Past-paper walk-through

Ecosystem Services ▪ 2.2

eXercise

Questions in this set

- 2025 Set 2 Q1
- 2024 Set 1 Q3
- 2024 Set 2 Q1
- 2024 Set 2 Q2
- 2023 Set 2 Q2
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- 2021 Set 1 Q3
- 2019 Q2
- 2019 Q1
- 2018 Q1

Questions in this set

- 2017 Q1
- 2016 Q1

Reading the mark scheme

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

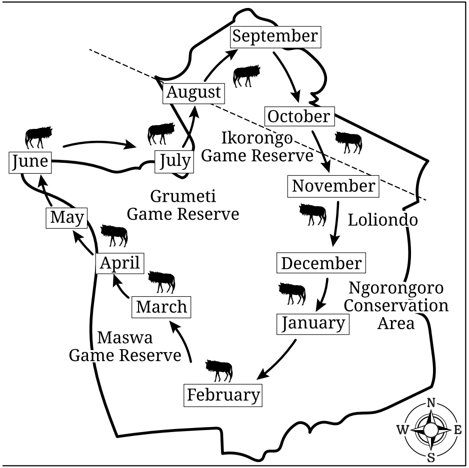
Question 1

2025 Set 2 ▪ Q1

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

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

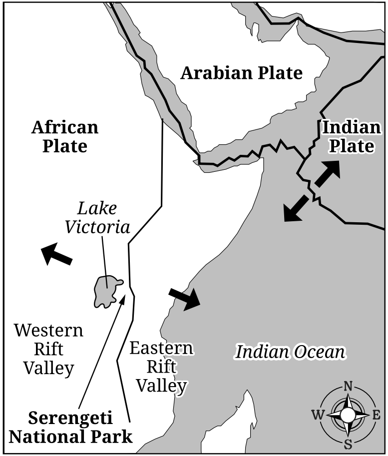
Question 1


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

Question 1

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

Question 1



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

Question 1

2025 Set 2 ▪ Q1

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

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

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

Question 1

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

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

Question 1

2025 Set 2 ▪ Q1

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

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

Solution 1

(a)

Mark scheme

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

Solution 1

(b)

Mark scheme

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

Solution 1

(c)

Mark scheme

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

Solution 1

(d)

Mark scheme

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

Solution 1

(e)(i)

Mark scheme

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

Solution 1

(e)(ii)

Mark scheme

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

Solution 1

(f)

Mark scheme

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

Solution 1

(g)

Mark scheme

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

Solution 1

(h)

Mark scheme

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

Solution 1

(i) Mark scheme

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

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(a) Identify a fuel used in a nuclear power plant.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(b) Describe a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9
Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(e) Justify the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

Solution 3

(a)

Mark scheme

- A fuel used in a nuclear power plant: Uranium (U-235) or Plutonium.

Solution 3

(b)

Mark scheme

- Using water for cooling in nuclear power plants causes thermal pollution: discharged water raises the temperature of nearby bodies of water outside organisms' range of tolerance and/or decreases dissolved oxygen; organisms can also be wounded or killed at the water intake; and water loss through evaporation can decrease stream flow/volume.

Solution 3

(c)

Mark scheme

- Calculate electricity generated by nuclear power in the US in 2021 (2 points: 1 for setup, 1 for the answer). Setup: $(4.1\times10\hat{}12\text{ kWh}) \times 18.9\% = (4.1\times10\hat{}12) \times 0.189$. Calculation: $4.1\times10\hat{}12 \times 0.189 = 7.749\times10\hat{}11$ kWh $\approx$ 774,900,000,000 kWh (accept $7.75\times10\hat{}11$ or $7.7\times10\hat{}11$ kWh).

Solution 3

(d)

Mark scheme

- Switching from coal-burning to natural gas power plants improves air quality because burning natural gas produces less NOx, SOx, ash, particulates, toxic metals, and smog compared to burning coal.

Solution 3

(e)

Mark scheme

- An additional advantage of large-scale tree planting beyond reducing atmospheric greenhouse gases: provides forest habitat/increases biodiversity/diversifies niches; creates jobs (planting, recreation, wood harvesting); creates a more aesthetically pleasing environment/enhances cultural ecosystem services; decreases soil loss/erosion/sedimentation in waterways; provides shade/decreases ambient temperature; or slows water runoff/reduces flooding.

Solution 3

(f)

Mark scheme

- Calculate how many homes could be powered by the natural gas extracted (2 points: 1 for setup, 1 for the answer). Setup: $(7.4\times10\hat{}7\ m^3) \times (4.76\ kWh\ /\ 1\ m^3) \times (1\ home\ /\ 10{,}715\ kWh)$. Calculation: $7.4\times10\hat{}7 \times 4.76\ /\ 10{,}715 \approx$ 32,874 homes (accept 32,873 or $\approx$33,000).

Solution 3

(g)

Mark scheme

- Calculate how much less CO_2 would be produced if all coal plants were replaced by natural gas plants in 2021 (2 points: 1 for setup, 1 for the answer). Setup: difference in emission rate $\times$ total kWh from coal $=$ (1.0 kg CO_2/kWh $-$ 0.42 kg CO_2/kWh) $\times$ ($8.99\times10\hat{}11$ kWh); equivalently compute CO_2 from coal ($8.99\times10\hat{}11$ kWh $\times$ 1.0 kg/kWh $=$ $8.99\times10\hat{}11$ kg) minus CO_2 if that electricity were from natural gas ($8.99\times10\hat{}11$ kWh $\times$ 0.42 kg/kWh $=$ $3.776\times10\hat{}11$ kg). Calculation: $0.58 \times 8.99\times10\hat{}11 =$ $5.2142\times10\hat{}11$ kg $\approx$ 521 billion kg (accept 521,420,000,000 kg, $5.21\times10\hat{}11$ kg, or $5.2\times10\hat{}11$ kg).

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:

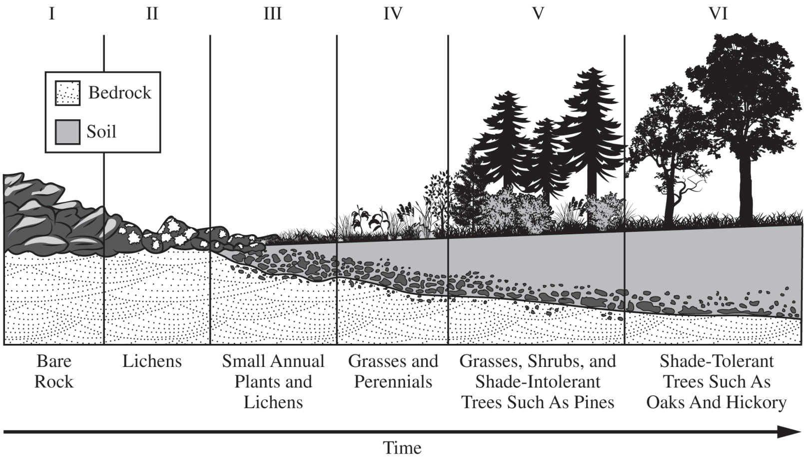
- Stage I: Bare Rock

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]

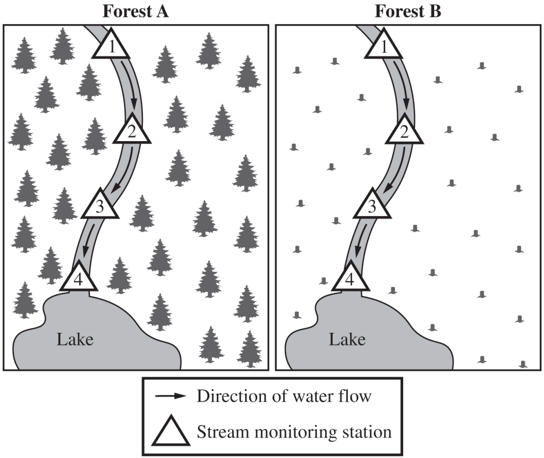
(a) Identify the ecological change over time illustrated in the diagram.

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
Direction of water flow
Stream monitoring station

Question 1

2024 Set 2 ▪ Q1

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Question 1

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- 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

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

Question 1

2024 Set 2 ▪ Q1

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

Question 1

2024 Set 2 ▪ Q1

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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

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(f) Identify the independent variable in the experiment.

Question 1

2024 Set 2 ▪ Q1

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

Question 1

2024 Set 2 ▪ Q1

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

Solution 1

(a)

Mark scheme

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

Solution 1

(b)

Mark scheme

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

Solution 1

(c)

Mark scheme

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

Solution 1

(d)

Mark scheme

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

Solution 1

(e)

Mark scheme

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

Solution 1

(f)

Mark scheme

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

Solution 1

(g)

Mark scheme

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

Solution 1

(h)

Mark scheme

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

Solution 1

(i)

Mark scheme

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

Solution 1

(j)

Mark scheme

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

Question 2

2024 Set 2 ▪ Q2

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

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Question 2

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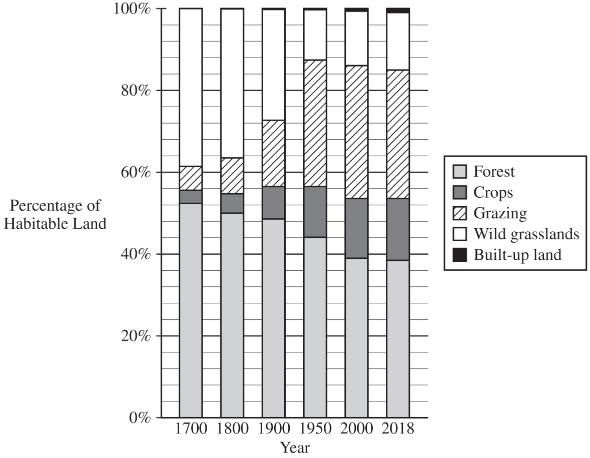
(a) Based on the data in the graph, identify the year with the highest percentage of forest.

Question 2


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

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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

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

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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Question 2

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

Question 2

2024 Set 2 ▪ Q2

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Question 2

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

Describe a disadvantage of introducing only a small population of bobcats.

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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

Solution 2

(a)

Mark scheme

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

Solution 2

(b)

Mark scheme

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

Solution 2

(c)

Mark scheme

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

Solution 2

(d)

Mark scheme

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

Solution 2

(e)

Mark scheme

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

Solution 2

(f) Mark scheme

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

Solution 2

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

Solution 2

(g)

Mark scheme

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

Solution 2

(h)

Mark scheme

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

Solution 2

(i)

Mark scheme

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

Solution 2

(j) Mark scheme

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

Question 2

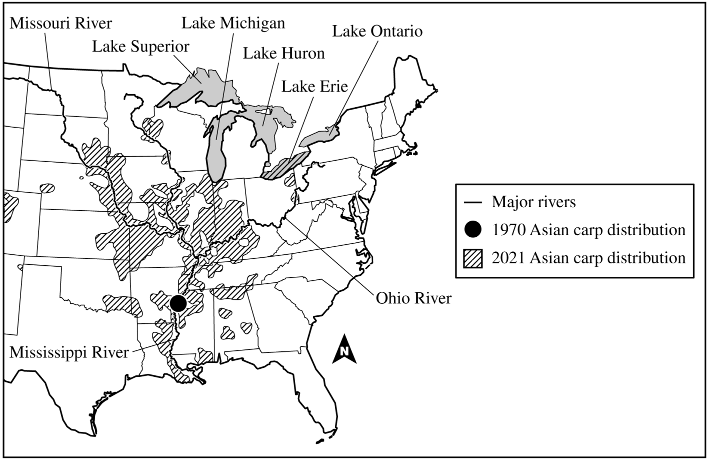
2023 Set 2 ▪ Q2

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
Ohio River
Mississippi River
N
Major rivers
1970 Asian carp distribution
2021 Asian carp distribution

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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

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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.

Question 2

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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[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.

Question 2

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.

(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, CO_2, 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

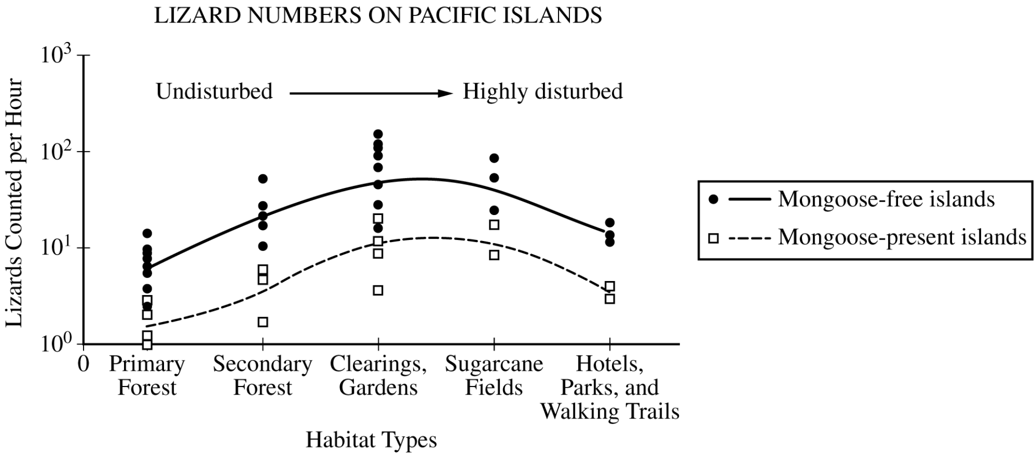
lizards/hour; mongoose-present peak $\approx$ 10 lizards/hour), then decline toward Hotels, Parks, and Walking Trails (mongoose-free $\approx$ 15 lizards/hour; mongoose-present $\approx$ 3 lizards/hour). At every habitat type, the mongoose-free (solid) curve lies above the mongoose-present (dashed) curve.]

(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

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.]

(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

2022 Set 2 ▪ Q2

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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 3

2021 Set 1 ▪ Q3

Habitat destruction and fragmentation can have many different effects on species.
(a) Describe a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species.

Question 3

2021 Set 1 ▪ Q3

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

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

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

Question 3

2021 Set 1 ▪ Q3

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

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

Question 3

2021 Set 1 ▪ Q3

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

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

Question 3

2021 Set 1 ▪ Q3

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

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

Question 3

2021 Set 1 ▪ Q3

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

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

Question 3

2021 Set 1 ▪ Q3

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

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

Solution 3

(a) Mark scheme

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

Solution 3

(b)

Mark scheme

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

Solution 3

(c) Mark scheme

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

Solution 3

(d) Mark scheme

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

Solution 3

(e)

Mark scheme

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

Solution 3

(f)

Mark scheme

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

Solution 3

(g)

Mark scheme

- Calculate the percentage of each of the 1,000 (1,100

  m^2)$lotsthatmustbesetasidetosupportthegoalof275malewoodthrushterritories.Setup(1poi$

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

  of each lot.

Question 2

2019 ▪ Q2

As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oils sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.

(a) Identify one ecological benefit, other than providing habitat, that is provided by forests.

(b) Identify one economic benefit that is provided by forests.

Question 2

(c) Describe TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.

(d) Assuming the above extraction rate, calculate how many days will be needed to extract the recoverable volume of bitumen from the oil sands.

(e) Calculate how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.

(f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. Calculate the number of barrels of freshwater needed each year to supply this demand.

Solution 2

(a)

Mark scheme

- One ecological benefit, other than providing habitat, provided by forests, e.g.: absorb carbon dioxide/produce oxygen (gas exchange); maintain ecological and/or species diversity; provide food for organisms; moderate/regulate (local) climate; purify/filter water or air; reduce soil erosion; absorb/store/regulate water; help maintain stream temperature/stream flow; aid in nutrient cycling; aid in soil formation. Full credit for any one valid benefit.

Solution 2

(b)

Mark scheme

- One economic benefit provided by forests, e.g.: source of forest products (timber, medicine, nuts, crops such as shade-grown coffee, etc.); tourism; jobs in recreation/tourism/forestry; reduction in air pollutants, which can reduce health care costs or improve crop yields. Full credit for any one valid benefit.

Solution 2

(c) Mark scheme

- Describe TWO environmental consequences, other than those related to loss of boreal forest habitat, that result from bitumen extraction or transport of synthetic oil, 1 point per correct distinct consequence (max 2), e.g.: release of greenhouse gases/air pollutants such as NO_x from fossil fuel combustion powering equipment/transportation/oil processing; release of air pollutants (NO_x, SO_x, or particulates) during mining operations or oil processing; storage and disposal of large amounts of solid/liquid mining waste, which can be toxic to organisms; pollution of surface water and/or groundwater from oil spills/leaks during transport; sediment pollution in surface water and/or groundwater from strip mining; disturbance from pipelines, such as habitat fragmentation or disruption of

Solution 2

migratory routes; noise pollution from use of machinery during processing or transport; diversion/use of water from surface water and/or groundwater for processing oil.

Solution 2

(d)

Mark scheme

- Setup: 7.3×10^{10} barrels of bitumen $\times \dfrac{1 \text{ day}}{1.0 \times 10^{6} \text{ barrels of bitumen}} = 7.3 \times 10^{4}$ days $= 73{,}000$ days. 1 point for the correct dimensional-analysis setup, 1 point for the correct numeric answer (73,000 days). Units are not required in the final answer.

Solution 2

(e)

Mark scheme

- Setup: 7.3×10^4 days $\times \dfrac{1 \text{ year}}{365 \text{ days}} = 2 \times 10^2$ years $= 200$ years. 1 point for correct setup, 1 point for the correct answer (200 years). An incorrect numeric answer carried over from part (d), if used correctly here, can still earn both points. Units are not required.

Solution 2

(f) Mark scheme

- Setup: $\dfrac{3 \times 10^7 \text{ barrels of synthetic oil}}{1 \text{ month}} \times \dfrac{2 \text{ barrels of fresh water}}{1 \text{ barrel of synthetic oil}} \times \dfrac{12 \text{ months}}{1 \text{ year}} =$ 7.2×10^8 barrels of fresh water $= 720{,}000{,}000$ barrels of fresh water per year. 1 point for correct setup, 1 point for the correct numeric answer. Units are not required.

Question 1

2019 ▪ Q1

The piping plover is a globally threatened species, with perhaps as few as 2,000 nesting pairs remaining in the Atlantic population of these migratory shorebirds. Plovers were nearly hunted to extinction in the nineteenth century.
Plovers prefer to nest and search for food on open sandy beaches between sparsely vegetated sand dunes. Washovers, where sand is washed up from the beach and buries vegetated areas during big storms, are also important to plovers because they provide moist and undisturbed habitat for plover adults and their chicks. Ecologists with the Elliott Oceanographic Institute mapped the distribution of plover nests during two seasonal surveys of nesting sites over a ten-year period on Assateague Island. This is a barrier island, a long, narrow island running parallel to the Atlantic coast of Virginia.
SPRING PIPING PLOVER NESTING SITES ON ASSATEAGUE ISLAND, VIRGINIA

Question 1

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

Question 1

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

(a)(i) Use the maps provided to answer the following questions.

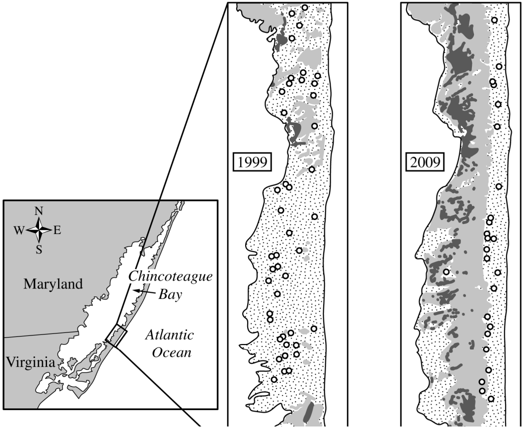
Identify the preferred nesting habitat for piping plovers.

(a)(ii) Describe the change in the number of piping plover nests on Assateague Island between 1999 and 2009.

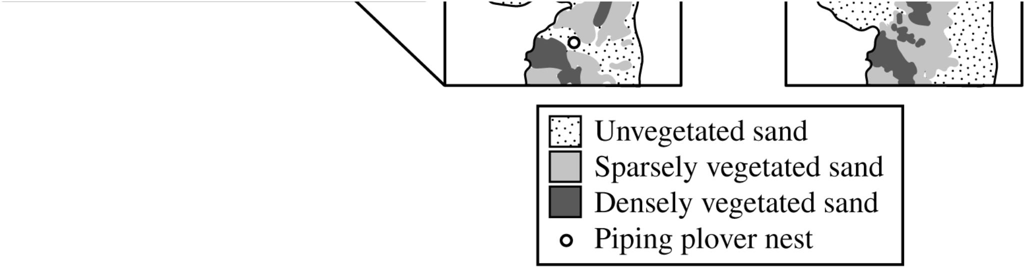
(a)(iii) Describe one likely reason for the change in the number of piping plover nests between 1999 and 2009.

Question 1

SPRING PIPING PLOVER NESTING SITES
ON ASSATEAGUE ISLAND, VIRGINIA



Question 1


Unvegetated sand
Sparsely vegetated sand
Densely vegetated sand
Piping plover nest

Question 1

2019 ▪ Q1

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

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Question 1

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

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

Question 1

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

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

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

Question 1

2019 ▪ Q1

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

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

Question 1

2019 ▪ Q1

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Question 1

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

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

Solution 1

(a)(i)

Mark scheme

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

Solution 1

(a)(ii)

Mark scheme

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

Solution 1

(a)(iii)

Mark scheme

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

Solution 1

(b)(i)

Mark scheme

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

Solution 1

(b)(ii)

Mark scheme

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

Solution 1

(b)(iii) Mark scheme

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

Solution 1

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

Solution 1

(c) Mark scheme

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

Solution 1

(d) Mark scheme

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

Question 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.

Question 1

2017 ▪ Q1

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

[Newspaper clipping, headed “Fremont Daily Times”, article title “Scientists Discuss Threats from Plastic Pollution”:] In testimony before the United States Senate Committee on Environment and Public Works, Dr. Duke Ewoldsen, an eminent toxicologist, discussed a new water pollutant that threatens aquatic life: microbeads. Ewoldsen noted that while posing a different threat than more conventional water pollutants such as nitrates, phosphates and PCBs, tiny beads of plastic contained in many products, especially cosmetics, now threaten plankton and small fish that ingest the particles because they mistake them for food. The microbeads cannot be digested and can fill or block the digestive tracts of the fish, leading to starvation. In addition, surfaces of these small spheres can adsorb organic pollutants such as PCBs and dioxin.

Question 1

When asked about steps to reduce this threat, Ewoldsen noted that the beads are so small that they are not easily removed by wastewater treatment plants and thus often enter aquatic ecosystems in wastewater discharges.

(a) Describe TWO effects that ingesting microbeads has on aquatic organisms.

Question 1

Fremont Daily Times

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(b) Dr. Ewoldsen states that nitrates pose different threats to aquatic ecosystems than microbeads do. Describe how nitrate levels can negatively affect water quality in some aquatic ecosystems.

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(c)(i) While wastewater treatment plants are ineffective at removing microbeads, they are very effective at removing large pieces of plastic waste and other pollutants. Identify one way large pieces of plastic are removed from wastewater during primary treatment.

(c)(ii) Prior to discharge, wastewater is often disinfected. Identify one technique commonly used to disinfect wastewater.

(c)(iii) Sludge or biosolids produced during the wastewater treatment process can be spread on agricultural fields. Identify one advantage and one disadvantage of this practice.

Question 1

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(d)(i) Coastal ecosystems are threatened by other human activities in addition to wastewater disposal. Mangrove swamps are one such threatened ecosystem. Provide one reason why mangrove trees are being removed by humans.

(d)(ii) Identify one ecosystem service provided by intact mangrove ecosystems.

Question 1

2016 ▪ Q1

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

Fremont New Tribune — May 2, 2016

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

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

Question 1

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

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

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

Question 1

Fremont New Tribune May 2, 2016

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

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

Question 1

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

Question 1

2016 ▪ Q1

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Fremont New Tribune — May 2, 2016

As another winter concludes, biologists are alarmed by the continued spread of white nose syndrome (WNS) in bats. WNS is a fungal disease that is decimating bat populations across eastern North American forests, with mortality rates reaching up to 100 percent at many sites. WNS has been found in at least 25 states in the United States and 5 Canadian provinces. The fungus (*Pseudogymnoascus destructans*) grows well in cool conditions such as those found in caves and has been observed as white patches on the muzzles, noses, ears, and wings of many cave-dwelling bats. WNS has caused significant population declines for several bat species, including once-numerous species such as the little brown bat (*Myotis lucifugus*). Little brown bats hunt using echolocation by emitting up to 200 high-frequency calls per second when pursuing their prey. When healthy, the little brown bat can live up to ten years and have one or two offspring (called pups) each year.

Question 1

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

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

Question 1

2016 ▪ Q1

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

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

Solution 1

(a)

Mark scheme

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

Solution 1

(b)(i) Mark scheme

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

Solution 1

(b)(ii)

Mark scheme

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

Solution 1

(c) Mark scheme

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

Solution 1

(d) Mark scheme

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

Solution 1

(e) Mark scheme

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

Solution 1

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