Past-paper walk-through

Methods to Reduce Urban Runoff ▪ 5.13

eXercise

Questions in this set

- 2025 Set 1 Q2
- 2024 Set 2 Q1
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- 2021 Set 2 Q1
- 2018 Q1
- 2015 Q1
- 2014 Q2

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 2

2025 Set 1 ▪ Q2

There is a natural climate phenomenon that occurs in the equatorial Pacific Ocean because of periodic fluctuations in sea surface conditions and atmospheric circulation. This phenomenon happens every few years, resulting in shifts in temperature and precipitation in many parts of the world.

Figure 1 shows temperature and precipitation patterns associated with one phase of this phenomenon in the equatorial Pacific Ocean. Figure 2 shows the associated temperature and precipitation patterns that occur over North America.

Figure 1. Effects of Changes in Sea Surface Conditions in Equatorial Pacific Ocean

[Map of the equatorial Pacific Ocean region spanning from Africa/the Indian Ocean on the left to Australia and the western coast of South America on the right, with dashed horizontal reference lines at "30° North" and "Equator 0°". A large hatched region (diagonal lines, labeled in the legend as "Ocean water cooler than average") covers the

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western/central Pacific Ocean around and south of Australia and Indonesia. A large solid-shaded region (labeled “Ocean water warmer than average”) lies to the west of the hatched region, overlapping the Indian Ocean/Indonesia area. A solid black patch (labeled “Increased chance of precipitation”) sits over Australia. A bold horizontal arrow points from right (near South America) to left (toward Indonesia/Australia) along the Equator, labeled “Stronger than normal trade winds”. A compass rose (N/S/E/W) is shown in the lower right. Legend: ⊠ (diagonal hatch) = Ocean water cooler than average; ⊟ (grey fill) = Ocean water warmer than average; ■ (black fill) = Increased chance of precipitation; ← (bold arrow) = Stronger than normal trade winds.]

Figure 2. Polar Jet Stream and Climate Conditions in North America

[Map of North America showing a thick curved arrow labeled “Polar Jet Stream” that dips from the northwest, curves down over the western/central United States, and rises

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(a) Identify the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.

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(b) Based on the information in Figure 1, identify the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.

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(c) Based on the information in Figure 2, describe a difference in climate patterns between the regions A and B.

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(d) Increases in regional precipitation can lead to increased flooding in certain locations. Describe one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.

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2025 Set 1 ▪ Q2

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(e) Propose a realistic solution a city could implement to decrease the risk of flooding in urban areas.

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2025 Set 1 ▪ Q2

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(f) Justify the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.

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(g) Terrestrial biomes are primarily determined by temperature and precipitation patterns. Describe one difference between the climate of a temperate seasonal forest and that of a savanna.

Question 2

2025 Set 1 ▪ Q2

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(h) Droughts are one environmental problem that can affect the frequency and severity of forest fires. Identify the ecological process that occurs following a forest fire that leaves the soil intact.

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(i) Describe one way burning forests contribute to atmospheric pollution.

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(j) Describe one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

Solution 2

(a)

Mark scheme

- The sea surface condition in the eastern equatorial Pacific shown in Figure 1: ocean water is cooler than average.

Solution 2

(b)

Mark scheme

- The climate phenomenon associated with these cooler-than-average equatorial Pacific sea surface conditions is La Niña.

Solution 2

(c)

Mark scheme

- Difference in climate patterns between regions A and B (Figure 2): Region A has an increased chance of precipitation while Region B has a decreased chance of precipitation — i.e., Region A will be wetter while Region B will be drier.

Solution 2

(d)

Mark scheme

- One reason for increased flood risk in urban areas during extended precipitation: impervious/paved surfaces (parking lots, roads, buildings, sidewalks) increase runoff and reduce infiltration/absorption; urban areas also have less vegetation, further reducing infiltration/absorption.

Solution 2

(e)

Mark scheme

- A realistic city solution to decrease urban flood risk: use permeable pavement; or plant vegetation/establish parks/create rain gardens/build green roofs; or install retention ponds/stormwater basins.

Solution 2

(f) Mark scheme

- Justify the part-E solution with an advantage beyond flood reduction, matched to the chosen solution. Permeable pavement: increased recharge of nearby aquifers/groundwater; decreased pollution in runoff. Vegetation/parks/rain gardens/green roofs: absorbs pollutants; stores carbon dioxide/produces oxygen; decreases erosion; increases/restores wildlife habitat and biodiversity; reduces the urban heat island effect; improves aesthetic enjoyment/quality of life; creates landscaping/park-maintenance jobs. Retention ponds/stormwater basins: decreased pollution in runoff; increased habitat/biodiversity.

Solution 2

(g)

Mark scheme

- One climate difference between a temperate seasonal forest and a savanna: temperate seasonal forests have a cooler climate with a stronger/colder winter and four distinct seasons, and receive more annual precipitation (spread throughout the year), whereas savannas are warmer with a distinct rainy season and dry season and do not have four distinct seasons.

Solution 2

(h)

Mark scheme

- The ecological process that occurs following a forest fire that leaves the soil intact is secondary succession.

Solution 2

(i)

Mark scheme

- One way burning forests contributes to atmospheric pollution: burning trees releases CO2, CO, NOx, particulate matter, and/or VOCs into the atmosphere.

Solution 2

(j)

Mark scheme

- One sustainable forestry practice to reduce the occurrence/severity of forest fires: prescribed burns (remove excess fuel/dead leaves/underbrush); brush removal (removes excess fuel); selective cutting (creates a fire break); agroforestry, where ground crops that might otherwise become fuel are harvested/removed.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing "Bedrock" (dotted pattern) and "Soil" (solid gray). A horizontal arrow below labeled "Time" points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

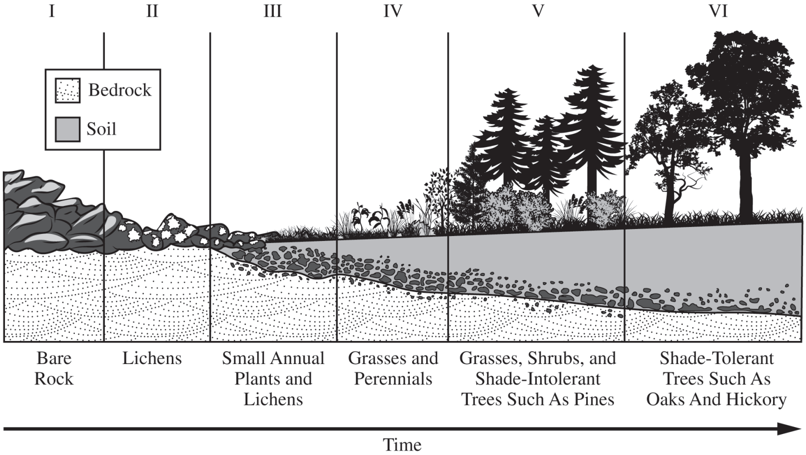
- Stage I: Bare Rock

Question 1

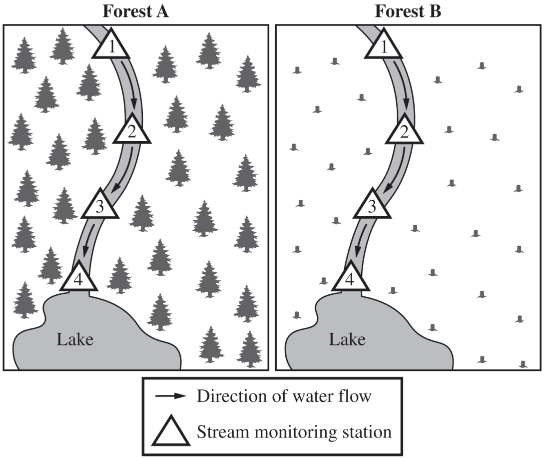
- Stage II: Lichens
- Stage III: Small Annual Plants and Lichens
- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(a) Identify the ecological change over time illustrated in the diagram.

Question 1


I
II
III
IV
V
VI
Bedrock
Soil
Bare Rock
Lichens
Small Annual Plants and Lichens
Grasses and Perennials
Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
Shade-Tolerant Trees Such As Oaks And Hickory
Time

Question 1



Forest A
Forest B
1
2
3
4
Lake
1
2
3
4
Lake
Direction of water flow
Stream monitoring station

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing "Bedrock" (dotted pattern) and "Soil" (solid gray). A horizontal arrow below labeled "Time" points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

- Stage I: Bare Rock
- Stage II: Lichens
- Stage III: Small Annual Plants and Lichens

Question 1

- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(b) Identify the stage in which pioneer species first appear.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

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(c) Describe how soil forms from stage II to stage III.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing "Bedrock" (dotted pattern) and "Soil" (solid gray). A horizontal arrow below labeled "Time" points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

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- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(d) Identify a cultural ecosystem service that may be provided by a mature forest.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing "Bedrock" (dotted pattern) and "Soil" (solid gray). A horizontal arrow below labeled "Time" points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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(e) Researchers are interested in investigating the effect of the removal of trees on the water quality of nearby waterways. To conduct their experiment, the researchers locate two identical forest watersheds, both with a river running through them. Forest A is an intact forest and forest B is a clear-cut forest. Four stream monitoring stations are set up in each forest study area. Each station monitors a variety of water quality indicators, including water temperature, at various locations along the river. The experimental setup is shown in the following diagrams. The arrows shown in the rivers represent the direction of water flow. The triangles in the river show the location of the stream monitoring stations.

Question 1

[Diagram: Two side-by-side maps labeled "Forest A" and "Forest B", each showing a river flowing from the top of the map down to a "Lake" at the bottom, with 4 numbered triangular stream monitoring stations (labeled 1 at the top near where the river enters, 2, 3, and 4 near the lake) placed along the river's path. Arrows along the river indicate the direction of water flow, flowing downward toward the lake. Forest A is densely covered with many tree symbols (an intact forest). Forest B has only a few scattered tree symbols, showing that most trees have been cleared (a clear-cut forest). A legend below both maps indicates: an arrow icon = "Direction of water flow"; a triangle icon = "Stream monitoring station".]
Identify a testable hypothesis being investigated by the researchers.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

- Stage IV: Grasses and Perennials
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- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(f) Identify the independent variable in the experiment.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

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- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(g) Describe the purpose of forest A in the experiment.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(h) Explain why the water temperature might change because of clear-cutting trees in forest B.

Question 1

2024 Set 2 ▪ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.
[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing "Bedrock" (dotted pattern) and "Soil" (solid gray). A horizontal arrow below labeled "Time" points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(i) After the experiment was completed, land developers constructed a golf course in the clear-cut area of forest B. To prepare the land, developers removed any remaining stumps and newly grown trees and began planting and fertilizing new grass. The researchers are interested in the effect the golf course may have on the water quality of the river. To monitor the river in forest B, the researchers repeated the experiment once the golf course had been constructed.
Explain why an indicator of water quality other than temperature could be altered by the golf course in forest B.

Question 1

2024 Set 2 ▪ Q1

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[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

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Question 1

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(j) Explain how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course.

Solution 1

(a)

Mark scheme

- The diagram shows primary succession – the stepwise development of an ecosystem starting on bare rock/parent material with no pre-existing soil, progressing through stages to a mature community. Full credit for identifying 'primary succession.'

Solution 1

(b)

Mark scheme

- Pioneer species first appear in Stage II (labeled '2' in the diagram) – the stage where organisms like lichens, algae, or fungi first colonize the bare rock. Full credit for identifying stage II/2.

Solution 1

(c)

Mark scheme

- Soil forms from stage II to stage III through weathering and biological activity. Accept any one of: (1) wind/rain/weather erodes the rock/parent material; (2) wind/rain breaks rocks down into smaller particles; (3) pioneer species (lichens/algae/fungi) die off, adding small amounts of organic material to the forming soil; (4) pioneer species (lichens/algae/fungi) help break down the rock. Full credit for any one mechanism.

Solution 1

(d)

Mark scheme

- A cultural ecosystem service from a mature forest: any one of recreation, aesthetic enjoyment, spiritual use, ecotourism, or education. Full credit for naming one such non-material benefit.

Solution 1

(e)

Mark scheme

- A testable hypothesis for the experiment, e.g.: removal of trees/clear-cutting will lead to an increase/decrease in a water-quality indicator (temperature, turbidity, or dissolved oxygen) compared with the intact forest, OR the null form – clear-cutting will have no effect on water quality; equivalently, water quality will/will not change between stations. Full credit for any hypothesis stating a predicted increase/decrease/no-change relationship between clear-cutting (or station location) and a water-quality indicator.

Solution 1

(f)

Mark scheme

- Independent variable: presence or absence of clear-cutting (intact forest A vs. clear-cut forest B), equivalently the intact-or-clearcut status of the forest or the location of the stream monitoring stations. Full credit for identifying this manipulated/comparison variable.

Solution 1

(g)

Mark scheme

- Forest A (the intact forest) serves as the control – it lets researchers compare water quality (temperature/turbidity) in the clear-cut area (forest B) against an intact, unaltered baseline. Full credit for describing forest A's role as the control/comparison for forest B.

Solution 1

(h)

Mark scheme

- Water temperature in forest B is likely to increase after clear-cutting. Accept any one mechanism: (1) fewer/no trees to block sunlight from reaching the water, so it warms more; (2) additional sediment from erosion affects the water; (3) more direct sunlight reaches the water surface without the tree canopy. Full credit for any one causal explanation linking tree removal to warmer water.

Solution 1

(i)

Mark scheme

- A water-quality indicator besides temperature (e.g. dissolved oxygen, turbidity, or nutrients) could be altered by the golf course. Accept any one: (1) dissolved oxygen could decrease because fertilizer runoff causes algal blooms/eutrophication; (2) sedimentation/turbidity could decrease because grass reduces erosion compared with bare clear-cut land; (3) nitrates/phosphates could increase due to fertilizer runoff, driving algal growth/bloom. Full credit for any one linked mechanism.

Solution 1

(j)

Mark scheme

- Effect on aquatic organisms in the forest B lake from the new golf course. Accept any one: (1) organisms die off from lack of oxygen caused by decomposition of algae/eutrophication (from fertilizer runoff); (2) organisms survive at a higher rate because less sediment clogs their gills (grass reduces erosion versus clear-cut land); (3) organisms die off due to increased toxicity from pesticide runoff. Full credit for any one plausible, correctly reasoned effect.

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:

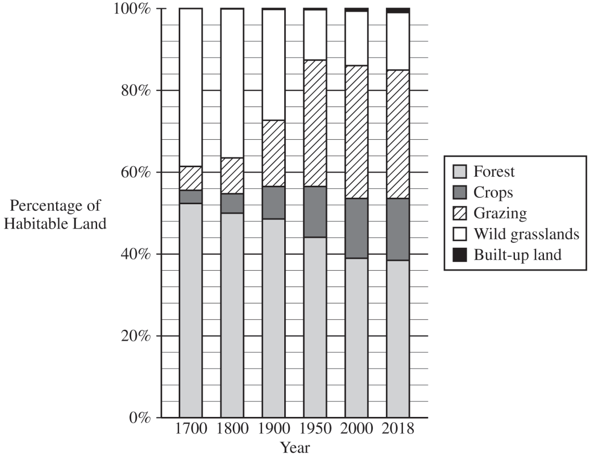
- 1700: Forest $\approx$ 53%, Crops $\approx$ 2%, Grazing $\approx$ 6%, Wild grasslands $\approx$ 38% (top reaches 100%), Built-up land negligible.
- 1800: Forest $\approx$ 51%, Crops $\approx$ 4%, Grazing $\approx$ 9%, Wild grasslands $\approx$ 36%, Built-up land negligible.

Question 2

- 1900: Forest $\approx$ 49%, Crops $\approx$ 8%, Grazing $\approx$ 16%, Wild grasslands $\approx$ 27%, Built-up land negligible.
- 1950: Forest $\approx$ 45%, Crops $\approx$ 12%, Grazing $\approx$ 31%, Wild grasslands $\approx$ 12%, Built-up land $\approx$ small sliver.
- 2000: Forest $\approx$ 39%, Crops $\approx$ 15%, Grazing $\approx$ 32%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.
- 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

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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(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

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Question 2

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(c) Identify an environmental problem associated with overgrazing by livestock.

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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(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

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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(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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- 2018: Forest $\approx$ 38%, Crops $\approx$ 15%, Grazing $\approx$ 33%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.]

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

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:

- 1700: Forest $\approx$ 53%, Crops $\approx$ 2%, Grazing $\approx$ 6%, Wild grasslands $\approx$ 38% (top reaches 100%), Built-up land negligible.
- 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.
- 1950: Forest $\approx$ 45%, Crops $\approx$ 12%, Grazing $\approx$ 31%, Wild grasslands $\approx$ 12%, Built-up land $\approx$ small sliver.
- 2000: Forest $\approx$ 39%, Crops $\approx$ 15%, Grazing $\approx$ 32%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.
- 2018: Forest $\approx$ 38%, Crops $\approx$ 15%, Grazing $\approx$ 33%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.]

(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

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:

- 1700: Forest $\approx$ 53%, Crops $\approx$ 2%, Grazing $\approx$ 6%, Wild grasslands $\approx$ 38% (top reaches 100%), Built-up land negligible.
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Question 2

- 1900: Forest $\approx$ 49%, Crops $\approx$ 8%, Grazing $\approx$ 16%, Wild grasslands $\approx$ 27%, Built-up land negligible.
- 1950: Forest $\approx$ 45%, Crops $\approx$ 12%, Grazing $\approx$ 31%, Wild grasslands $\approx$ 12%, Built-up land $\approx$ small sliver.
- 2000: Forest $\approx$ 39%, Crops $\approx$ 15%, Grazing $\approx$ 32%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.
- 2018: Forest $\approx$ 38%, Crops $\approx$ 15%, Grazing $\approx$ 33%, Wild grasslands $\approx$ 13%, Built-up land $\approx$ small sliver.]

(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 2

2023 Set 1 ▪ Q2

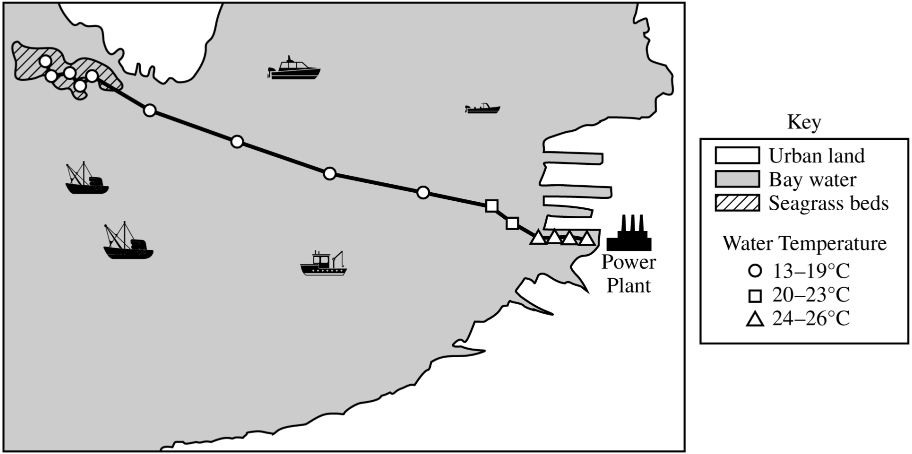
The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze. Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below $20°\text{C}$ for extended periods of time.
Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period
[Map diagram of a bay/river channel showing a coastline with urban land at upper left near a cluster of small circles (13-19°C markers) close to shore, and hatched "Seagrass beds" also near that shore. A black line with a series of point markers runs from the seagrass-bed/urban-land area near the top-left, diagonally down and to the right across open bay water, passing several boats (fishing boats and small craft scattered across

Question 2

the bay), and ending at the lower right near a "Power Plant" (with smokestack icon) on the opposite shore. The markers along this track are open circles (13-19°C) for most of the track's length across the open bay, changing to open squares (20-23°C) near the shore closer to the power plant, and open triangles (24-26°C) immediately adjacent to the power plant outflow. Key: Urban land = open/white box; Bay water = gray shaded box; Seagrass beds = diagonal-hatched box. Water Temperature legend: circle = 13-19°C, square = 20-23°C, triangle = 24-26°C.]

(a) Based on the information in the diagram, identify the temperature range of the water through which the majority of the adult manatee's daily movement occurs.

Question 2


Power
Plant
Key
Urban land
Bay water
Seagrass beds
Water Temperature
13–19°C
20–23°C
24–26°C

Question 2

2023 Set 1 ▪ Q2

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Question 2

near a "Power Plant" (with smokestack icon) on the opposite shore. The markers along this track are open circles (13-19°C) for most of the track's length across the open bay, changing to open squares (20-23°C) near the shore closer to the power plant, and open triangles (24-26°C) immediately adjacent to the power plant outflow. Key: Urban land = open/white box; Bay water = gray shaded box; Seagrass beds = diagonal-hatched box. Water Temperature legend: circle = 13-19°C, square = 20-23°C, triangle = 24-26°C.]

(b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, identify a characteristic of the power plant waste water that would attract the manatees.

Question 2

2023 Set 1 ▪ Q2

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(c) Based on the information in the diagram, describe a potential negative impact of the waste water released by the power plant on other aquatic species.

Question 2

2023 Set 1 ▪ Q2

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(d) Seagrass beds have declined significantly over the last several years. In 2021 manatee mortality was three times higher than the previous five-year average.

(d)(i) Describe a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.

(d)(ii) Describe the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

Question 2

2023 Set 1 ▪ Q2

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(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

(e)(i) Propose a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development.

(e)(ii) Justify the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

Question 2

2023 Set 1 ▪ Q2

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(f) Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

Describe how summertime weather conditions can increase the frequency of photochemical smog.

Question 2

2023 Set 1 ▪ Q2

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(g) Identify one ecological problem that results from exposure to photochemical smog.

Question 2

2023 Set 1 ▪ Q2

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(h) A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

Describe a potential disadvantage of using hydrogen fuel cells to power automobiles.

Solution 2

(a)

Mark scheme

- 13-19 degrees C, based on the temperature range through which the majority of adult manatee daily movement occurs in the diagram.

Solution 2

(b)

Mark scheme

- The waste water is warm (approximately 24-26 degrees C), which is why manatees are attracted to it in winter.

Solution 2

(c)

Mark scheme

- Any one of: warming of the water near the outfall reduces the dissolved oxygen available for aquatic organisms to use/breathe; the warming could impact the survival/health of species with a range of tolerance for the original (lower) water temperature; or the warming could alter/affect the timing of reproductive cycles for aquatic species.

Solution 2

(d)

Mark scheme

- This line is introductory/context text (seagrass decline and the 2021 manatee mortality spike) setting up parts (d)(i) and (d)(ii) below; it carries no points of its own – see 2di and 2dii.

Solution 2

(d)(i)

Mark scheme

- Any one of: manatees are herbivores/eat seagrass, so they would have less food and could starve; they require a lot of energy to survive, so a reduced food supply threatens them; they inhabit warm water, so they would need to travel farther to colder waters to find remaining seagrass/food; or they have a low reproductive/maturation rate, so they would take longer to recover from the loss of their food source.

Solution 2

(d)(ii)

Mark scheme

- Less energy flows to/is available for organisms at higher trophic levels, because less energy from the Sun is captured/stored by producers (seagrass) once seagrass is significantly lost.

Solution 2

(e)

Mark scheme

- This line is introductory/context text (nutrient and sediment runoff causing seagrass decline) setting up parts (e)(i) and (e)(ii) below; it carries no points of its own – see 2ei and 2eii.

Solution 2

(e)(i)

Mark scheme

- Any one solution: replace existing pavement with permeable pavement; add vegetation (e.g., a riparian buffer) where it will intercept runoff; reduce fertilizer use in the area; install barriers/construct fences where they will intercept runoff; or improve wastewater treatment plants in the area.

Solution 2

(e)(ii)

Mark scheme

- Any one additional advantage (not related to manatees): reduces eutrophication; increases biodiversity/species richness; improves water clarity; increases ecotourism; reduces the cost of water treatment; or increases profits for commercial fishermen.

Solution 2

(f)

Mark scheme

- Any one of: sunlight is more intense/there is more sunlight in summer, so more primary pollutants (nitrogen oxides/NOx) react in sunlight; summertime temperatures are warmer than other seasons, and chemical reactions occur more quickly at warmer temperatures; or trees release more VOCs in summer, leading to more reactions that form photochemical smog.

Solution 2

(g)

Mark scheme

- Any one ecological problem: causes respiratory problems/eye irritation in animals; reduces photosynthesis; slows/inhibits/stunts plant growth; or increases the susceptibility of plants to pests and disease.

Solution 2

(h)

Mark scheme

- Any one disadvantage: high cost to manufacture hydrogen-fuel-cell automobiles; obtaining hydrogen requires a lot of energy and may consume more energy than the hydrogen fuel can produce; hydrogen is explosive/flammable (may catch fire); there is a lack of infrastructure (such as fueling stations) for hydrogen fuel; or hydrogen must be obtained by separating it from natural gas or water (often using fossil fuels).

Question 1

2023 Set 2 ▪ Q1

Two restoration methods designed to reclaim the overburden piles removed from open pit coal mines in temperate forests of eastern Europe were studied over several years. The first method was spontaneous restoration, where the soil and rock were dumped in noncompacted, random piles and not replanted with vegetation. The second method was technical restoration, where the land was leveled by heavy machinery, organic material was added, and eight plant species were added. Technical restoration started 5 years after the piles were formed, so no bar is included in the 1-5 year range in the graph.

Number of Plant Species in Spontaneous and Technically Restored Overburden Piles over Time

Question 1

[Bar graph titled "Number of Plant Species in Spontaneous and Technically Restored Overburden Piles over Time". Y-axis: "Average Number of Plant Species", from 0 to 20, gridlines at 0, 10, 20. X-axis: "Age (years) of Overburden Piles", with six categories: 1-5, 6-10, 11-15, 16-25, 26-35, $>$35. Two bars per category (legend: light gray = Spontaneous restoration piles, dark/black = Technical restoration piles). Approximate bar heights: 1-5: Spontaneous ~6.5, Technical (none, no bar); 6-10: Spontaneous ~12, Technical ~9.5; 11-15: Spontaneous ~13, Technical ~11.5; 16-25: Spontaneous ~13, Technical ~8.5; 26-35: Spontaneous ~14, Technical ~8; $>$35: Spontaneous ~17.5, Technical ~8.]

Scientists hypothesized that after 35 years, the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.

Question 1

Limiting runoff on disturbed land improves soil and water quality. To model water runoff, students set up three large plastic trays and filled each tray with loam soil to 1 centimeter below the edge. Loam soil is a balance of sand, silt, and clay soil. One tray was seeded with wheatgrass and grown for 30 days, one tray was covered with small wood chips, and one tray was soil only. Five hundred milliliters of water was sprinkled evenly onto the soil surface of each tray. All three trays were placed on a slight slope, and water that ran off the surface was collected. The results are shown in the following table.

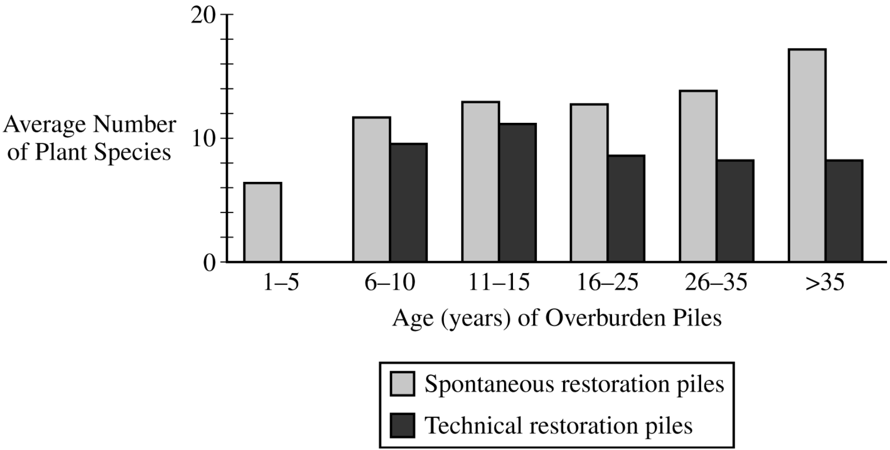
Tray	**Water Collected (mL)**	**Water Appearance**
Wheatgrass grown in soil; no small wood chips	190	Clear
Small wood chips covered soil; no wheatgrass	300	Transparent; light brown
Soil only; no wheatgrass or small wood chips	360	Cloudy; dark brown

Question 1

Runoff from mining waste can also affect water quality.

(a) Based on the data in the graph, **identify** the average number of species found in technically restored piles 16-25 years after restoration started.

Question 1


20
10
0
Average Number of Plant Species
1–5
6–10
11–15
16–25
26–35
>35
Age (years) of Overburden Piles
Spontaneous restoration piles
Technical restoration piles

Question 1

2023 Set 2 ▪ Q1

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