Past-paper walk-through

Invasive Species ▪ 9.8

eXercise

Questions in this set

- 2025 Set 1 Q1
- 2025 Set 2 Q2
- 2024 Set 2 Q3
- 2023 Set 1 Q1
- 2023 Set 2 Q2
- 2022 Set 2 Q2
- 2018 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.

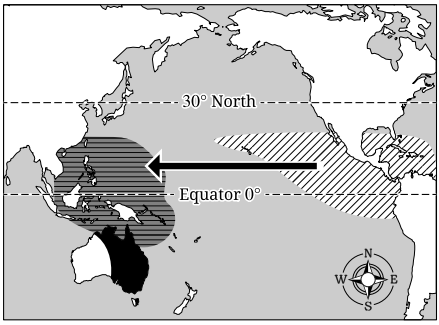
Question 1

2025 Set 1 ▪ Q1

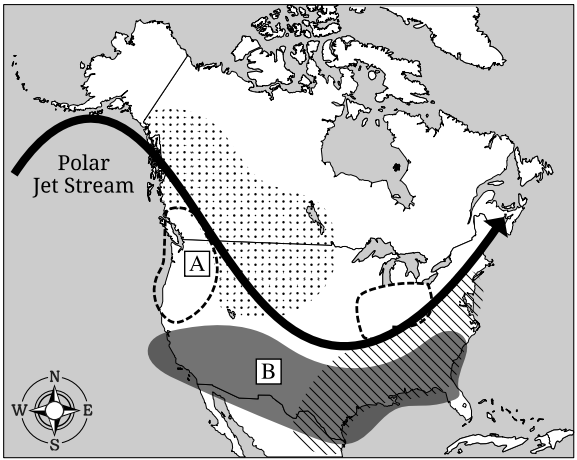
Respond to parts A, B, C, D, E, F, G, and H, and all subparts.

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

Question 1


30° North
Equator 0°
N
W
E
S
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 2

2025 Set 2 ▪ Q2

Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

Figure 1. Tectonic Plate Movement near East Coast of Africa

[Map figure showing tectonic plates near the east coast of Africa. Labels: "Arabian Plate" (north-central), "African Plate" (west), "Indian Plate" (east), "Lake Victoria" (small lake, west, with an arrow pointing away from it/west), "Western Rift Valley" and "Eastern Rift Valley" (two branching rift lines running north-south through the African Plate), "Serengeti National Park" (marked at the point where the Western and Eastern Rift Valleys meet), "Indian Ocean" (to the east). Bold arrows show direction of plate movement: one arrow points west/away from Lake Victoria area, one arrow points southeast from the rift valley junction, and a double-headed arrow (pointing

Question 2

both directions, apart) is shown at the boundary between the Arabian Plate and the Indian Plate. A compass rose (N/E/S/W) is in the bottom right. Legend: wavy line = Plate boundaries; solid line = East African Rift; bold arrow = Direction of plate movement.]

Serengeti National Park contains a variety of tropical habitats but is dominated by wide-open lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park's herbivores, such as wildebeest and zebra, migrate through the park in an annual cycle following the growth of new grass (Figure 2).

Figure 2. Annual Migration of Wildebeest in Serengeti National Park

[Circular diagram showing the annual wildebeest migration route around Serengeti National Park, with a wildebeest icon and arrows connecting labelled month boxes in a loop: June → July → August → September → October (near "Ikorongo Game

Question 2

Reserve") → November (near "Loliondo") → December (near "Ngorongoro Conservation Area") → January → February → March → April (near "Maswa Game Reserve") → May → back to June. "Grumeti Game Reserve" is labelled near June/July. A dashed line labelled "Proposed location for new highway" crosses the northern part of the park near August/September. A solid line marks the "Serengeti National Park boundary." A compass rose (N/E/S/W) is in the bottom right. Legend: arrow = Wildebeest migration route; wildebeest icon = Wildebeest; dashed line = Proposed location for new highway; solid line = Serengeti National Park boundary.] Respond to parts A, B, C, D, E, F, G, H, I, and J.

(a) Based on the information in Figure 1, **identify** the type of plate boundary that runs beneath Serengeti National Park.

Question 2

2025 Set 2 ▪ Q2

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highway" crosses the northern part of the park near August/September. A solid line marks the "Serengeti National Park boundary." A compass rose (N/E/S/W) is in the bottom right. Legend: arrow = Wildebeest migration route; wildebeest icon = Wildebeest; dashed line = Proposed location for new highway; solid line = Serengeti National Park boundary.]

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

(b) Based on the information provided, **identify** the dominant biome within the Serengeti.

Question 2

2025 Set 2 ▪ Q2

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

(c) Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, **identify** the location in the Serengeti where wildebeest are most likely to give birth.

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

(d) The Serengeti has two primary types of grasses: long and short. The two grass types provide similar levels of nutrition for animals. Wildebeest primarily consume long grasses, while other herbivores such as gazelle consume the short grasses. These two similar species coexist in Serengeti National Park.

Explain why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.

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2025 Set 2 ▪ Q2

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

(e) The Tanzanian government plans to build a highway across the northern portion of the Serengeti, as shown in Figure 2.

Describe one way the planned highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.

Question 2

2025 Set 2 ▪ Q2

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

(f) Propose a solution to the negative effect created by the planned highway described in part E.

Question 2

2025 Set 2 ▪ Q2

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

(g) Many organisms live in grasslands. One weed species, the spotted knapweed, was introduced at one location in North America in the 1890s and is currently found throughout the rangelands of the western United States. The spotted knapweed poses several environmental problems in North America. Farmers often use crop rotation to control populations of pests like the spotted knapweed. A more traditional method of controlling pests involves spraying pesticides.

Describe a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species.

Question 2

2025 Set 2 ▪ Q2

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

(h) Justify the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations.

Question 2

2025 Set 2 ▪ Q2

Serengeti National Park is located in Tanzania, Africa. The park is located in a valley along a tectonic plate boundary called the East African Rift. Figure 1 shows the East African Rift and other plate boundaries near the east coast of Africa.

Figure 1. Tectonic Plate Movement near East Coast of Africa

[Map figure showing tectonic plates near the east coast of Africa. Labels: "Arabian Plate" (north-central), "African Plate" (west), "Indian Plate" (east), "Lake Victoria" (small lake, west, with an arrow pointing away from it/west), "Western Rift Valley" and "Eastern Rift Valley" (two branching rift lines running north-south through the African Plate), "Serengeti National Park" (marked at the point where the Western and Eastern Rift Valleys meet), "Indian Ocean" (to the east). Bold arrows show direction of plate movement: one arrow points west/away from Lake Victoria area, one arrow points southeast from the rift valley junction, and a double-headed arrow (pointing both directions, apart) is shown at the boundary between the Arabian Plate and the Indian Plate. A compass rose (N/E/S/W) is in the bottom right.

Question 2

Legend: wavy line = Plate boundaries; solid line = East African Rift; bold arrow = Direction of plate movement.]

Serengeti National Park contains a variety of tropical habitats but is dominated by wide-open lands that include a variety of grass species with scattered trees and shrubs. Most grass growth occurs after the March through May rainy season. Many of the park's herbivores, such as wildebeest and zebra, migrate through the park in an annual cycle following the growth of new grass (Figure 2).

Figure 2. Annual Migration of Wildebeest in Serengeti National Park

[Circular diagram showing the annual wildebeest migration route around Serengeti National Park, with a wildebeest icon and arrows connecting labelled month boxes in a loop: June → July → August → September → October (near "Ikorongo Game Reserve") → November (near "Loliondo") → December (near "Ngorongoro Conservation Area") → January → February → March → April (near "Maswa Game Reserve") → May → back to June. "Grumeti Game Reserve" is labelled near June/July. A dashed line labelled "Proposed location for new

Question 2

highway" crosses the northern part of the park near August/September. A solid line marks the "Serengeti National Park boundary." A compass rose (N/E/S/W) is in the bottom right. Legend: arrow = Wildebeest migration route; wildebeest icon = Wildebeest; dashed line = Proposed location for new highway; solid line = Serengeti National Park boundary.]

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

(i) Describe an environmental problem associated with controlling pest populations with large amounts of pesticide.

Question 2

2025 Set 2 ▪ Q2

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Question 2

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Question 2

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

(j) Propose a solution to controlling pests, other than pesticides or crop rotation.

Solution 2

(a)

Mark scheme

- Divergent (boundary) - the plate boundary running beneath Serengeti National Park (part of the East African Rift) is a divergent boundary. 1 point for identifying it as divergent.

Solution 2

(b)

Mark scheme

- The dominant biome within the Serengeti is savanna (tropical grassland). 1 point for identifying savanna/tropical grassland.

Solution 2

(c)

Mark scheme

- Wildebeest are most likely to give birth in the Grumeti Game Reserve, i.e. the west/northwestern side/edge of Serengeti National Park, where new grasses are growing (per Figure 2). 1 point for identifying this location.

Solution 2

(d)

Mark scheme

- Resource partitioning allows wildebeest (which eat long grasses) and gazelle (which eat short grasses) to coexist because it reduces the negative impact of competition for limited resources - each species uses the shared, limited resource (grass) in a different way (different grass types), so they are not competing directly for the exact same food source. 1 point for explaining this reduced-competition mechanism.

Solution 2

(e)

Mark scheme

- One way the planned highway could negatively affect the wildebeest population: building the highway would fragment/destroy habitat, food, or resources; the highway could prevent, reduce, or disturb migration; wildebeest could be hit/killed by vehicles; or noise pollution from the highway could cause stress or change migratory routes. 1 point for any one valid negative effect.

Solution 2

(f) Mark scheme

- A realistic solution must correspond to the problem identified in part E. If habitat fragmentation/destruction was described: construct a habitat corridor over/under the highway, construct the highway over/above the habitat, relocate the highway north/outside the migratory path, or expand the national park/create additional protected habitat. If migration disturbance or vehicle strikes was described: relocate the highway north/outside the migratory path, or construct a habitat corridor over/under the highway. If noise pollution/stress was described: install a sound barrier to mitigate noise pollution, or relocate the highway north/outside the migratory path. 1 point for a solution that logically addresses the specific problem given in part E.

Solution 2

(g)

Mark scheme

- A characteristic of an invasive species (such as spotted knapweed) that allows it to outcompete native species: it has many offspring/reproduces quickly/matures early/invests minimal energy per offspring (tends to be r-selected); it can feed on/use many different types of resources; or it can survive in conditions outside its normal habitat/has a wide tolerance range (tends to be a generalist). 1 point for any one valid characteristic.

Solution 2

(h)

Mark scheme

- An additional advantage of crop rotation (besides pest control): improved soil fertility/soil structure/soil quality; increased nutrient cycling/reduced need for fertilizer; reduced soil erosion; increased food security/crop yield; or increased biological activity in the soil. 1 point for any one valid additional advantage.

Solution 2

(i)

Mark scheme

- An environmental problem from controlling pests with large amounts of pesticide: pesticides can harm/kill nontarget species, or pests can develop resistance to the pesticide (leading to a pesticide treadmill). 1 point for either problem.

Solution 2

(j)

Mark scheme

- A solution to controlling pests other than pesticides or crop rotation: use biocontrol/intercropping/natural predators; trap insects/use mechanical controls to eliminate pests; or use genetically modified crops that are pest resistant. 1 point for any one valid alternative solution.

Question 3

2024 Set 2 ▪ Q3

The Rocky Mountains, the headwaters for the Colorado River, have experienced a severe drought for many of the past twenty years. States and cities downstream that depend on the river water have had to find solutions to the reduced water flow.
One city located downstream from the Rocky Mountains is Las Vegas, Nevada. In Las Vegas, one solution to reduce the amount of water used for irrigation is to remove landscaping and lawns that use grasses not native to the local area and replace them with desert-tolerant landscaping.

(a) Identify a typical type of plant that would be used in desert-tolerant landscaping.

Question 3

2024 Set 2 ▪ Q3

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(b) Justify the removal of landscaping and lawns that use grasses not native to the local area by describing an additional advantage, other than reducing the amount of water needed for irrigation.

Question 3

2024 Set 2 ▪ Q3

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(c) Warmer seasonal temperatures in the Rocky Mountains have led to earlier mountain snowmelt and an increased risk of forest fires as soil and vegetation dry out. Describe how a prescribed burn would reduce the severity and spread of forest fires.

Question 3

2024 Set 2 ▪ Q3

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(d) Describe a disadvantage of a prescribed burn in a forested ecosystem.

Question 3

2024 Set 2 ▪ Q3

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One city located downstream from the Rocky Mountains is Las Vegas, Nevada. In Las Vegas, one solution to reduce the amount of water used for irrigation is to remove landscaping and lawns that use grasses not native to the local area and replace them with desert-tolerant landscaping.

(e) Lake Powell is a large reservoir on the Colorado River. Lake Powell is formed by a dam with a hydroelectric power plant. At full capacity or full pool, Lake Powell contains 25.16 million acre-feet (maf) of water. Currently, Lake Powell is at 36% full capacity.

Question 3

Calculate the number of million acre-feet (maf) of water currently in Lake Powell. Show your work.

Question 3

2024 Set 2 ▪ Q3

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One city located downstream from the Rocky Mountains is Las Vegas, Nevada. In Las Vegas, one solution to reduce the amount of water used for irrigation is to remove landscaping and lawns that use grasses not native to the local area and replace them with desert-tolerant landscaping.

(f) In 2021, after years of drought, Lake Powell held 7.9 million acre-feet (maf) of water. One million acre-feet is equivalent to 3.26×10^{11} gallons.

The watershed of the Upper Colorado River contributes an average of 9.60 maf of water to Lake Powell annually. The melted mountain snow found in the watershed contributes 50

Question 3

2024 Set 2 ▪ Q3

The Rocky Mountains, the headwaters for the Colorado River, have experienced a severe drought for many of the past twenty years. States and cities downstream that depend on the river water have had to find solutions to the reduced water flow.

One city located downstream from the Rocky Mountains is Las Vegas, Nevada. In Las Vegas, one solution to reduce the amount of water used for irrigation is to remove landscaping and lawns that use grasses not native to the local area and replace them with desert-tolerant landscaping.

(g) The average household in the United States consumes 5.0×10^4 gallons of water in a year. Calculate the number of households that could be supported for one year by the average flow of 9.60 maf of water into Lake Powell. Show your work.

Solution 3

(a)

Mark scheme

- A typical desert-tolerant landscaping plant: cactus/cacti, succulent plants, or other drought-tolerant plants. Full credit for naming one such plant type.

Solution 3

(b)

Mark scheme

- An additional advantage (besides reduced irrigation water) of removing non-native grass lawns: any one of (1) native desert plants support habitat/provide food for local wildlife; (2) less mowing means decreased yard-maintenance time/cost; (3) desert-tolerant plants need less fertilizer/pesticide; (4) it creates jobs for landscapers to remove/replace turf; (5) less use of gas-powered yard tools reduces air pollution/noise pollution/gasoline consumption. Full credit for any one such advantage.

Solution 3

(c)

Mark scheme

- A prescribed burn reduces the severity/spread of forest fires because it removes undergrowth, decreasing available fuel/flammable material, and/or it thins the forest, creating a fire break that reduces the spread of future fires. Full credit for either mechanism.

Solution 3

(d)

Mark scheme

- A disadvantage of a prescribed burn: any one of (1) it reduces habitat for wildlife/can harm or displace animals; (2) it releases carbon dioxide, contributing to climate change; (3) it releases particulates/air pollutants, worsening air quality; (4) runoff after the burn can degrade water quality; (5) it reduces competition, which can help invasive species spread/expand. Full credit for any one such disadvantage.

Solution 3

(e)

Mark scheme

- Setup (1 point): 25.16 maf $\times\, 36\% = 25.16 \times 0.36$. Calculation (1 point): ≈ 9.06 maf (accept 9.0576, 9.058, 9.06, or 9.1). Full credit (2 points) needs both a correct setup showing 25.16 maf multiplied by 36

Solution 3

(f)

Mark scheme

- Setup (1 point): 9.60 maf $\times\, 36\% \times 50\% = 9.60 \times 0.36 \times 0.5$. Calculation (1 point): ≈ 1.73 maf (accept 1.728, 1.73, or 1.7). Full credit (2 points) needs both the correct multiplicative setup (annual average flow times 2021's 36

Solution 3

(g)

Mark scheme

- Setup (1 point): 9.60 maf $\times \dfrac{3.26 \times 10^{11} \text{ gallons}}{1 \text{ maf}} \times \dfrac{1 \text{ household}}{5.0 \times 10^{4} \text{ gallons}}$.
  Calculation (1 point): $\approx 62{,}592{,}000$ households (i.e. 6.2592×10^{7}). Full credit (2 points) needs both the correct unit-conversion setup (maf to gallons to households) AND the correct resulting value.

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

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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 2

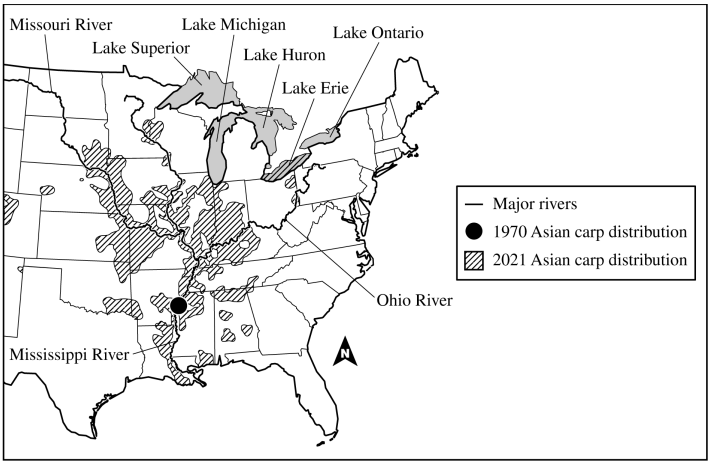
2023 Set 2 ▪ Q2

Asian carp were first introduced in the southern United States in the 1970s by fish farmers wanting to control algal growth in fish ponds. Asian carp can eat up to 40
Distribution of the Asian Carp in the United States
[Map of the eastern/central United States titled "Distribution of the Asian Carp in the United States". Labeled features: Missouri River, Mississippi River, Ohio River, and the five Great Lakes (Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario), each shown shaded gray. A compass rose (N) is shown. Legend: a solid line = Major rivers; a filled black circle = 1970 Asian carp distribution (shown as a single point near the lower Mississippi River/southern states); a diagonal-hatched pattern = 2021 Asian carp distribution (shown spread widely along the Mississippi, Missouri, and Ohio River systems and extending toward the Great Lakes, with hatching also appearing over Lake Erie).]

Question 2

The Great Lakes are a group of five major freshwater inland lakes that all share the same watershed.
The following is an example of a simple food chain in the Great Lakes.
Algae $\rightarrow$ Zooplankton $\rightarrow$ Macroinvertebrates $\rightarrow$ Yellow perch $\rightarrow$ Rainbow trout
The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.
(a) Based on the information given, **identify** a body of water invaded by Asian carp that is labeled on the map.

Question 2


Missouri River
Lake Michigan
Lake Ontario
Lake Superior
Lake Huron
Lake Erie
Major rivers
1970 Asian carp distribution
2021 Asian carp distribution
Ohio River
Mississippi River
N

Question 2

2023 Set 2 ▪ Q2

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Question 2

The following is an example of a simple food chain in the Great Lakes.
Algae → Zooplankton → Macroinvertebrates → Yellow perch → Rainbow trout
The blue pike, a fish that was endemic to the Great Lakes, was commercially fished from the late 1800s until their population crashed in 1958. In 1970, the species was declared to be extinct.

(b) Based on the information shown in the map, **describe** the change in the distribution of Asian carp since their introduction in the 1970s.

Question 2

2023 Set 2 ▪ Q2

Asian carp were first introduced in the southern United States in the 1970s by fish farmers wanting to control algal growth in fish ponds. Asian carp can eat up to 40

Distribution of the Asian Carp in the United States

[Map of the eastern/central United States titled "Distribution of the Asian Carp in the United States". Labeled features: Missouri River, Mississippi River, Ohio River, and the five Great Lakes (Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario), each shown shaded gray. A compass rose (N) is shown. Legend: a solid line = Major rivers; a filled black circle = 1970 Asian carp distribution (shown as a single point near the lower Mississippi River/southern states); a diagonal-hatched pattern = 2021 Asian carp distribution (shown spread widely along the Mississippi, Missouri, and Ohio River systems and extending toward the Great Lakes, with hatching also appearing over Lake Erie).]

The Great Lakes are a group of five major freshwater inland lakes that all share the same watershed.

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(c) Describe one impact the introduction of Asian carp could have on the ecosystem services provided by the Great Lakes region.

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2023 Set 2 ▪ Q2

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(d) Propose a realistic solution to help reduce the spread of the Asian carp from their current distribution.

Question 2

2023 Set 2 ▪ Q2

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(e) Justify the solution proposed in part (d) by providing an additional advantage.

Question 2

2023 Set 2 ▪ Q2

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(f) Identify the primary consumer in the Great Lakes food chain.

Question 2

2023 Set 2 ▪ Q2

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(g) Describe what the arrows in the aquatic food chain represent.

Question 2

2023 Set 2 ▪ Q2

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(h) Describe one possible effect of the introduction of the Asian carp on the Great Lakes food chain.

Question 2

2023 Set 2 ▪ Q2

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(i) Describe one way that overfishing of blue pike illustrates the tragedy of the commons.

Question 2

2023 Set 2 ▪ Q2

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(j) One potential solution to reduce overfishing is to use aquaculture. **Describe** one disadvantage of this solution.

Solution 2

(a)

Mark scheme

- A body of water labeled on the map, e.g.: the Mississippi River, Lake Erie, the Missouri River, or the Ohio River.

Solution 2

(b)

Mark scheme

- Since their introduction in the 1970s, Asian carp have become far more widely distributed — found in most of the watershed / a much larger area than before — moving up and down the Mississippi River and up the Missouri and Ohio Rivers (i.e., spreading northwest and northeast up the river systems).

Solution 2

(c)

Mark scheme

- One impact on ecosystem services, e.g.: improved drinking water quality as carp consume algae; decreased recreational opportunities (boating/swimming) from the larger carp population; decreased fishing as carp outcompete native fish species; decreased drinking water quality as carp displace filter feeders like native mussels; or a decreased algae population leading to decreased photosynthesis and either increased greenhouse gases/warming or decreased oxygen production.

Solution 2

(d)

Mark scheme

- A realistic solution such as: offering incentives for fishers to catch and kill carp; encouraging consumption of carp; building fencing/netting between waterways; using shock treatment (a dispersal barrier system); creating/using an Asian-carp-specific poison or deterrent (e.g., carpicide, CO2, microparticles); implementing a high-frequency sound deterrent system; or prohibiting the transfer of bait or ballast water from one body of water to another.

Solution 2

(e) Mark scheme

- An additional advantage that matches the solution proposed in (d). For fencing/netting, sound deterrents, carp-specific poison/deterrent, or shock treatment: creates jobs in the Great Lakes fishing industry, causes little/no harm to native animal/plant populations, reduces carp's negative impact on watershed feeding relationships, or maintains revenue for the existing fishing industry/tourism. For encouraging carp consumption or incentivizing fishers to catch/kill carp: increases revenue in the fishing industry/from carp sales, reduces carp's negative feeding-relationship impacts, provides a new food source (domestically/internationally) or combats hunger, or allows native species to return as competition from carp decreases. For prohibiting bait/ballast transfer:

Solution 2

causes no harm to native populations, reduces carp's negative feeding impacts, or maintains existing fishing/tourism revenue.

Solution 2

(f)

Mark scheme

- Zooplankton — the primary consumer in the Great Lakes food chain.

Solution 2

(g)

Mark scheme

- The arrows represent the flow of energy (or equivalently, the flow of matter) through the aquatic food chain.

Solution 2

(h)

Mark scheme

- One possible effect, e.g.: there will be fewer zooplankton/macroinvertebrates/yellow perch/rainbow trout; there will be less food available for other species at the same trophic level; or there will be less food for species that don't eat carp but are higher on the food chain.

Solution 2

(i)

Mark scheme

- The blue pike were a shared/common resource with unregulated access, so fishers maximized their own profits/catch, depleting (and ultimately causing the extinction of) the shared resource — illustrating the tragedy of the commons.

Solution 2

(j)

Mark scheme

- One disadvantage of aquaculture, e.g.: it contaminates water with excess organic waste/antibiotics; escaped fish compete or breed with wild fish; facilities can spread disease to wild fish; high fish density increases disease; it causes job losses in the fishing industry; it puts pressure on wild fish stocks used to make food pellets; it decreases the genetic diversity of farm-raised fish; it causes habitat degradation from converting ecosystems to fish farms; or antibiotic overuse creates antibiotic-resistant bacteria harmful to humans.

Question 2

2022 Set 2 ▪ Q2

Biologists collected data on the abundance of lizards on several Pacific islands with and without mongoose populations. The surveys were conducted at different locations on the islands by counting the number of lizards observed per hour and included habitats with both undisturbed areas and anthropogenically disturbed areas.
[Scatter/line graph titled "LIZARD NUMBERS ON PACIFIC ISLANDS". Y-axis: "Lizards Counted per Hour", logarithmic scale from 10^0 to 10^3. X-axis: "Habitat Types", with categories in order from "Undisturbed" to "Highly disturbed": Primary Forest, Secondary Forest, Clearings, Gardens, Sugarcane Fields, Hotels, Parks, and Walking Trails. Two data series with individual data points and a smoothed trend curve for each: "Mongoose-free islands" (filled circles, solid curve) and "Mongoose-present islands" (open squares, dashed curve). Both curves rise from Primary Forest, peak around Clearings, Gardens (mongoose-free peak $\approx$ 50

Question 2

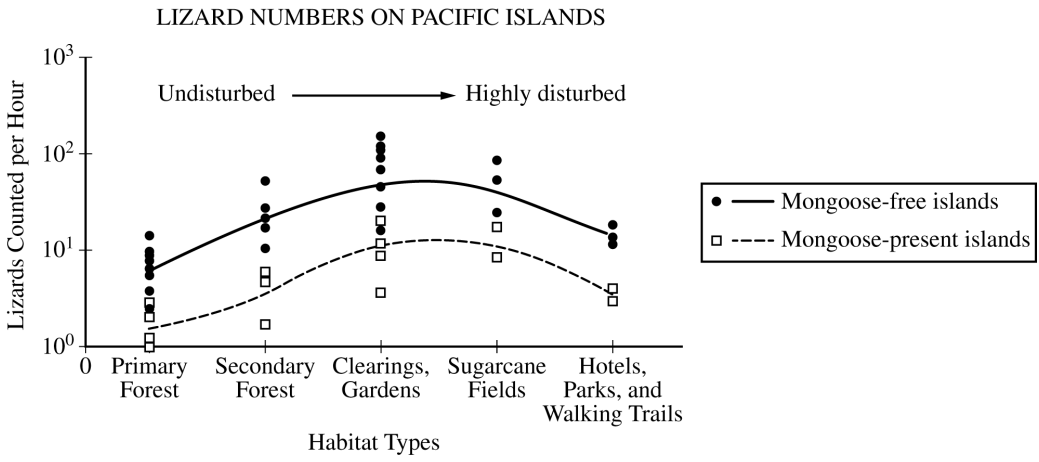
lizards/hour; mongoose-present peak $\approx$ 10 lizards/hour), then decline toward Hotels, Parks, and Walking Trails (mongoose-free $\approx$ 15 lizards/hour; mongoose-present $\approx$ 3 lizards/hour). At every habitat type, the mongoose-free (solid) curve lies above the mongoose-present (dashed) curve.]

(a)(i) The graph shows data collected by biologists on lizard numbers on several Pacific islands.

Based on the data in the graph, **identify** the habitat type with the greatest number of lizards.

(a)(ii) Based on the data in the graph, **describe** the relationship between the lizard numbers observed on islands with and without mongoose populations.

Question 2


LIZARD NUMBERS ON PACIFIC ISLANDS
Undisturbed
Highly disturbed
Lizards Counted per Hour
10^3
10^2
10^1
10^0
0
Primary Forest
Secondary Forest
Clearings, Gardens
Sugarcane Fields
Hotels, Parks, and Walking Trails
Habitat Types
Mongoose-free islands
Mongoose-present islands

Question 2

2022 Set 2 ▪ Q2

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Question 2

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(b) Globally, islands vary in size, location, and habitat.

Based on the theory of island biogeography, **describe** the characteristics of an island with the greatest species diversity.

Question 2

2022 Set 2 ▪ Q2

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(c)(i) Island ecosystems are often threatened by invasive species, such as the mongoose populations studied in the survey.
Describe one environmental problem caused by invasive animal species.

(c)(ii) Invasive species are often pests. **Make a claim** that proposes one way to control pest species.

(c)(iii) **Justify** the solution proposed in (c)(ii) by providing an additional benefit of the solution.

Question 2

2022 Set 2 ▪ Q2

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(d)(i) Islands provide humans with many ecosystem services. However, humans may alter ecosystems when they obtain these services. Large-scale commercial sugarcane farming on the Pacific islands has led to significant ecological damage.

Identify a provisioning ecosystem service provided by primary forests.

(d)(ii) Based on the data in the graph, **explain** how replacing primary forests with sugarcane fields may have affected the number of lizards counted on the mongoose-free Pacific islands.

(d)(iii) The long-term use of monocultures in commercial sugarcane farming is one cause of the ecological damage. **Describe** one problem associated with monocultures.

Question 2

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(e) One solution to the ecological damage of monocultures is to use a form of crop rotation using legumes.

Describe an advantage of crop rotation using legumes on soil fertility.

Solution 2

(a)(i)

Mark scheme

- Clearings/Gardens — this habitat type has the greatest number of lizards in the graph.

(a)(ii)

Mark scheme

- Any one description: lizard populations are smaller on islands where mongooses are present than on mongoose-free islands; lizard populations are larger on mongoose-free islands than on islands with mongooses; the relationship between lizard numbers and mongoose population is an inverse (negative) relationship.

Solution 2

(b)

Mark scheme

- A large island located near the mainland will have the greatest species diversity — per island biogeography theory, larger area supports a larger population/lower extinction rate, and proximity to the mainland increases the immigration (colonization) rate.

Solution 2

(c)(i)

Mark scheme

- Any one environmental problem: invasive species outcompete native species for resources, causing food web disruptions/trophic cascades/habitat loss; invasive species outcompete or prey on native organisms, decreasing biodiversity/reducing native population sizes.

Solution 2

(c)(ii)

Mark scheme

- Any one claim proposing pest control: introduce biological controls (natural predators of the species) to reduce pest numbers; use chemical controls such as pesticides to kill off pests; use manual/mechanical methods to remove plant species; trap/hunt animal species and remove/kill them from the area.

Solution 2

(c)(iii)

Mark scheme

- Justification must match the solution proposed in (c)(ii): biological control, manual/mechanical removal, or trapping/hunting is justified as least likely to harm other species because the pest species can be specifically targeted, and harmful synthetic chemicals are not introduced into the environment (manual/trapping methods can also cite financial gain from selling killed pest organisms); chemical control (pesticides) is justified as a quick/efficient method to reduce/eliminate the pest species.

Solution 2

(d)(i)

Mark scheme

- Any one provisioning ecosystem service from primary forests: timber/lumber/wood; medicine; food.

Solution 2

(d)(ii)

Mark scheme

- Any one explanation: the cleared land is preferred habitat for the lizards, leading to increased lizard numbers in the sugarcane fields compared to forests; the cleared land has fewer predators, leading to increased lizard numbers in the sugarcane fields compared to forests; the cleared land has more food for the lizards, leading to increased lizard numbers in the sugarcane fields compared to forests.

Solution 2

(d)(iii)

Mark scheme

- Any one problem associated with monocultures: decreased genetic diversity of the monoculture species; decreased species diversity; increased susceptibility of the monoculture to disease/pests; depletion of nutrients from the soil; increased use of irrigation water/fertilizer/pesticide.

Solution 2

(e)

Mark scheme

- Any one advantage of crop rotation using legumes: improved nitrogen fixation in the soil; less nitrogen-based fertilizer required.

Question 1

2018 ▪ Q1

Read the following article from the *Fremont Daily Times* and answer the questions that follow.

[Newspaper article, masthead "Fremont Daily Times", dated May 1, 2018, headline "GREEN IS THE NEW SCHOOL COLOR AT FREMONT HIGH SCHOOL!"]

A group of students from Fremont High School addressed the city council last night and proposed that one of the existing buildings at Fremont High School, which was built in 1970, be renovated to take advantage of recent advances in green technology. Currently the heat for the school is provided by fossil fuel combustion. The students said that the redesigned building would reduce the school's carbon footprint, which is a measure of the amount of carbon dioxide and other carbon compounds released by various human activities. Incorporating specific features that conserve energy and utilize renewable energy sources can help reduce the carbon footprint.

Question 1

Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a "shining beacon" of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

(a)(i) Define carbon footprint.

(a)(ii) Identify one way the school's heating system is likely adding to the school's carbon footprint.

(a)(iii) Describe one realistic way to reduce the contribution of the heating system to the school's carbon footprint.

(b) Identify TWO environmental benefits of a living green roof, such as that suggested by Councilperson Fassler.

Question 1

(c) Describe TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.
(d) Discuss TWO benefits of using native plants for landscaping at Fremont High School.
(e) During the renovation, the carpeting must be replaced. Discuss one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

Question 1

Fremont Daily Times May 1, 2018

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Councilperson Gail Fassler praised the idea, saying that the project could conserve local water resources, reduce the need for consuming new resources, and act as a "shining beacon" of sustainability for the greater Fremont community. Fassler suggested the project could even incorporate a living green roof as an additional sustainable feature. The council approved the initial site planning request and urged students to report back when the project was under way.

Solution 1

(a)(i)

Mark scheme

- 1 point for a correct definition of carbon footprint. Carbon footprint = the amount of carbon dioxide and/or other carbon compounds released to the environment by a product, process, or activity (a measurement of the amount of carbon released by human activities).

Solution 1

(a)(ii)

Mark scheme

- 1 point for correctly identifying a way the heating system adds to the carbon footprint. Accept: the burning/combustion of fossil fuels releases carbon dioxide; OR incomplete combustion of fossil fuels releases carbon monoxide.

Solution 1

(a)(iii)

Mark scheme

- 1 point for a correct description of a realistic way to reduce the heating system's contribution. Accept any one of: switch to renewables (solar, wind) or a more efficient fossil fuel (natural gas, propane) or a provider using nuclear energy; decrease the thermostat/program it to lower energy use at certain times; purchase carbon-offset credits through environmental agencies; increase insulation or other efficiency/design methods (green roof, double-paned glass, south-facing windows for passive solar heating, change air filters, etc.).

Solution 1

(b)

Mark scheme

- 2 points, 1 point per correct identification of an environmental benefit of a green roof (up to 2). Accept any two of: insulation/reduced fossil fuel use for heating and/or cooling; habitat for wildlife/plants, increases biodiversity; area to grow crops/local food production; reduction in urban heat islands; photosynthesis/carbon capture/CO2 storage/oxygen release; stormwater treatment/runoff reduction; filters particulates, VOCs, O3 from air.

Solution 1

(c) Mark scheme

- 2 points, 1 point per correct description of a practice that decreases the school's environmental impact (up to 2). Accept any two of: offer more vegetarian options/serve fewer animal products; use locally sourced food to reduce transportation; grow food at school; compost food waste; donate leftover food; use energy-friendly practices (LED lighting, more cold-cut sandwiches) to reduce energy use; purchase bulk packaged items; use recyclable containers/avoid disposable straws-trays; install a water fountain/stop selling single-serving bottled water; use reusable take-out containers/offer credit for reuse; allow students to choose appropriate portions to reduce food waste; purchase organic foods to reduce pesticide use; use gray water to irrigate landscaping.

Solution 1

(d)

Mark scheme

- 2 points, 1 point per correct discussion of a benefit of native plants (up to 2). Accept any two of: native plants need less pesticide/fertilizer/irrigation water because they are adapted to the local environment; increase biodiversity by providing native habitat; support native food webs/food production; reduce land available for invasive species to establish/spread; save the school money by needing less water/fertilizer/pesticide/upkeep.

Solution 1

(e) Mark scheme

- 1 point for a correct discussion of a benefit of plant-based flooring (e.g. cork, bamboo) over synthetic carpet. Accept any one of: plant-based material is more easily compostable/biodegradable/reusable, unlike carpet; it comes from a renewable resource, making it more sustainable than carpet; it is a carbon sink/reservoir (growing the plant material removes CO2 from the atmosphere), unlike carpet; it requires fewer fossil fuels/toxic chemicals to produce than synthetic carpet fibers; it produces fewer indoor pollutants (off-gassed VOCs/toxins) than carpet; it harbors fewer pathogenic vectors/diseases/allergens (fleas, ticks, dust mites, mold spores) than carpet; when cultivated it provides habitat for native species.