Past-paper walk-through

Ecological Succession ▪ 2.7

eXercise

Questions in this set

- 2025 Set 1 Q2
- 2024 Set 2 Q1
- 2023 Set 1 Q1
- 2023 Set 2 Q1
- 2019 Q1
- 2014 Q3

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

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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; $\leftarrow$ (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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back up toward the northeast (Atlantic Canada), with an arrowhead at the northeast end. A region labeled "A" (dashed-outline circle, dotted fill pattern) is located over the northwestern/western Canada-US border area. A dotted-fill band (same pattern as region A, labeled in the legend as "Increased chance of precipitation") stretches along the path under the jet stream curve across the northern/central US. A region labeled "B" (dashed-outline box, solid grey fill) sits over the south-central/southeastern United States, within a larger grey-shaded band (labeled "Decreased chance of precipitation"). A diagonally hatched region (labeled "Warmer than average") covers the southeastern United States. A compass rose (N/S/E/W) is shown in the lower left. Legend: □ (dotted outline/fill) = Increased chance of precipitation; ⊟ (solid grey fill) = Decreased chance of precipitation; □ (dotted fill, different pattern) = Cooler than average; ⊠ (diagonal hatch) = Warmer than average.]

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

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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:

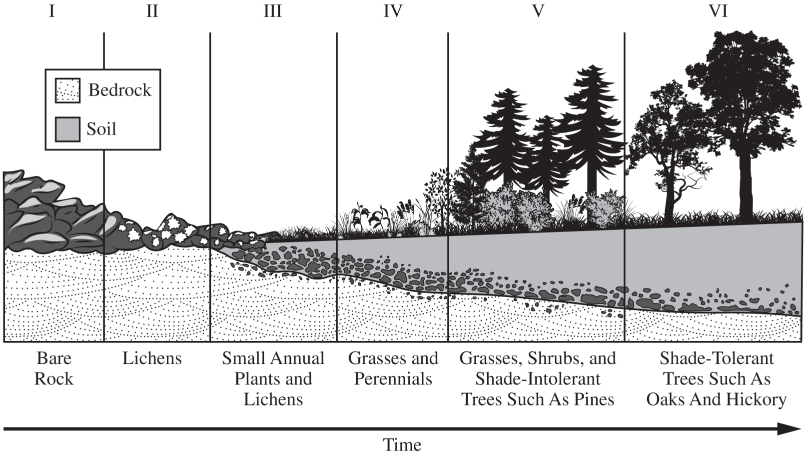
- Stage I: Bare Rock

Question 1

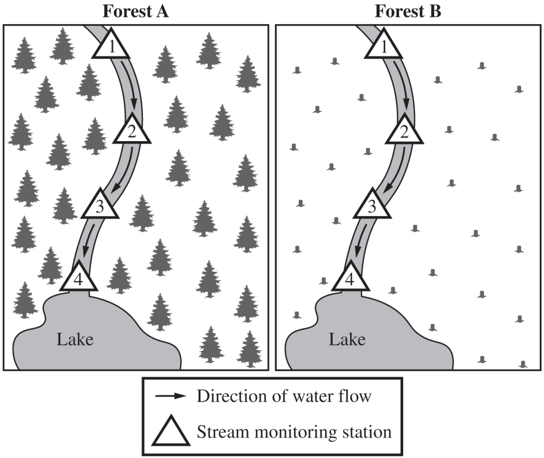
- Stage II: Lichens
- Stage III: Small Annual Plants and Lichens
- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

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

(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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Question 1

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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

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(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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(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

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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

- 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 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

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.

(b) Identify the scientific question for the investigation.

Question 1

2023 Set 1 ▪ Q1

Question 1

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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

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(f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the

Question 1

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

Question 1

2023 Set 1 ▪ Q1

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(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

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(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

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(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

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(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 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.

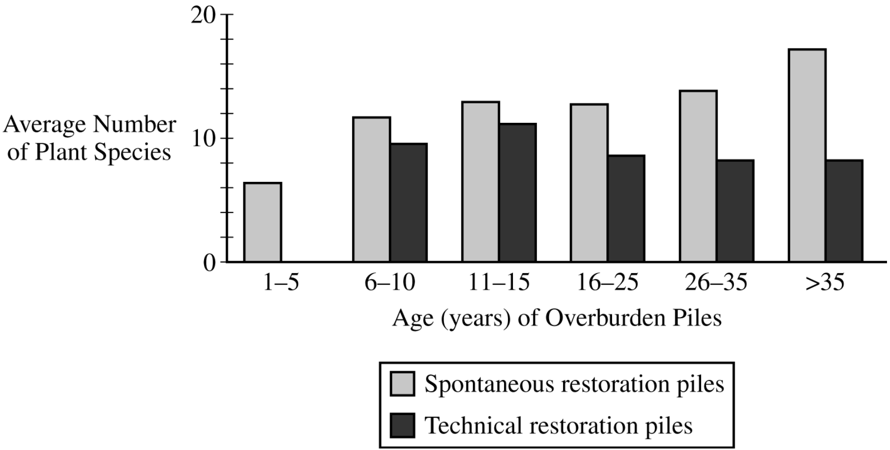
Tray	**Water Collected (mL)**	**Water Appearance**
Wheatgrass grown in soil; no small wood chips	190	Clear
Small wood chips covered soil; no wheatgrass	300	Transparent; light brown
Soil only; no wheatgrass or small wood chips	360	Cloudy; dark brown

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

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

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[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.

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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