

Mark scheme

- A regulating ecosystem service provided by wetlands: wetlands filter/purify/improve water quality; wetlands provide flood regulation/erosion control; or wetlands store/sequester carbon. 1 point for any one correct regulating service.

Solution 1

(h)

Mark scheme

- Increased sediment (turbidity) can reduce the ability of wading birds, which locate prey visually, to see prey/food/fish, reducing their hunting success; sediment can also negatively impact organisms in lower trophic levels (e.g., reducing light infiltration decreases primary producers), which reduces food/energy available to the wading birds and could shrink their population size. 1 point for a valid mechanism linking increased sediment to a change in wading bird population size.

Solution 1

(i) Mark scheme

- An environmental problem (other than increased sediment) linked to urbanization/development near wetlands: construction projects reducing/fragmenting wetland habitat; runoff of fertilizers/wastewater effluent causing eutrophication (decreasing dissolved oxygen and killing fish); runoff of litter killing animals via ingestion/entanglement; more impervious surfaces (roads/buildings/sidewalks/parking lots) increasing flooding; runoff of heavy metals/pesticides killing or weakening organisms; noise/light pollution disrupting hunting, migration, or behavior; oil runoff blocking light and preventing photosynthesis; or increased water use lowering groundwater and drying up wetlands. 1 point for any one valid problem.

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).

Global Warming Potential and Land Use from Animal Protein Production

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Question 2

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

Mealworms, the larvae of the darkling beetle, consume grains and decaying plant material. Darkling beetles are an *r*-selected species, and the entire mealworm can be consumed by humans for protein.

Question 2

Figure 1

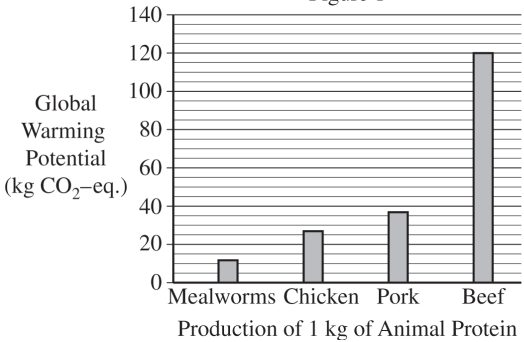
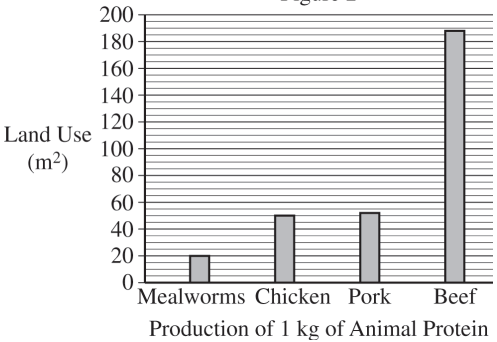


Figure 2



Question 2

2024 Set 1 ▪ Q2

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Question 2

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

Question 2

2024 Set 1 ▪ Q2

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Question 2

(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.
An individual's diet choices affect greenhouse gas emissions and land use.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(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.
Cattle emit methane from fermentation in their digestive systems. The other animals do not emit methane.

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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Question 2

(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.
Agricultural practices can have negative impacts on rivers and streams.

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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Question 2

(f) Describe how water quality can be altered by cattle grazing that occurs near a stream or river.

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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Question 2

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

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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Question 2

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

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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Question 2

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

Question 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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Question 2

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

Solution 2

(a)

Mark scheme

- 50 m^2 of land is required to produce 1 kilogram of chicken protein (read from the graph).

Solution 2

(b)

Mark scheme

- The darkling beetle exhibits a Type III survivorship curve (high mortality early in life, few survivors reach old age — consistent with an r-selected species).

Solution 2

(c)

Mark scheme

- Darkling beetles are r-selected and reproduce quickly with many offspring, which allows a large amount of protein (mealworm biomass) to be produced in a short period of time — an advantage for feeding a rapidly growing human population.

Solution 2

(d)

Mark scheme

- Producing 1 kg of chicken protein causes less environmental damage than producing 1 kg of pork protein: chicken production has a lower global warming potential (releases less greenhouse gas) than pork, and/or chicken has lower land use than pork, so it causes less deforestation/habitat destruction/soil erosion/fossil fuel use.

Solution 2

(e)

Mark scheme

- Beef production has a larger impact on global warming than the other animals studied because cattle emit methane from digestive (enteric) fermentation, and methane is a greenhouse gas with a high global warming potential; beef also requires much more land use, which causes loss of forests/habitat/grasslands and releases stored CO2 (reducing carbon storage).

Solution 2

(f)

Mark scheme

- Cattle grazing near a stream or river can alter water quality by: causing erosion that increases sedimentation/turbidity in the water; adding nutrients (nitrogen/phosphorus) to waterways via feces; and/or contaminating waterways with bacteria from feces.

Solution 2

(g)

Mark scheme

- A solution that reduces waterway damage while still allowing grazing: practice rotational grazing (alternate grazing parcels so land can recover); reduce dietary reliance on meat/beef; fence/barricade the riparian zone to keep cattle out of the waterway; or provide alternative water sources for the cattle away from the stream.

Solution 2

(h)

Mark scheme

- A sustainable agricultural practice to reduce soil erosion: switch crops to perennial plants; plant crops on terraces; implement contour plowing/farming; or use no-till farming/cover crops.

Solution 2

(i)

Mark scheme

- Justify the practice named in part (h) with an advantage beyond reduced erosion. Matching the scoring table: perennial crops or no-till/cover crops → reduce fossil fuel use, reduce farming costs, increase/maintain soil carbon storage, and preserve soil habitat for organisms (cover crops can also serve as green manure); terracing or contour plowing → allows otherwise-too-steep areas to be farmed and increases groundwater absorption (terracing also lets sediment/contaminants settle out behind the ridge, further reducing runoff).

Solution 2

(j)

Mark scheme

- Climate change could negatively affect crop production/yields through: increased drought; increased flooding; increased insect infestation due to warmer temperatures; increased temperature generally; changes in seasonal rain patterns; expansion of the geographic range of invasive pests/species; or climate conditions moving outside crops' range of tolerance.

Question 1

2019 ▪ Q1

The piping plover is a globally threatened species, with perhaps as few as 2,000 nesting pairs remaining in the Atlantic population of these migratory shorebirds. Plovers were nearly hunted to extinction in the nineteenth century.

Plovers prefer to nest and search for food on open sandy beaches between sparsely vegetated sand dunes. Washovers, where sand is washed up from the beach and buries vegetated areas during big storms, are also important to plovers because they provide moist and undisturbed habitat for plover adults and their chicks. Ecologists with the Elliott Oceanographic Institute mapped the distribution of plover nests during two seasonal surveys of nesting sites over a ten-year period on Assateague Island. This is a barrier island, a long, narrow island running parallel to the Atlantic coast of Virginia.

SPRING PIPING PLOVER NESTING SITES ON ASSATEAGUE ISLAND, VIRGINIA

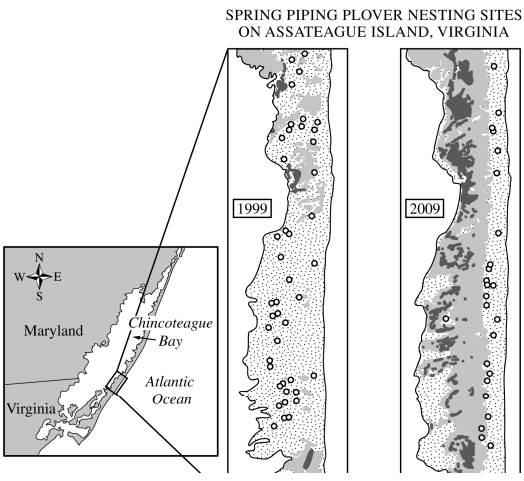
Question 1

[Two side-by-side maps of the barrier island Assateague Island, Virginia, labelled "1999" and "2009", each showing the shoreline with symbols marking piping plover nest locations. A small inset locator map at left shows Maryland and Virginia with Chincoteague Bay, the Atlantic Ocean, and a compass rose (N, S, E, W), with a box indicating the zoomed-in region of Assateague Island. Legend: hatched/dotted pattern = Unvegetated sand; light gray = Sparsely vegetated sand; dark gray = Densely vegetated sand; open circle (o) = Piping plover nest. The 1999 map shows nests scattered mainly in the unvegetated/sparsely vegetated (lighter) areas along the shoreline, with relatively little densely vegetated (dark gray) area. The 2009 map shows a similar shoreline but with a much larger area of densely vegetated (dark gray) sand covering the interior of the island, and nests still concentrated in the narrower band of unvegetated/sparsely vegetated sand along the coast.]

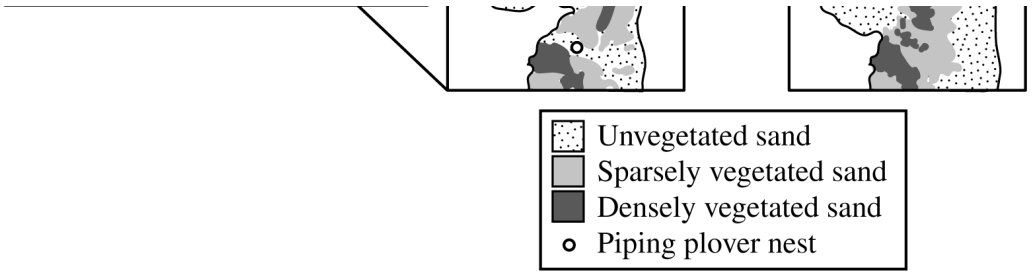
Question 1

Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.
(a)(i) Use the maps provided to answer the following questions.
Identify the preferred nesting habitat for piping plovers.
(a)(ii) Describe the change in the number of piping plover nests on Assateague Island between 1999 and 2009.
(a)(iii) Describe one likely reason for the change in the number of piping plover nests between 1999 and 2009.

Question 1


SPRING PIPING PLOVER NESTING SITES
ON ASSATEAGUE ISLAND, VIRGINIA
1999
2009
N
W
E
S
Maryland
Virginia
Chincoteague
Bay
Atlantic
Ocean

Question 1


Unvegetated sand
Sparsely vegetated sand
Densely vegetated sand
Piping plover nest

Question 1

2019 ▪ Q1

The piping plover is a globally threatened species, with perhaps as few as 2,000 nesting pairs remaining in the Atlantic population of these migratory shorebirds. Plovers were nearly hunted to extinction in the nineteenth century.

Plovers prefer to nest and search for food on open sandy beaches between sparsely vegetated sand dunes. Washovers, where sand is washed up from the beach and buries vegetated areas during big storms, are also important to plovers because they provide moist and undisturbed habitat for plover adults and their chicks. Ecologists with the Elliott Oceanographic Institute mapped the distribution of plover nests during two seasonal surveys of nesting sites over a ten-year period on Assateague Island. This is a barrier island, a long, narrow island running parallel to the Atlantic coast of Virginia.

SPRING PIPING PLOVER NESTING SITES ON ASSATEAGUE ISLAND, VIRGINIA

[Two side-by-side maps of the barrier island Assateague Island, Virginia, labelled “1999” and “2009”, each showing the shoreline with symbols marking piping plover nest locations. A small

Question 1

inset locator map at left shows Maryland and Virginia with Chincoteague Bay, the Atlantic Ocean, and a compass rose (N, S, E, W), with a box indicating the zoomed-in region of Assateague Island. Legend: hatched/dotted pattern = Unvegetated sand; light gray = Sparsely vegetated sand; dark gray = Densely vegetated sand; open circle (o) = Piping plover nest. The 1999 map shows nests scattered mainly in the unvegetated/sparsely vegetated (lighter) areas along the shoreline, with relatively little densely vegetated (dark gray) area. The 2009 map shows a similar shoreline but with a much larger area of densely vegetated (dark gray) sand covering the interior of the island, and nests still concentrated in the narrower band of unvegetated/sparsely vegetated sand along the coast.]

Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.

(b)(i) Coastal species are affected by more than just natural events.

Question 1

Special beach restrictions can help piping plovers during nesting season. Describe one restriction that could reasonably be implemented to help prevent the destruction of plover nests by human actions.

(b)(ii) In addition to providing habitat for piping plovers, barrier islands (and closely related landforms) are important for other reasons. Explain one way that these features help to preserve and protect the environment in coastal regions.

(b)(iii) Identify one human action that directly threatens coastal habitats and describe one impact on species, other than the piping plover, that use the habitat.

Question 1

2019 ▪ Q1

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Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.

(c) Identify one economic impact on coastal communities that has resulted from rising sea levels.

Question 1

2019 ▪ Q1

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SPRING PIPING PLOVER NESTING SITES ON ASSATEAGUE ISLAND, VIRGINIA

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Question 1

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Approximately 40% of the United States population resides in coastal areas, such as areas near Assateague Island, where sea level rise and shoreline erosion is occurring.

(d) Describe TWO methods that may be used locally to protect coastal communities from rising sea levels.

Solution 1

(a)(i)

Mark scheme

- Preferred nesting habitat for piping plovers: unvegetated sand / sandy areas / open sandy beaches / washovers. Full credit for identifying any one of these habitat types.

Solution 1

(a)(ii)

Mark scheme

- The number of piping plover nests decreased by almost half (about 43%) between 1999 and 2009 — from 44 nests in 1999 to 25 nests in 2009 (a decrease of 19 nests). Full credit for correctly describing this decrease (exact numbers not required).

Solution 1

(a)(iii)

Mark scheme

- One likely reason: the preferred nesting habitat (unvegetated sand) was reduced — either because of a decrease in unvegetated sandy areas, or because of an increase in vegetation/revegetation of the island. Full credit for identifying either cause of habitat loss.

Solution 1

(b)(i)

Mark scheme

- One reasonable restriction to prevent destruction of plover nests by human actions, e.g.: post warning signs/fencing/barrier tape/boardwalks around the nesting area; place wire enclosures/other barriers over active nests; limit specified recreational activity on beaches with plover nests (prohibit kite flying, fireworks, etc.); implement motor vehicle restrictions (limit times, size of vehicles, raking, etc.); require pets to remain indoors or on leashes. Full credit for any one reasonable restriction.

Solution 1

(b)(ii)

Mark scheme

- One way barrier islands help preserve/protect the coastal environment, e.g.: they block/buffer wind and/or waves, mitigating beach erosion; they reduce storm surge, protecting the interior coastline from flooding; they block/buffer waves and create wetland ecosystems/pools that serve as habitat for many species (fish, turtles, migratory birds); they trap sediments/pollutants in wetland habitats/marsh grasses, filtering the water. Full credit for any one correct explanation.

Solution 1

(b)(iii) Mark scheme

- 2 points — 1 point for identifying a human action that directly threatens coastal habitats, 1 point for describing a matching impact on a coastal species other than the piping plover. Acceptable paired examples: Tourism/Recreation → beachgoers step on/crush nests, unleashed pets disrupt nesting/survival, vehicles disrupt nesting/survival, litter attracts predators/harbors pathogens, sunscreen washes off and is toxic to coral/marine organisms; Coastal Development → loss of suitable habitat, noise/light pollution disrupts nesting/migration/survival, food/garbage attracts predators/harbors pathogens; Littering/Solid Waste Disposal → species get tangled in trash, or ingest trash which fills/blocks the respiratory/digestive tract; Offshore Oil Drilling → spilled oil coats coastal marine organisms impacting

Solution 1

survival, or is toxic if ingested; Commercial Fishing $\rightarrow$ dredging/trawling destroys coral/habitat for bottom-dwelling organisms, overharvesting decreases populations, species get trapped in fishing gear. Award 1 point for a valid human action, 1 point for a correctly linked impact on a non-plover species.

Solution 1

(c) Mark scheme

- One economic impact on coastal communities from rising sea levels, e.g.: decrease of tourist revenue; decrease of property value; increase in damage to property/land/infrastructure requiring repair or replacement; increase in insurance costs; loss of agricultural land or aquaculture operations resulting in financial loss; loss of fish nurseries in wetland areas leading to less revenue for commercial fisheries; increase in jobs in infrastructure/construction to repair damaged structures/properties; increase in costs associated with preventative measures (building sea walls, raising buildings, etc.). Full credit for any one valid economic impact.

Solution 1

(d) Mark scheme

- Describe TWO methods that may be used locally to protect coastal communities from rising sea levels, 1 point per correct distinct method (max 2), e.g.: raise structures to reduce/prevent water damage; move/build structures back from the beach (setbacks) to reduce/prevent water damage; install pumps to reduce flooding; build structures such as sea walls to protect the area from wave action/storm surge/flooding/erosion; plant vegetation along the shoreline to decrease erosion; replenish sand to address erosion problems or increase beach width; build jetties/groins to act as a barrier from waves.

Question 3

2018 ▪ Q3

An Arctic food web includes the following organisms.

[Food-web diagram showing organisms connected by arrows pointing from prey to predator (from what is eaten to what eats it), labeled: "Orca", "Polar Bear", "Arctic Cod", "Ringed Seal", "Krill (zooplankton)", "Diatom (phytoplankton)". Arrows: Diatom (phytoplankton) → Krill (zooplankton); Diatom (phytoplankton) → Ringed Seal; Krill (zooplankton) → Arctic Cod; Arctic Cod → Orca; Arctic Cod → Polar Bear; Ringed Seal → Polar Bear; Ringed Seal → Orca; Polar Bear → Orca. Note: Figures not drawn to scale.]

(a)(i) Refer to the food web above to complete the following table.

Question 3

	Organism from Arctic food web
(i) Identify a primary producer	
(ii) Identify a primary consumer	
(iii) Identify a secondary consumer	

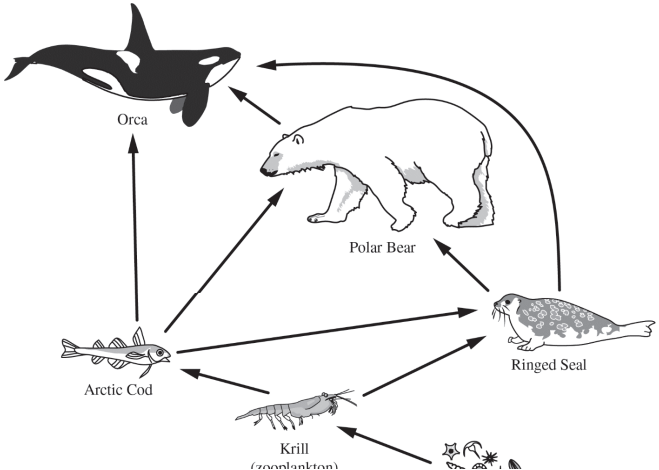
Identify a primary producer.

(a)(ii) Identify a primary consumer.

Question 3

(a)(iii) Identify a secondary consumer.

Question 3



Question 3

(zooplankton)

Diatom
(phytoplankton)

Note: Figures not drawn to scale.

Question 3

	Organism from Arctic food web
(i) **Identify** a primary producer	
(ii) **Identify** a primary consumer	
(iii) **Identify** a secondary consumer	

Question 3

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(b) Other than showing which organisms are consumed by other organisms, describe what is indicated by the direction of the arrows in the diagram.

Question 3

2018 ▪ Q3

An Arctic food web includes the following organisms.

[Food-web diagram showing organisms connected by arrows pointing from prey to predator (from what is eaten to what eats it), labeled: “Orca”, “Polar Bear”, “Arctic Cod”, “Ringed Seal”, “Krill (zooplankton)”, “Diatom (phytoplankton)”. Arrows: Diatom (phytoplankton) → Krill (zooplankton); Diatom (phytoplankton) → Ringed Seal; Krill (zooplankton) → Arctic Cod; Arctic Cod → Orca; Arctic Cod → Polar Bear; Ringed Seal → Polar Bear; Ringed Seal → Orca; Polar Bear → Orca. Note: Figures not drawn to scale.]

(c) As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

Describe how the change in sea ice habitat is affecting polar bears’ ability to hunt and feed.

Question 3

2018 ▪ Q3

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(d) Explain how melting sea ice leads to a feedback loop that increases Arctic warming.

Question 3

2018 ▪ Q3

An Arctic food web includes the following organisms.

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(e)(i) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

Provide one reason a species may migrate a long distance.

(e)(ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities.

Question 3

Describe one commercial activity, other than whaling, that may result in the death of right whales.

(e)(iii) Describe one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

Solution 3

(a)(i)

Mark scheme

- 1 point for correctly identifying a primary producer from the Arctic food web: Diatom (phytoplankton).

(a)(ii)

Mark scheme

- 1 point for correctly identifying a primary consumer from the Arctic food web: Krill (zooplankton).

Solution 3

(a)(iii)

Mark scheme

- 1 point for correctly identifying a secondary consumer from the Arctic food web: Cod or seal.

Solution 3

(b)

Mark scheme

- 1 point for a correct description of what the arrow direction indicates, other than which organisms are consumed by others. Accept: shows the flow of energy among trophic levels; OR shows the flow of matter through trophic levels.

Solution 3

(c) Mark scheme

- 1 point for a correct description of how the changing sea ice habitat affects polar bears' ability to hunt/feed. Accept any one of: decreasing area of hunting ground (fewer seal breathing holes/less ice for hauling out) makes it more difficult for polar bears to get food; increasing distance between hunting grounds means polar bears must exert more energy to swim to find food, causing physical exhaustion and less energy available for hunting; increasing physiological stress (dehydration, exhaustion, cub mortality) because polar bears are not physiologically adapted to warmer temperatures; increasing the time between successful kills means bears spend more time waiting/hunting for prey.

Solution 3

(d)

Mark scheme

- 2 points: 1 point for explaining the connection between melting ice and increased absorption of the sun's energy, and 1 point for explaining that this increased absorption leads to further ice melt (completing the positive feedback loop). Melting of sea ice leads to a decrease in albedo/reflectivity, causing water surfaces to absorb more of the sun's energy; AND this increasing absorption of the sun's energy warms the water surface further, which leads to further ice melt (completes the positive feedback loop).

Solution 3

(e)(i)

Mark scheme

- 1 point for a correct reason a species may migrate a long distance. Accept any one of: limited food/water supply leads to migration to locations with more food/water supply; food supply migrates and the species follows its prey; more hospitable climate during certain seasons; availability of mates/breeding/birthing occurs in a different location; protection of offspring from predators.

Solution 3

(e)(ii)

Mark scheme

- 1 point for a correct description of a commercial activity, other than whaling, that may result in right whale deaths. Accept any one of: fishing nets entangle whales as by-catch/fishing gear can accidentally trap whales; ships and whales use the same channels, which can increase the number of ship strikes; noise pollution from seismic surveys/sonar/engine noise can disrupt a whale's internal navigational system.

Solution 3

(e)(iii) Mark scheme

- 1 point for a correct strategy linked to the activity named in part (ii). If fishing gear/by-catch was named: require a change of fishing method (location, timing, or materials) that traps whales, to reduce the number of whales trapped in nets/gear; OR fines for discarded fishing gear so less gear is discarded, reducing whales trapped in gear. If ship strikes were named: improved navigational technology to spot whales close to ships to avoid collisions; OR increased education of ship captains/crews about whale habitat/migration routes/feeding behaviors; OR expansion of low-speed navigational zones around ports. If noise pollution was named: reduction of seismic survey activity/sonar use in coastal areas; OR installation of quieter motors to reduce/eliminate noise pollution.

Question 4

2016 ▪ Q4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.
(a) Describe how TWO climate factors affect the rate of soil formation.

Question 4

2016 ▪ Q4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

(b)(i) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.

Identify one specific biotic component of the A horizon.

(b)(ii) Identify one abiotic component of the A horizon.

Question 4

2016 ▪ Q4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

(c)(i) Resources such as soil and water can be degraded by human activities. Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.

Identify one agricultural practice that can lead to elevated nitrate levels in groundwater.

(c)(ii) Describe how the practice you identified in (c)(i) leads to elevated nitrate levels in groundwater.

Question 4

2016 ▪ Q4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

(d)(i) Acid deposition has affected soil quality in many parts of the northeastern United States.

Explain one way acid deposition onto soil can affect plant health.

(d)(ii) Describe one method for remediating soil affected by acid deposition.

Question 4

2016 ▪ Q4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and support ecosystem functions.

(e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

Solution 4

(a) Mark scheme

- 2 points: 1 point for each of TWO correctly described climate factors affecting the rate of soil formation (merely naming a factor earns no point) — only the first two given earn credit. Acceptable: Temperature — high temperature increases biological/chemical activity (increases soil formation rate); low temperature decreases biological activity (decreases formation) but increases weathering via freeze-thaw/frost wedging (increases formation). Precipitation/humidity — high precipitation increases biological activity and weathering (increases formation) but also increases erosion/runoff (decreases formation); low precipitation decreases biological activity and weathering (decreases formation). Wind — can carry in particles (increases accumulation) or hasten erosion (decreases accumulation).

Solution 4

(b)(i)

Mark scheme

- 1 point for a correct identification of a specific biotic component of the A horizon: humus, microorganisms, bacteria, earthworms, macroinvertebrates, roots, fungi, beetles, decomposers, or insects.

(b)(ii)

Mark scheme

- 1 point for a correct identification of an abiotic component of the A horizon: sand, silt, clay, water, air, nutrients (N, P, K compounds), decomposing parent material, minerals, rocks, or pebbles.

Solution 4

(c)(i)

Mark scheme

- 1 point for a correct agricultural practice that can lead to elevated nitrate levels in groundwater: application of fertilizer; improper sealing of feedlots; or improper construction/maintenance of animal waste lagoons.

Solution 4

(c)(ii)

Mark scheme

- 1 point for a correct description linked to the practice identified in (c)(i): nitrates infiltrate/percolate/seep down into groundwater; or nitrates enter surface waters that recharge aquifers, connecting surface water to groundwater.

Solution 4

(d)(i) Mark scheme

- 1 point for a correct explanation of one way acid deposition onto soil can affect plant health: increased soil acidity may fall outside the plant's optimal tolerance range, causing poor growth or death; acid can leach cations/metal ions/nutrients from the soil, making them less available to plants and decreasing growth; aluminum is released and can be toxic to plants; acid can diminish the soil's buffering ability, leading to poor plant growth; increased soil acidity can damage plant root systems, stressing plants; or sulfur and nitrogen from acid deposition can build up to levels toxic to plants (or over-fertilize soils).

Solution 4

(d)(ii)

Mark scheme

- 1 point for a correct description of a remediation method for soil affected by acid deposition: add crushed limestone / lime / marble dust / bone meal / crushed egg shells or oyster shells to raise soil pH.

Solution 4

(e) Mark scheme

- 2 points: 1 point for each of TWO correctly described ways climate change can degrade soil — only the first two given earn credit. Acceptable: increased global temperatures and decreased precipitation cause desertification; increased temperatures increase evaporation of irrigation water, resulting in soil salinization; increased erosion and/or leaching from increased precipitation in certain areas; increased temperature leads to faster breakdown of organic matter (less organic matter in soil); increased temperatures and shifting climatic belts result in longer growing seasons, which can deplete soil nutrients; rising sea levels can flood coastal areas, leading to salinization and increased soil erosion; increased temperatures can lead to soil desiccation.

Question 1

2015 ▪ Q1

Read the article below and answer the questions that follow.

[Newspaper clipping: "The Floridian Daily", dated May 21, 2013]

The small community located on the edge of the magnificent wetlands of Florida's Everglades was the site of a press conference today where Governor Gayle Moss announced that the restoration of the Everglades is successfully underway. She noted that the Everglades ecosystem has suffered threats to its water quality, water quantity, and habitats in recent decades. Moss noted that intensive urban and agricultural development in adjacent areas has diverted substantial amounts of freshwater resources and impaired water quality. Governor Moss then emphasized that the preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state. She closed the press conference by saying, "The Everglades is a gem not only for Florida but for

Question 1

the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

(a) Describe how TWO human activities, other than those that result in anthropogenic climate change, have resulted in a decrease in the amount of freshwater flowing into the Everglades ecosystem.

Question 1

The Floridian Daily May 21, 2013

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Question 1

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Question 1

only for Florida but for the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

(b) In addition to water quantity problems, the Everglades is faced with a variety of water quality issues. For example, phosphorus concentrations in the Everglades have increased since the 1960s.

(b)(i) Describe how one specific human activity contributes to increased phosphorus levels in the Everglades.

(b)(ii) Explain one way in which an increase in phosphorus levels can adversely affect the Everglades ecosystem.

(b)(iii) Describe one step that could be taken to reduce phosphorus inputs from the activity you identified in part (i).

Question 1

2015 ▪ Q1

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Question 1

only for Florida but for the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

(c) Climate change could have a variety of impacts on water quantity, water quality, and habitat. For EACH of these three factors, identify and describe one specific example of an impact on the Everglades likely to result from climate change.

Question 1

2015 ▪ Q1

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Question 1

only for Florida but for the entire world. Each of us has the responsibility to do our part to preserve this magnificent resource."

(d) The article states that Governor Moss believes that the "preservation and enhancement of the Everglades, key goals of the restoration program, are absolutely essential for the continued environmental and economic health of the state."

(d)(i) Describe one way that restoring water quantity and water quality in the Everglades is expected to improve the structure and function of the ecosystem.

(d)(ii) Describe one way that restoring the Everglades is expected to provide economic benefits to Florida.

Question 4

2014 ▪ Q4

Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.

(a)(i) The atmosphere is one important carbon reservoir.
Describe a biological process by which carbon is removed from the atmosphere and converted to organic molecules.

(a)(ii) Describe a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.

Question 4

2014 ▪ Q4

Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.

(b)(i) Oceans and terrestrial systems are also important carbon reservoirs. Explain how atmospheric carbon is incorporated into two oceanic sinks.

(b)(ii) Identify one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.

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(c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. Discuss TWO other human activities that increase the concentration of carbon in the atmosphere.

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(d) Identify an environmental problem that results from elevated atmospheric carbon concentrations. Discuss one consequence of the problem you identified.

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(e)(i) Phosphorus is another element important to all organisms.
Describe one major way in which the phosphorus cycle differs from the carbon cycle.

(e)(ii) Identify one reason that phosphorus is necessary for organisms.