Past-paper walk-through

Introduction to Biodiversity ▪ 2.1

eXercise

Questions in this set

- 2026 Q1
- 2025 Set 1 Q1
- 2025 Set 2 Q1
- 2024 Set 1 Q1
- 2024 Set 2 Q2
- 2023 Set 1 Q1
- 2021 Set 1 Q3
- 2021 Set 2 Q2
- 2019 Q1
- 2017 Q4

Questions in this set

- 2016 Q1

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.

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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
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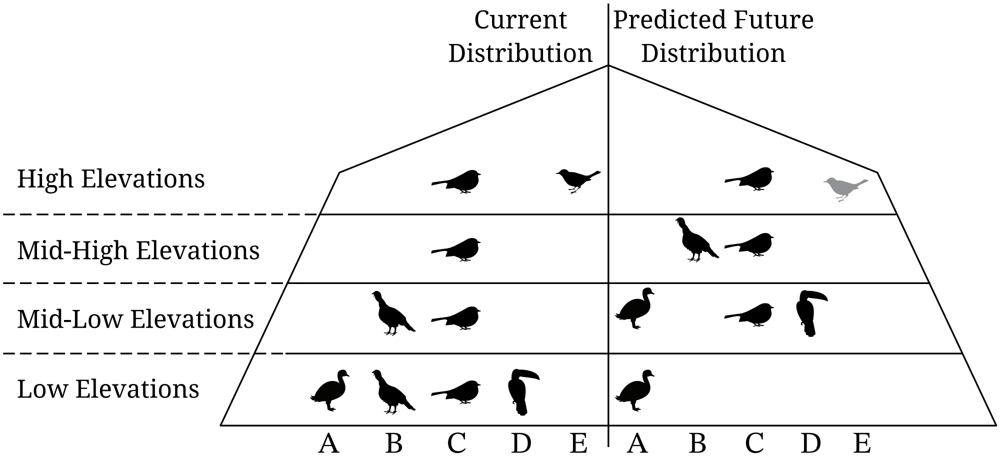
- Tank 3: 27°C and high sediment

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
Mid-Low Elevations
Low Elevations
A B C D E
A B C D E

Question 1

2026 ▪ Q1

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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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(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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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

[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.

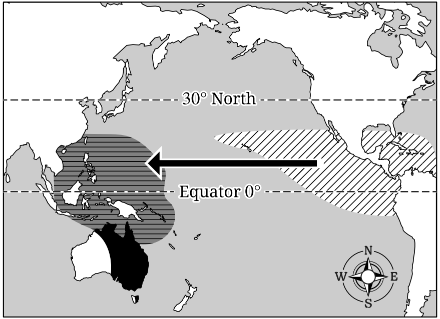
Question 1

2025 Set 1 ▪ Q1

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

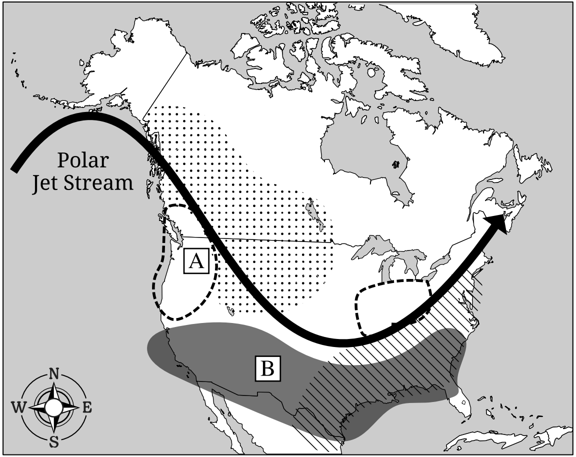
(a) Describe one reproductive strategy used by a K-selected species such as the chickadee.

Question 1



Ocean water cooler than average
Ocean water warmer than average
Increased chance of precipitation
Stronger than normal trade winds

Question 1



Question 1

Site	Species A	Species B	Species C	Species D	Species E	Species F
Urban park	X			X	X	
Grassland	X	X	X	X		X

Question 1

2025 Set 1 ▪ Q1

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

(b) Based on the information provided, explain how a decrease in spider populations could affect a lower trophic level.

Question 1

2025 Set 1 ▪ Q1

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

(c) Based on the data in Figure 1, identify the number of spiders per sample at 25% nonnative plants.

Question 1

2025 Set 1 ▪ Q1

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

(d) Based on the data in Figure 1, describe the trend in the number of insects per sample in relation to the percentage of nonnative plants.

Question 1

2025 Set 1 ▪ Q1

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

(e) Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. Describe one way that the data in Figure 2 support this hypothesis.

Question 1

2025 Set 1 ▪ Q1

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

(f) Insect biodiversity is important to maintain ecosystem health. A group of students was interested in learning about factors that affect ant biodiversity. They located two study sites near their school: a frequently mowed urban park and an unmowed grassland. The students used traps designed to collect ants. They loaded 10 of these traps with the same food and placed them randomly at different locations within each site. Students collected the traps after 24 hours and counted the number of different ant species in each trap to determine species richness.

(f)(i) Identify a likely scientific question for the students' investigation of ant diversity.

(f)(ii) Identify the dependent variable in the students' investigation.

Question 1

2025 Set 1 ▪ Q1

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

(g) The data from the student investigation of ant diversity are shown in the following table. An "X" in the table indicates that the species was present at that site.

Ant Species Present in an Urban Park and Unmowed Grassland

Site	**Species A**	**Species B**	**Species C**	**Species D**	**Species E**	**Species F**
Urban park	X			X	X	
Grassland	X	X	X	X		X

Question 1

(g)(i) Explain why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would.
(g)(ii) Explain how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland.

Question 1

2025 Set 1 ▪ Q1

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

(h) Habitat fragmentation has impacts on a variety of species. Paved roads can lead to habitat fragmentation.

Describe one effect that a paved road in a forest can have on animal species such as deer or bears.

Solution 1

(a)

Mark scheme

- Describe one reproductive strategy of a K-selected species (e.g., chickadee). Any one of: provides considerable parental care for offspring; has few offspring; parents expend significant energy per offspring; individuals reproduce more than once in their lifetime (iteroparity); has a long gestation period/reaches reproductive maturity later.

Solution 1

(b)

Mark scheme

- Explain how a decrease in spider populations affects a lower trophic level: insects/insect populations would increase because they are no longer being preyed on/eaten as much by spiders; consequently plant populations would decrease because more insects are now eating the plants (a trophic cascade down through insects to plants).

Solution 1

(c)

Mark scheme

- From Figure 1, the number of spiders per sample at 25% nonnative plants is 2.0 (accept 2).

Solution 1

(d)

Mark scheme

- Trend in Figure 1: as the percentage of nonnative plants increases, the number of insects per sample decreases (equivalently, as nonnative plant percentage decreases, insects increase) — an inverse/negative relationship between nonnative plant percentage and insect abundance.

Solution 1

(e)

Mark scheme

- One way Figure 2 supports the hypothesis that chickadee populations are stable or growing below 25% nonnative plants: below this threshold, the population growth rate shown is at or above replacement level (positive growth), meaning enough reproduction is occurring to replace or grow the population.

Solution 1

(f)

Mark scheme

- This is background/stem text introducing the student investigation of ant biodiversity (10 baited traps placed randomly at a frequently mowed urban park and an unmowed grassland, collected after 24 hours, species counted). It is context for parts (i) and (ii) and carries no scoring point of its own.

Solution 1

(f)(i)

Mark scheme

- A likely scientific question for the investigation: "Does the number of species/species richness/biodiversity differ between an urban park and a grassland?" or "Does mowing affect the number of species/species richness/biodiversity?"

Solution 1

(f)(ii)

Mark scheme

- The dependent variable is the number of ant species / ant species richness / the presence-absence of different ant species observed at each site.

Solution 1

(g)

Mark scheme

- This presents the data table of ant species present (X) at the urban park vs. the unmowed grassland (species A-F). It is context for parts (i) and (ii) and carries no scoring point of its own.

Solution 1

(g)(i)

Mark scheme

- The unmowed grassland's ant community would more likely recover from a disturbance because, with a larger number of species, the grassland is more likely to have some species/individuals with adaptations that allow them to survive the disturbance; the grassland is more diverse, so the loss of any one species is less likely to cause collapse of the whole community/ecosystem.

Solution 1

(g)(ii)

Mark scheme

- If biodiversity had been measured at a paved playground instead of the grassland, the playground would show fewer species than the grassland/urban park, because the paved area is not suitable habitat for many ant species, and/or because humans could trample the ants/ant habitat there.

Solution 1

(h)

Mark scheme

- One effect of a paved road through a forest on animals such as deer or bears: animals can be hit by cars when trying to cross the road while hunting/migrating (roadkill); fragmentation can isolate individuals and reduce genetic diversity; noise pollution can damage hearing, cause stress, or mask sounds used to communicate/hunt; the road/noise can alter migratory routes or prevent movement to access resources; species that thrive in edge habitats might increase. Any one of these earns the point.

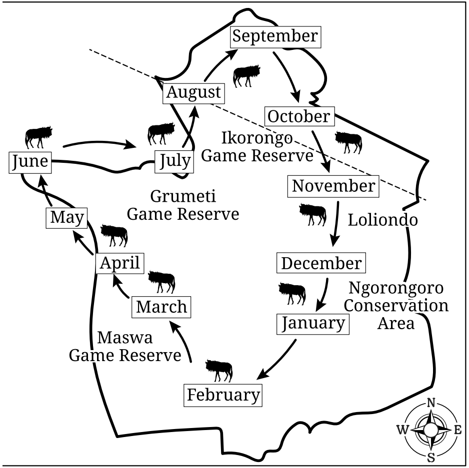
Question 1

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.

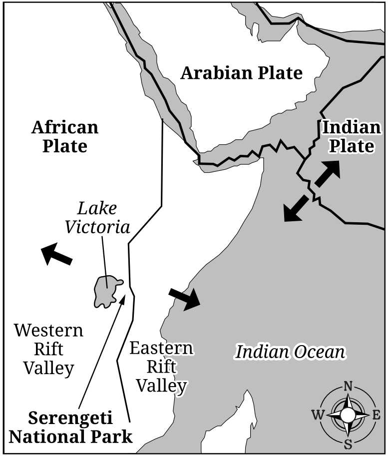
Question 1


September
August
October
Ikorongo
Game Reserve
June
July
November
Grumeti
Game Reserve
Loliondo
May
April
December
Ngorongoro
Conservation
Area
March
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 1

2024 Set 1 ▪ Q1

Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

[Diagram: a cross-section of a stream divided into five vertical zones (A through E) labeled left to right, with "Direction of Streamflow" arrow pointing right along the bottom axis. The y-axis (unlabeled numerically) ranges from "Low" at the bottom to "High" at the top, showing two curves: a solid line for "Dissolved oxygen" and a

Question 1

dashed line for "Biological oxygen demand". Common fish/macroinvertebrate species listed above each zone:

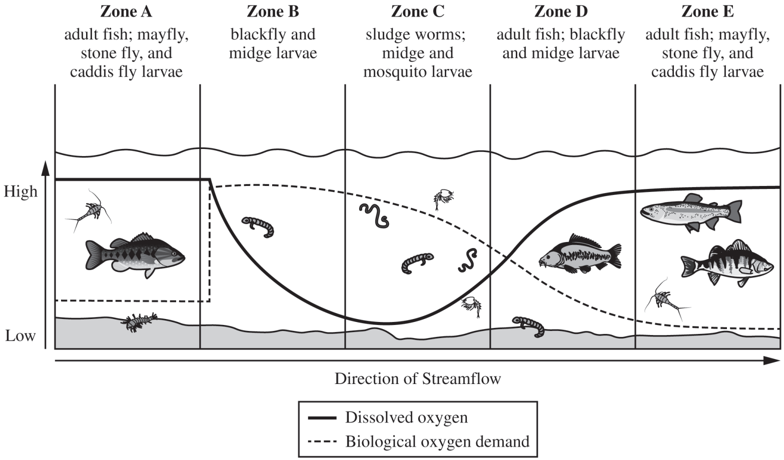
- Zone A: adult fish; mayfly, stone fly, and caddis fly larvae
- Zone B: blackfly and midge larvae
- Zone C: sludge worms; midge and mosquito larvae
- Zone D: adult fish; blackfly and midge larvae
- Zone E: adult fish; mayfly, stone fly, and caddis fly larvae

Question 1

Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen.

Question 1



Zone A
adult fish; mayfly, stone fly, and caddis fly larvae
Zone B
blackfly and midge larvae
Zone C
sludge worms; midge and mosquito larvae
Zone D
adult fish; blackfly and midge larvae
Zone E
adult fish; mayfly, stone fly, and caddis fly larvae
High
Low
Direction of Streamflow
Dissolved oxygen
Biological oxygen demand

Question 1

2024 Set 1 ▪ Q1

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Question 1

- Zone B: blackfly and midge larvae
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- Zone D: adult fish; blackfly and midge larvae
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Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to

Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen.

Question 1

2024 Set 1 ▪ Q1

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Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

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Question 1

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- Zone C: sludge worms; midge and mosquito larvae
- Zone D: adult fish; blackfly and midge larvae
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Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to

Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(c) Based on the information in the diagram, **identify** the zone where there is most likely point-source water pollution discharged into the stream.

The research team is interested in investigating the relationship between dissolved oxygen levels and macroinvertebrate species richness in the stream. Researchers counted the number of macroinvertebrate species in zones A, B, and C during the summer months. The researchers selected zone A to serve as the control in the investigation.

Question 1

2024 Set 1 ▪ Q1

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Question 1

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Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(d) Identify the dependent variable in the researchers' investigation.

Question 1

2024 Set 1 ▪ Q1

Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

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- Zone A: adult fish; mayfly, stone fly, and caddis fly larvae

Question 1

- Zone B: blackfly and midge larvae
- Zone C: sludge worms; midge and mosquito larvae
- Zone D: adult fish; blackfly and midge larvae
- Zone E: adult fish; mayfly, stone fly, and caddis fly larvae

Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to

Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(e) Identify a testable hypothesis for the researchers' investigation.

Question 1

2024 Set 1 ▪ Q1

Researchers are studying the stream ecosystem shown in the following diagram. They have identified five different zones based on the dissolved oxygen levels and biological oxygen demand as the water flows downstream. Biological oxygen demand is the amount of oxygen needed by bacteria and other microorganisms to break down organic material in water. Some of the most common fish and macroinvertebrate species found in each zone are listed in the diagram.

Dissolved Oxygen and Biological Oxygen Demand in a Stream Ecosystem

[Diagram: a cross-section of a stream divided into five vertical zones (A through E) labeled left to right, with “Direction of Streamflow” arrow pointing right along the bottom axis. The y-axis (unlabeled numerically) ranges from “Low” at the bottom to “High” at the top, showing two curves: a solid line for “Dissolved oxygen” and a dashed line for “Biological oxygen demand”. Common fish/macroinvertebrate species listed above each zone:

- Zone A: adult fish; mayfly, stone fly, and caddis fly larvae

Question 1

- Zone B: blackfly and midge larvae
- Zone C: sludge worms; midge and mosquito larvae
- Zone D: adult fish; blackfly and midge larvae
- Zone E: adult fish; mayfly, stone fly, and caddis fly larvae

Curve behavior: In Zone A, dissolved oxygen is High (solid line flat at top) and biological oxygen demand is Low (dashed line flat at bottom). Moving into Zone B, dissolved oxygen (solid line) drops sharply from High to Low while biological oxygen demand (dashed line) rises sharply from Low to High. In Zone C, dissolved oxygen remains Low (solid line near bottom) while biological oxygen demand remains High (dashed line near top), with the two curves close together at their extremes. Moving into Zone D, dissolved oxygen (solid line) rises back up from Low to High while biological oxygen demand (dashed line) falls back down from High to

Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(f) Describe the reason the researchers selected zone A to serve as the control in the investigation.

The researchers decided to repeat their data collection during the winter months.

Question 1

2024 Set 1 ▪ Q1

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Question 1

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Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(g) Explain how the modification to collect data in the winter months could alter the results of the investigation.

Stream ecosystems are affected by point-source organic pollution in a variety of ways.

Question 1

2024 Set 1 ▪ Q1

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Question 1

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Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(h) Describe the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream.

Question 1

2024 Set 1 ▪ Q1

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Question 1

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Question 1

Low. In Zone E, dissolved oxygen is High (solid line flat at top) again and biological oxygen demand is Low (dashed line flat at bottom), mirroring Zone A.]

(i) Identify an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream.

Question 1

2024 Set 1 ▪ Q1

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Question 1

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Question 1

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(j) Explain how persistent organic pollutants can affect higher trophic levels in an aquatic food web.

Solution 1

(a)

Mark scheme

- Zone C has the lowest level of dissolved oxygen (based on the diagram).

Solution 1

(b)

Mark scheme

- Biological oxygen demand (BOD) and dissolved oxygen (DO) are inversely related: as BOD increases, DO decreases (equivalently, as DO increases, BOD decreases).

Solution 1

(c)

Mark scheme

- Zone B is where point-source water pollution is most likely discharged into the stream (based on the diagram).

Solution 1

(d)

Mark scheme

- The dependent variable is the number of macroinvertebrate species (macroinvertebrate diversity / macroinvertebrate species richness) — the researchers measured this in response to dissolved oxygen level.

Solution 1

(e)

Mark scheme

- A testable hypothesis relates dissolved oxygen level to macroinvertebrate species number, e.g.: 'As dissolved oxygen levels increase, the number of macroinvertebrate species increases' (or the inverse: as DO decreases, species number increases; or a general statement of a direct/inverse relationship between DO and macroinvertebrate species number). A null hypothesis of no relationship is also acceptable.

Solution 1

(f)

Mark scheme

- Zone A was chosen as the control because it is upstream from the pollution/organic waste source, so it is not affected by (not impacted by) the discharge — its dissolved oxygen levels reflect conditions unaffected by the pollution, giving a baseline for comparison.

Solution 1

(g)

Mark scheme

- Collecting data in winter could alter the results because: (1) cold water holds more dissolved oxygen, which could increase the number of species; or (2) colder temperatures may fall below the tolerance range of some organisms, decreasing the number of species; or (3) lower light levels in winter reduce plant photosynthesis, which lowers dissolved oxygen and could decrease the number of species.

Solution 1

(h)

Mark scheme

- Raw sewage introduces nutrients (and/or organic matter) that increase the bacteria population (more food source), and/or raw sewage directly contains bacteria that increases the bacteria population size in the stream.

Solution 1

(i)

Mark scheme

- Any abiotic factor other than dissolved oxygen and organic pollution that affects bacteria population size, e.g.: temperature, pH, light/sunlight, turbidity/sediment, salinity, or nitrate/phosphate concentration.

Solution 1

(j)

Mark scheme

- Persistent organic pollutants (POPs) bioaccumulate/biomagnify in the tissues of organisms at higher trophic levels because those organisms consume prey that have already accumulated the pollutants, so pollutant concentration increases up the food web (often concentrating in fatty tissue); this can cause effects such as neurological toxicity in top predators.

Question 2

2024 Set 2 ▪ Q2

The following graph shows how global uses of habitable land have changed since 1700. [Bar chart titled "Land Use Changes on Earth, 1700-2018". Y-axis: "Percentage of Habitable Land" from 0% to 100% in increments of 20%. X-axis: "Year", with stacked bars shown for 1700, 1800, 1900, 1950, 2000, and 2018. Each bar is stacked (from bottom to top) with five categories per the legend: Forest (light gray), Crops (dark gray), Grazing (diagonal hatched pattern), Wild grasslands (white), Built-up land (black, thin sliver at the very top). Approximate stacked values read from the graph:

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- 1800: Forest $\approx$ 51%, Crops $\approx$ 4%, Grazing $\approx$ 9%, Wild grasslands $\approx$ 36%, Built-up land negligible.

Question 2

- 1900: Forest $\approx$ 49%, Crops $\approx$ 8%, Grazing $\approx$ 16%, Wild grasslands $\approx$ 27%, Built-up land negligible.
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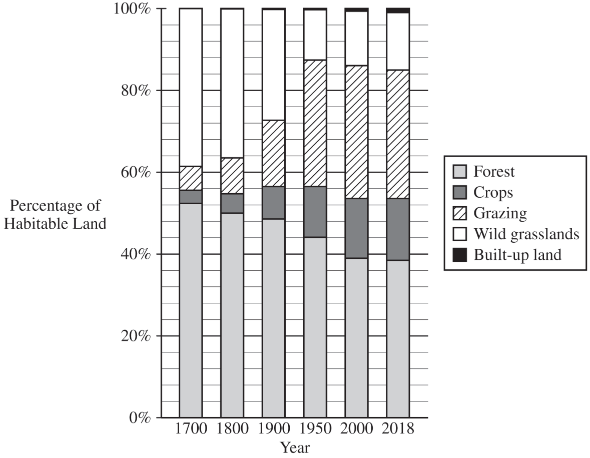
- 2018: Forest $\approx$ 38%, Crops $\approx$ 15%, Grazing $\approx$ 33%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.]

(a) Based on the data in the graph, identify the year with the highest percentage of forest.

Question 2



100%
80%
60%
40%
20%
0%
Percentage of Habitable Land
1700
1800
1900
1950
2000
2018
Year
Forest
Crops
Grazing
Wild grasslands
Built-up land

Question 2

2024 Set 2 ▪ Q2

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(b) Based on the data in the graph, describe the relationship between the land use changes in the wild grasslands and grazing from 1700 to 1950.

Question 2

2024 Set 2 ▪ Q2

The following graph shows how global uses of habitable land have changed since 1700.
[Bar chart titled "Land Use Changes on Earth, 1700-2018". Y-axis: "Percentage of Habitable Land" from 0% to 100% in increments of 20%. X-axis: "Year", with stacked bars shown for 1700, 1800, 1900, 1950, 2000, and 2018. Each bar is stacked (from bottom to top) with five categories per the legend: Forest (light gray), Crops (dark gray), Grazing (diagonal hatched pattern), Wild grasslands (white), Built-up land (black, thin sliver at the very top).
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(c) Identify an environmental problem associated with overgrazing by livestock.

Question 2

2024 Set 2 ▪ Q2

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(d) A student hypothesized that the change in the percentage of forest from 1700 to 2018 has decreased atmospheric carbon dioxide concentrations. Explain whether the hypothesis is supported or refuted based on the data in the graph.

Question 2

2024 Set 2 ▪ Q2

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(e) Urban environments have accounted for an increasing percentage of land use within the last few decades.
Describe a water-related environmental problem associated with urbanization.

Question 2

2024 Set 2 ▪ Q2

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(f) Describe a potential response to mitigate the environmental problem identified in part (e).

Question 2

2024 Set 2 ▪ Q2

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Question 2

(g) Farmers who own large sections of cropland notice that bobcats, a medium-sized predatory forest cat, were present many years ago but are now virtually absent in the area. Instead, smaller mammal species now inhabit the area. Over time, the farmers have cleared nearly all of the forest on their property and converted it to farmland. Explain why there are fewer bobcats present on the farmland now compared to several decades ago.

Question 2

2024 Set 2 ▪ Q2

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Question 2

(h) The small mammal species are considered pests by the farmers. The farmers partner with a conservation group to increase the number of bobcats in the area. As a solution, the conservation group will introduce bobcats onto the few isolated patches of the original forested habitat left in the area. They can introduce only a small number of bobcats in each patch.
Describe a disadvantage of introducing only a small population of bobcats.

Question 2

2024 Set 2 ▪ Q2

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(i) Propose a solution to improve the chances that the bobcat reintroductions will be successful in reestablishing wild populations.

Question 2

2024 Set 2 ▪ Q2

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(j) Justify the solution proposed in part (i) by describing an additional advantage, other than reestablishing the bobcat population near the farms.

Solution 2

(a)

Mark scheme

- The year with the highest percentage of forest is 1700 (the earliest year shown, before land conversion to grazing/agriculture/urban use). Full credit for identifying 1700.

Solution 2

(b)

Mark scheme

- From 1700 to 1950, the percentage/amount of wild grasslands decreased while the percentage/amount of grazing land increased – the two variables have an inverse relationship (as one goes down, the other goes up). Full credit for describing this inverse relationship.

Solution 2

(c)

Mark scheme

- An environmental problem from overgrazing by livestock: any one of loss of vegetation, soil erosion, desertification, sedimentation/turbidity in waterways, or soil compaction. Full credit for naming one such problem.

Solution 2

(d)

Mark scheme

- The hypothesis is refuted/disproved/not supported. The percentage of forest has decreased from 1700 to 2018, so the amount of photosynthesis/carbon sequestration by forests has also decreased – this would tend to increase, not decrease, atmospheric CO2, contradicting the hypothesis. Full credit for concluding 'refuted' with reasoning tied to the graph.

Solution 2

(e)

Mark scheme

- A water-related environmental problem from urbanization: any one of (1) increased runoff/flooding because urban areas have more impermeable surfaces; (2) decreased groundwater/saltwater intrusion because urban areas have many people and groundwater is overused; (3) increased water pollution because precipitation/runoff carries contaminants/pollutants/waste; (4) destruction of aquatic habitats from increased development/land-use change. Full credit for describing one such problem.

Solution 2

(f) Mark scheme

- A potential mitigation matched to the problem named in part (e): if increased runoff/flooding – use permeable road/parking materials, set aside green spaces/parks/conservation areas, or construct green roofs/rain gardens/stormwater retention ponds; if decreased groundwater/saltwater intrusion – permeable materials, groundwater conservation/management plans, protected recharge zones, or green roofs/rain gardens/retention ponds; if increased water pollution – encourage walking/biking, reduce home pesticide/fertilizer use, reduce road salt/de-icing chemical use, pick up trash/litter along waterways, or properly dispose of toxic chemicals; if destruction of aquatic habitats – create conservation

Solution 2

areas/preserves/wetlands or restore degraded aquatic habitats. Full credit for any response that logically mitigates the problem identified in (e).

Solution 2

(g)

Mark scheme

- Fewer bobcats are present on the farmland now because: (1) loss of forest habitat (cleared for farmland) has decreased resources such as food, shelter, mates, or migration routes; or (2) trapping/hunting has reduced the bobcat population. Full credit for either explanation.

Solution 2

(h)

Mark scheme

- A disadvantage of introducing only a small bobcat population: any one of (1) lower genetic diversity; (2) genetic bottlenecks leading to inbreeding/passing on negative traits; (3) greater vulnerability to disease or disturbances like wildfire; (4) less effective control of small mammal/pest populations than a larger population; (5) lower likelihood of survival. Full credit for any one such disadvantage.

Solution 2

(i)

Mark scheme

- A solution to improve reintroduction success: (1) increase connectivity/build habitat corridors so bobcats can safely mate, find food, and build dens; or (2) restore/reforest/preserve areas of bobcat habitat. Full credit for either proposal.

Solution 2

(j) Mark scheme

- An additional advantage of the proposed solution (beyond reestablishing bobcats), matched to the answer given in (i): if habitat corridors – they can be used by other species, increase biodiversity/population of other species, attract species beneficial to farmers (pest predators/pollinators), or reduce roadkill/vehicle collisions with wildlife; if restoring/reforesting/preserving habitat – restored habitat can be used by other species, restoration can increase biodiversity/improve air or water quality, or added trees improve aesthetic value, tourism, reduce erosion, or serve as a carbon sink. Full credit for any advantage consistent with the part (i) solution.

Question 1

2023 Set 1 ▪ Q1

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.

Question 1

2023 Set 1 ▪ Q1

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(b) Identify the scientific question for the investigation.

Question 1

2023 Set 1 ▪ Q1

Question 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.

Question 1

(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	3.5	0.15	1.24	17.6

Question 1

2023 Set 1 ▪ Q1

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

Question 1

2023 Set 1 ▪ Q1

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

Question 1

2023 Set 1 ▪ Q1

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.

(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

Question 1

table and the experimental design, explain whether the researchers' hypothesis was supported or refuted.

Question 1

2023 Set 1 ▪ Q1

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.

(g) 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.

Question 1

Describe the ecological process that occurred on the plots after the crops were burned.

Question 1

2023 Set 1 ▪ Q1

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.

(h) 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.

Question 1

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.

Question 1

2023 Set 1 ▪ Q1

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.

(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

Question 1

declining populations. Explain why the new beetle species could be better able to successfully populate this plot than the existing beetle species could.

Question 1

2023 Set 1 ▪ Q1

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.

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

Solution 1

(a)

Mark scheme

- The control group is Plot D, the unmodified (non-GMO) green beans.

Solution 1

(b)

Mark scheme

- Any one of: 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?

Solution 1

(c)

Mark scheme

- With only 20 minutes/day of spray irrigation (less water than the original setup), crop yield/number of green beans harvested would be lower in all plots. Alternatively: the genetically modified beans would stay similar in yield because they are drought-resistant/need less water, while the unmodified beans would decrease in yield because they receive less water than they need.

Solution 1

(d)

Mark scheme

- Plot D (the unmodified green beans) has the lowest soil temperature, based on the data table.

Solution 1

(e)

Mark scheme

- Both sediment runoff and fertilizer (phosphorus/nitrogen) runoff are lower with the genetically modified beans than with the unmodified beans (equivalently: both types of runoff are higher with the unmodified beans).

Solution 1

(f)

Mark scheme

- The hypothesis is supported. Any one justification: there is less fertilizer (phosphorus/nitrogen) in the runoff from Plot B, so the Type 2 GMO beans are absorbing/taking up more fertilizer; or there is more fertilizer in the runoff from Plot D, so the unmodified beans in Plot D are taking up less fertilizer; or the Plot B beans produced more beans given the same amount of fertilizer.

Solution 1

(g)

Mark scheme

- Secondary succession occurred: fast-growing, early-successional (pioneer) organisms recolonized/returned to the soil after the fire (a major disturbance), since the soil itself was not destroyed.

Solution 1

(h)

Mark scheme

- Any one of: the higher-diversity plot has more species/organisms, so the flood harms a smaller proportion of the total species/organisms present; the higher-diversity plot has more connections between organisms (food-web links), so the flood disrupts a smaller percentage of those connections; or higher genetic diversity within species means more flood-tolerant individuals survive to repopulate.

Solution 1

(i)

Mark scheme

- Any one of: the new beetle is likely a generalist/r-selected species that can reproduce/spread quickly and outcompete the existing (native) beetle species; the flooding caused a natural disturbance to the existing community, eliminating predators/competitors and opening niches for the new/invasive beetle; low-diversity communities are more susceptible to disruption and recover poorly, allowing the new/nonnative beetle to invade; or the new beetle is an invasive species able to live outside its normal environment and threaten native species.

Solution 1

(j)

Mark scheme

- Any one realistic method: remove beetles by trapping/physical removal to reduce their population size; apply a chemical/pesticide to kill the beetles; or introduce a predator/parasite/pathogen (biological control) that harms the beetles.

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(a) Describe a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(b) A rapidly growing suburban municipality purchases nearby forested land and proposes a newly planned housing development, which would involve clear-cutting much of the area for the construction of single-family homes. While evaluating the land, the development committee discovers that development will encroach upon the habitat of a wood thrush population. The wood thrush is a solitary, territorial bird whose preferred habitat consists of large, intact densely forested areas. Wood thrush populations are also threatened by cowbirds. A cowbird lays her egg in an existing nest of a wood thrush. After the cowbird egg hatches, the cowbird pushes the unhatched wood thrush eggs out. The wood thrush parents raise the cowbird hatchling as their own.

Identify the symbiotic relationship between the wood thrush and the cowbird.

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(c) Describe one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property.

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(d) Propose a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development.

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(e) A male wood thrush needs a minimum of 800 m^2 of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work.

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of $1,100$ m^2. The developer has proposed setting aside land equal to 10

Question 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.

(g) Calculate the percentage of each of the 1,000 lots that would need to be set aside in order to support the goal of 275 male wood thrush territories. **Show** your work.

Solution 3

(a) Mark scheme

- A characteristic of a specialist species that makes it more vulnerable to habitat fragmentation than a generalist species (accept one): specialists have a narrow ecological niche (compared to a generalist's broad niche), which is reduced even further by fragmentation; specialists have specialized adaptations and cannot adjust quickly to a changed/fragmented habitat, unlike generalists that adapt quickly; or specialists tend to have small populations with less genetic variation than generalist populations, which are larger and more genetically diverse, making specialists more vulnerable.

Solution 3

(b)

Mark scheme

- Identify the symbiotic relationship between the wood thrush and the cowbird: parasitism, specifically brood parasitism — the cowbird lays its eggs in the wood thrush's nest and uses the wood thrush as a surrogate parent to raise its hatchling, which benefits the cowbird and negatively affects the wood thrush.

Solution 3

(c) Mark scheme

- One ecological advantage of leaving areas of undeveloped forest instead of clear-cutting the property (accept one): since the habitat isn't clear-cut, it preserves some biodiversity by letting species survive in the remaining/fragmented forest areas; habitat fragmentation can benefit some generalist or edge species, whose populations may increase in edge habitat; buffer zones around conserved areas can reduce edge disturbance for specialist species; the remaining forest/trees reduce soil erosion; or the remaining forest helps with climate/cooling via transpiration and shade from trees.

Solution 3

(d) Mark scheme

- Propose a solution that minimizes the effect of development on the resident wood thrush population while still meeting the municipality's need for housing (accept one): leave wildlife corridors/crossings to prevent population isolation; include conservation easements in the plan that preserve species (and provide tax breaks for residents); create buffer zones near the development to separate it from wildlife habitat; create a mitigation plan that preserves land of similar quality elsewhere; cluster housing or build vertically to limit the development footprint; or incorporate common green spaces that promote wood thrush populations.

Solution 3

(e)

Mark scheme

- Calculate the area that must be set aside to support 275 male wood thrush territories at a minimum of 800 $m^2 per territory. Setup (1 point)$:275 territories $\times \frac{800\ \text{m}^2}{1\ \text{territory}}$. Calculation (1 point): $= 220{,}000\ \text{m}^2$.

Solution 3

(f)

Mark scheme

- Calculate the maximum number of male wood thrush territories created under the developer's proposal (1,000 lots of 1,100 m^2*each*, *with*10

Solution 3

(g)

Mark scheme

- Calculate the percentage of each of the 1,000 (1,100 m^2)$lotsthatmustbesetasidetosupportthegoalof275malewoodthrushterritories.Setup(1poi$

  100 (equivalently $\dfrac{275 \text{ territories} \times 10\%}{137.5 \text{ territories}} \times 100$). Calculation (1 point): $= 20\%$ of each lot.

Question 2

2021 Set 2 ▪ Q2

Biodiversity around the world is changing as a result of anthropogenic influences. [World map titled "GLOBAL AMPHIBIAN SPECIES RICHNESS", drawn in an oval (Robinson-style) projection with latitude lines labeled 60°, 30°, 0°, 30°, 60° (top to bottom) and longitude lines labeled 180°, 120°, 60°, 0°, 60°, 120°, 180° (left to right). A legend "Number of species" shows four shading categories: diagonal hatching = 0-20 species; light gray = 21-50 species; medium gray = 51-100 species; black = 101-136 species. The map shows the darkest shading (101-136 species, highest richness) concentrated in a band along the equator (0°) in South America (the Amazon basin) and a small patch in central Africa; medium-gray shading (51-100 species) in a broader band around the tropics in South America, Central America, sub-Saharan Africa, and parts of Southeast Asia/South Asia (e.g., India, Myanmar/Thailand region); lighter shading (21-50 species) in a band through central Africa and parts of South America;

Question 2

and diagonal-hatch shading (0-20 species, lowest richness) at higher latitudes including North America, Europe, northern Asia/Russia, and most of Australia.]

(a)(i) The map represents species richness of amphibians around the globe. Use the map to answer the following questions.

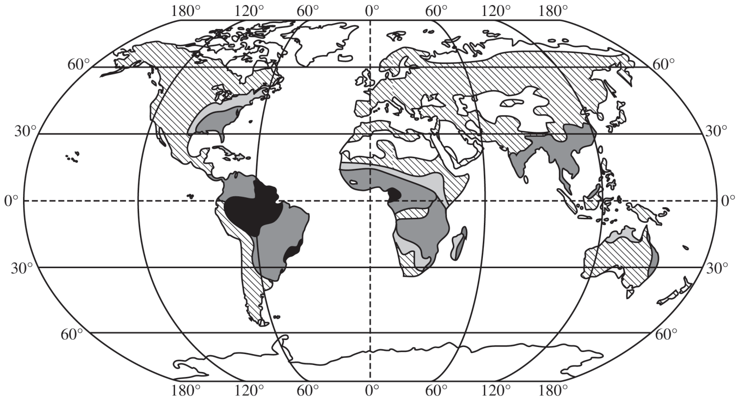
Identify the latitudinal range with the greatest amphibian species richness.

(a)(ii) Identify what biome this range most likely represents.

(a)(iii) Describe one reason amphibian species richness would tend to be highest in this region.

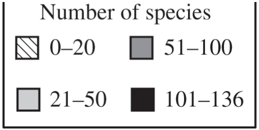
Question 2

GLOBAL AMPHIBIAN SPECIES RICHNESS



Number of species

Question 2



Question 2

2021 Set 2 ▪ Q2

Biodiversity around the world is changing as a result of anthropogenic influences. [World map titled "GLOBAL AMPHIBIAN SPECIES RICHNESS", drawn in an oval (Robinson-style) projection with latitude lines labeled 60°, 30°, 0°, 30°, 60° (top to bottom) and longitude lines labeled 180°, 120°, 60°, 0°, 60°, 120°, 180° (left to right). A legend "Number of species" shows four shading categories: diagonal hatching = 0-20 species; light gray = 21-50 species; medium gray = 51-100 species; black = 101-136 species. The map shows the darkest shading (101-136 species, highest richness) concentrated in a band along the equator (0°) in South America (the Amazon basin) and a small patch in central Africa; medium-gray shading (51-100 species) in a broader band around the tropics in South America, Central America, sub-Saharan Africa, and parts of Southeast Asia/South Asia (e.g., India, Myanmar/Thailand region); lighter shading (21-50 species) in a band through central Africa

Question 2

and parts of South America; and diagonal-hatch shading (0-20 species, lowest richness) at higher latitudes including North America, Europe, northern Asia/Russia, and most of Australia.]

(b) There are many environmental threats facing amphibians today, such as deforestation. Describe one possible anthropogenic reason for deforestation.

Question 2

2021 Set 2 ▪ Q2

Biodiversity around the world is changing as a result of anthropogenic influences.

[World map titled "GLOBAL AMPHIBIAN SPECIES RICHNESS", drawn in an oval (Robinson-style) projection with latitude lines labeled 60°, 30°, 0°, 30°, 60° (top to bottom) and longitude lines labeled 180°, 120°, 60°, 0°, 60°, 120°, 180° (left to right). A legend "Number of species" shows four shading categories: diagonal hatching = 0-20 species; light gray = 21-50 species; medium gray = 51-100 species; black = 101-136 species. The map shows the darkest shading (101-136 species, highest richness) concentrated in a band along the equator (0°) in South America (the Amazon basin) and a small patch in central Africa; medium-gray shading (51-100 species) in a broader band around the tropics in South America, Central America, sub-Saharan Africa, and parts of Southeast Asia/South Asia (e.g., India, Myanmar/Thailand region); lighter shading (21-50 species) in a band through central Africa

Question 2

and parts of South America; and diagonal-hatch shading (0-20 species, lowest richness) at higher latitudes including North America, Europe, northern Asia/Russia, and most of Australia.]

(c)(i) Many factors influence biodiversity.

Explain how the species richness of an ecosystem influences its response to environmental stressors.

(c)(ii) Explain why amphibian biodiversity is declining globally, other than from deforestation.

Question 2

2021 Set 2 ▪ Q2

Biodiversity around the world is changing as a result of anthropogenic influences.
[World map titled "GLOBAL AMPHIBIAN SPECIES RICHNESS", drawn in an oval (Robinson-style) projection with latitude lines labeled 60°, 30°, 0°, 30°, 60° (top to bottom) and longitude lines labeled 180°, 120°, 60°, 0°, 60°, 120°, 180° (left to right). A legend "Number of species" shows four shading categories: diagonal hatching = 0-20 species; light gray = 21-50 species; medium gray = 51-100 species; black = 101-136 species. The map shows the darkest shading (101-136 species, highest richness) concentrated in a band along the equator (0°) in South America (the Amazon basin) and a small patch in central Africa; medium-gray shading (51-100 species) in a broader band around the tropics in South America, Central America, sub-Saharan Africa, and parts of Southeast Asia/South Asia (e.g., India, Myanmar/Thailand region); lighter shading (21-50 species) in a band through central Africa

Question 2

and parts of South America; and diagonal-hatch shading (0-20 species, lowest richness) at higher latitudes including North America, Europe, northern Asia/Russia, and most of Australia.]

(d)(i) Currently, wildlife species are going extinct at an alarming rate. To combat this threat, governments around the world have enacted legislation and signed treaties to protect species threatened by extinction.

Identify one specific piece of legislation that has been designed to protect species threatened by extinction.

(d)(ii) Explain how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction.

Question 2

2021 Set 2 ▪ Q2

Biodiversity around the world is changing as a result of anthropogenic influences. [World map titled "GLOBAL AMPHIBIAN SPECIES RICHNESS", drawn in an oval (Robinson-style) projection with latitude lines labeled 60°, 30°, 0°, 30°, 60° (top to bottom) and longitude lines labeled 180°, 120°, 60°, 0°, 60°, 120°, 180° (left to right). A legend "Number of species" shows four shading categories: diagonal hatching = 0-20 species; light gray = 21-50 species; medium gray = 51-100 species; black = 101-136 species. The map shows the darkest shading (101-136 species, highest richness) concentrated in a band along the equator (0°) in South America (the Amazon basin) and a small patch in central Africa; medium-gray shading (51-100 species) in a broader band around the tropics in South America, Central America, sub-Saharan Africa, and parts of Southeast Asia/South Asia (e.g., India, Myanmar/Thailand region); lighter shading (21-50 species) in a band through central Africa

Question 2

and parts of South America; and diagonal-hatch shading (0-20 species, lowest richness) at higher latitudes including North America, Europe, northern Asia/Russia, and most of Australia.]

(e)(i) A town is considering selling an undeveloped parcel of land along its border for residential developments. The square parcel of land consists of approximately 30% wetland and 70% pasture. The wetland runs through the middle of the property for its entire width and is home to three native frog species.

Propose a viable solution that will result in the protection of the native frog species while still allowing for maximum profit of the property development.

(e)(ii) Justify the solution proposed in (e)(i) by describing a potential advantage of the plan, other than frog protection.

Solution 2

(a)(i)

Mark scheme

- The greatest amphibian species richness occurs in the latitudinal range between the Tropic of Cancer and the Tropic of Capricorn (equivalently, roughly 30 degrees N to 30 degrees S, or more narrowly about 10 degrees N to 15 degrees S).

(a)(ii)

Mark scheme

- This latitudinal range most likely represents the tropical rainforest biome.

Solution 2

(a)(iii)

Mark scheme

- Amphibian species richness tends to be highest here because year-round rainfall and warm temperatures are the preferred conditions for amphibians, and greater biodiversity/higher net primary productivity (NPP) provides more habitat, food sources, and niches.

Solution 2

(b)

Mark scheme

- A possible anthropogenic reason for deforestation is human demand for agriculture, housing, firewood, or other forest products (e.g., medicine, food, lumber).

Solution 2

(c)(i)

Mark scheme

- An ecosystem with greater species richness/diversity is more resilient/resistant to environmental stressors, because even if some species are harmed, other species will survive and help restore/stabilize the ecosystem.

Solution 2

(c)(ii) Mark scheme

- Amphibian biodiversity is declining globally (aside from deforestation) for reasons such as: increasing water pollution (pharmaceutical pollution harming reproduction, pesticide pollution absorbed through the skin being toxic, endocrine disruptors such as atrazine altering reproductive development); pesticide use reducing insect food sources; microclimatic changes from global climate change (warmer/drier conditions, loss of wetlands) reducing available habitat; illegal amphibian trafficking removing individuals from populations; introduced invasive species competing for niche space; habitat fragmentation limiting range and access to resources; or fungal infections such as chytridiomycosis causing skin to dry out so amphibians cannot breathe. Any one such reason earns the point.

Solution 2

(d)(i)

Mark scheme

- One specific piece of legislation designed to protect species threatened by extinction: the Endangered Species Act (ESA), the Convention on International Trade in Endangered Species (CITES), or the Lacey Act.

Solution 2

(d)(ii) Mark scheme

- Explanation depends on the legislation named in (d)(i). ESA: lists endangered/threatened plant and animal species and prevents them from being killed or harmed; designates/protects critical habitat to promote survival and recovery; creates plans to restore populations to healthy sizes; identifies species as threatened before they become endangered. CITES: a global agreement that protects endangered/threatened plants and animals (including goods such as ivory, shark fins, or rhinoceros' horns) by banning/regulating their trade. Lacey Act: prohibits the trade of wildlife, fish, and plants that have been illegally taken, possessed, transported, or sold.

Solution 2

(e)(i)

Mark scheme

- A viable solution: move/transplant the frog populations to an adjacent undeveloped area before development; designate a portion of the wetland as a park/preserve; build wildlife corridors (land or bridges) across a portion of the wetland; restrict development within a minimum setback away from the wetland; or group/cluster the buildings together (build up, not out) to leave the wetland undisturbed.

Solution 2

(e)(ii) Mark scheme

- Justification depends on the solution proposed in (e)(i). Move/transplant frogs: only a one-time disruption during removal rather than continued disruption (e.g., population growth, fertilizer/pesticide use), and the developer gets the maximum amount of usable land. Park/preserve: more food and space availability increases wildlife survival rates; a nearby park/preserve is an educational/environmental draw that may let the developer charge higher rents; the wetland has aesthetic value for residents; and the preserved wetland helps prevent flooding. Wildlife corridors: other species are less affected by habitat fragmentation and can keep moving for food, shelter, and reproduction. Setback: creates a buffer zone that filters runoff into the wetland and adds resident privacy. Clustered/grouped

Solution 2

development: species are less affected by multiple habitat fragments because the apartments are developed in groups while wetlands are preserved.

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

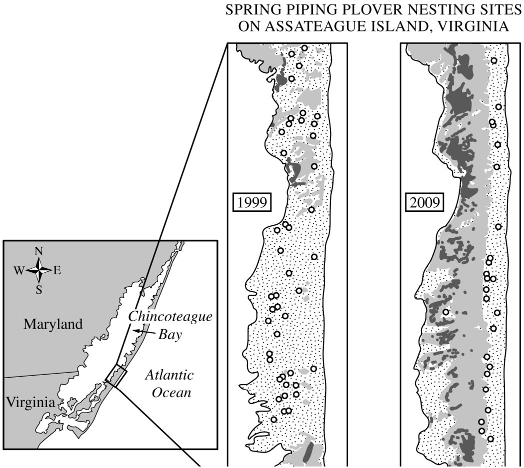
Question 1

[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.]

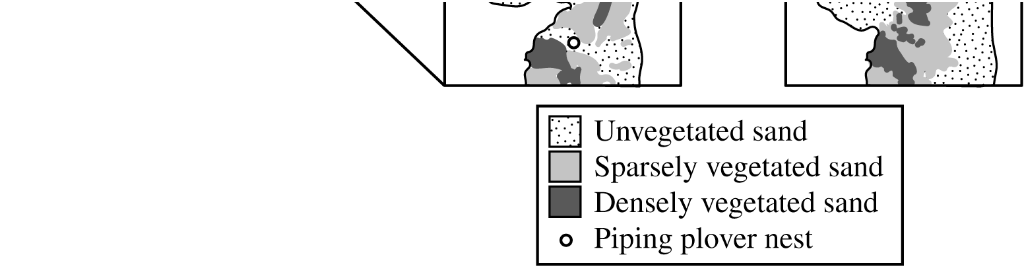
Question 1

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
N
W
E
S
Maryland
Chincoteague
Bay
Atlantic
Ocean
Virginia
1999
2009

Question 1



Unvegetated sand
Sparsely vegetated sand
Densely vegetated sand
Piping plover nest

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.

(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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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 4

2017 ▪ Q4

Dams are built by humans for various purposes including hydroelectric power generation and control of downstream flooding.

(a) Explain how electricity is generated at a hydroelectric dam.

(b) Identify TWO economic benefits, other than hydroelectric power generation and control of downstream flooding, associated with dams.

(c) Describe one ecological benefit of seasonal flooding of the floodplain of a free-flowing river.

(d)(i) Some dams have been removed from rivers.
Explain how removal of a dam can benefit fish populations.

(d)(ii) Describe one negative environmental consequence of removing a dam from a river (other than effects on fish populations).

Question 4

(e)(i) Dams are also built by beavers, a keystone species in some North American ecosystems.
Define keystone species.
(e)(ii) Describe how dams built by beavers can make beavers a keystone species in some ecosystems.

Question 1

2016 ▪ Q1

Read the following article from the *Fremont New Tribune*.

Fremont New Tribune — May 2, 2016

As another winter concludes, biologists are alarmed by the continued spread of white nose syndrome (WNS) in bats. WNS is a fungal disease that is decimating bat populations across eastern North American forests, with mortality rates reaching up to 100 percent at many sites. WNS has been found in at least 25 states in the United States and 5 Canadian provinces.

The fungus (*Pseudogymnoascus destructans*) grows well in cool conditions such as those found in caves and has been observed as white patches on the muzzles, noses, ears, and wings of many cave-dwelling bats. WNS has caused significant population declines for several bat species, including once-numerous species such as the little brown bat (*Myotis lucifugus*).

Question 1

Little brown bats hunt using echolocation by emitting up to 200 high-frequency calls per second when pursuing their prey. When healthy, the little brown bat can live up to ten years and have one or two offspring (called pups) each year.

"Little brown bats provide tremendous value to the United States economy every year by the essential services they provide to farmers and other people. We need to understand how this deadly disease spreads and attempt to help reduce its impact on the little brown bat and other bat species," said Dr. Duke Serach of the Fremont office of the United States Fish and Wildlife Service. Dr. Serach concluded with, "It may yet be possible to save the little brown bats, but the remaining population will be alarmingly small."

(a) Diseases can devastate populations; however, most diseases do not drive their host to extinction. **Provide** one explanation for why diseases seldom cause extinction.

Question 1

Fremont New Tribune **May 2, 2016**

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(b)(i) Dr. Serach suggests that even if the impact of WNS on little brown bat populations can be reduced and the extinction of the species avoided, the bat populations are likely to remain alarmingly small.

Describe TWO threats (other than WNS) to the survival of the bat species if the total number of bats becomes very small.

Question 1

(b)(ii) If the little brown bat species does not become extinct and can potentially recover, the rate of recovery is likely to be slow. **Discuss** one aspect of bat biology that might slow the recovery of little brown bat populations to pre-WNS numbers.

Question 1

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(c) Bats are found in ecosystems around the world. **Describe** TWO ways in which other organisms in an ecosystem could be affected by a decline in a bat population.

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(d) The Eastern deciduous forest in which the little brown bats live is an important ecosystem. **Identify** TWO ecosystem services that forests provide, and **explain** how each service benefits human society.

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(e) WNS is an emerging disease in bats. Humans are also subject to emerging diseases, such as Ebola. A recent study suggests that the number of emerging infectious diseases affecting human populations has been steadily increasing in recent decades. **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.

Solution 1

(a)

Mark scheme

- 1 point for any one valid explanation of why diseases seldom cause extinction: genetic diversity in wild populations lets some resistant individuals survive and reproduce; disease organisms often co-evolve with their hosts, allowing hosts to evolve resistance; pathogens/disease organisms that drive their host population to extinction jeopardize their own survival; initial deaths thin (reduce the density of) the population, making it less likely the disease will continue to spread.

Solution 1

(b)(i) Mark scheme

- 2 points: 1 point for each of TWO described threats (other than WNS) to a very small bat population — only the first two distinct threats given earn credit. Acceptable: difficulty finding mates when the population is small/widely dispersed or has a skewed sex ratio; competition from other species with a similar niche (e.g., nesting sites, food); problems from reduced genetic diversity (small gene pool, lack of hybrid vigor, a disease affecting all members, bottleneck effect); susceptibility to reduced fitness from decreased group protection (not enough individuals to create heat, less protection from predators, increased predation risk without safety-in-numbers); increased vulnerability to environmental disturbances (must name a specific disturbance).

Solution 1

(b)(ii)

Mark scheme

- 1 point for a correct discussion of one aspect of bat biology that would slow recovery to pre-WNS numbers: low fecundity/few babies per year; long generation times; advanced age at first reproduction; or increased parental care requirements.

Solution 1

(c) Mark scheme

- 2 points: 1 point for each of TWO described ways other ecosystem organisms could be affected by a bat population decline — only the first two given earn credit. Acceptable: increase in bat food sources (e.g., insect pest populations rise); increase in West Nile virus and other insect-borne diseases; decrease in the spread of rabies; decrease in the fungus that causes WNS; decrease in bat guano (affecting guano-dependent organisms); decline in plants that bats pollinate or disperse seeds for; decline in bat predators due to decreased food supply; increase in numbers of animals with similar food/habitat needs; a resulting trophic cascade.

Solution 1

(d) Mark scheme

- 2 points: 1 point for each of TWO correctly paired ecosystem services with their human benefit. Acceptable pairs — resource material (tree/forest): lumber, building materials, fuel, paper, food; oxygen production: human respiration; soil formation/protection: forestry, agriculture, flood control, water quality; protection of water supplies: drinking water, recreation, irrigation, fishing; habitat (specify, e.g., shade/temperature moderation): animals/plants humans use for fishing, hunting, food; biodiversity: food, medicine, gene diversity, breeding stock; carbon sink/sequestering: slows climate change; aesthetic/cultural/social value: inspiration for art/music/poetry, research, education, recreation, tourism.

Solution 1

(e) Mark scheme

- 2 points: 1 point for a valid reason for the increase in emerging infectious diseases, plus 1 point for a correctly linked explanation of how that reason increases disease emergence. Acceptable pairs — climate change/global warming: allows pathogens and disease vectors to survive in places previously too cold or dry; increase in global travel: increased likelihood of contracting/spreading disease; increased exposure to animals (zoonotic): changes in agricultural practices increase rodent exposure, trade in exotic species, intrusion into wild habitats, urban sprawl; increase in population density/distribution: increased likelihood of contracting/spreading disease from others; lack of vaccinations: increases human susceptibility, reduces herd immunity; antibiotic resistance: new

Solution 1

disease strains evolve; decrease in medical care/public health: poverty, war, migration, human behavior (refusing condoms, sharing needles, refusing aid).