Past-paper walk-through

Meat Production Methods ▪ 5.7

eXercise

Questions in this set

- 2024 Set 1 Q2
- 2024 Set 2 Q2
- 2023 Set 2 Q3
- 2022 Set 2 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 2

2024 Set 1 ▪ Q2

As the human population continues to grow, the demand for animal protein is expected to double by 2050. Animal protein can be obtained from conventional livestock and other sources. The production of all animal protein has environmental costs, as shown in the following graphs. In Figure 1, global warming potential (GWP) is measured in kilograms of carbon dioxide equivalent (kg CO_2-eq). Carbon dioxide equivalent is a measure of the warming effect of a gas relative to that of carbon dioxide. In Figure 2, land use is measured in meters squared (m^2).
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[Figure 1: bar graph titled "Figure 1". Y-axis "Global Warming Potential (kg CO_2-eq.)" from 0 to 140 in increments of 20. X-axis "Production of 1 kg of Animal Protein" with four bars: Mealworms (10), Chicken (27), Pork (37), Beef (120).]

Question 2

[Figure 2: bar graph titled "Figure 2". Y-axis "Land Use (m^2)" from 0 to 200 in increments of 20. X-axis "Production of 1 kg of Animal Protein" with four bars: Mealworms (18), Chicken (50), Pork (53), Beef (188).]

(a) Based on the data in the graphs, **identify** the amount of land required to produce 1 kilogram of chicken protein.

Mealworms, the larvae of the darkling beetle, consume grains and decaying plant material. Darkling beetles are an *r*-selected species, and the entire mealworm can be consumed by humans for protein.

Question 2

Figure 1

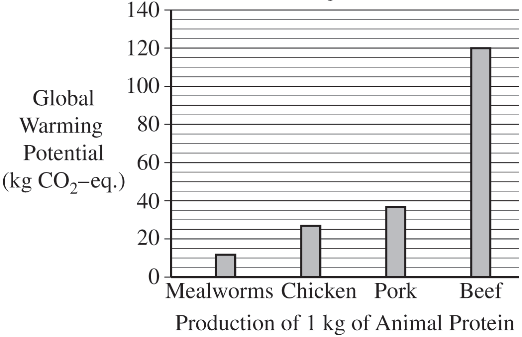
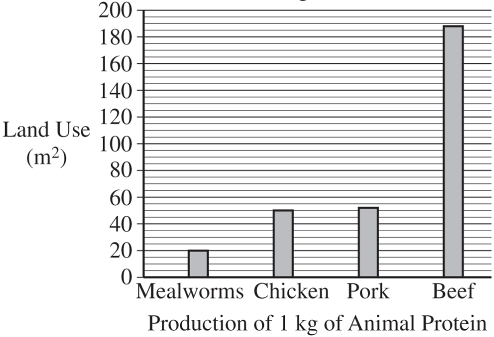


Figure 2



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Question 2

(b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle.

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2024 Set 1 ▪ Q2

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Question 2

(c) Explain why the reproductive strategy of the darkling beetle is an advantage for using mealworms as an alternative protein source for the rapidly growing human population.

An individual's diet choices affect greenhouse gas emissions and land use.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(d) Based on the data in the graphs, **explain** whether producing 1 kilogram of chicken protein or 1 kilogram of pork protein would cause less environmental damage.
Cattle emit methane from fermentation in their digestive systems. The other animals do not emit methane.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(e) Based on the data in the graphs, **explain** why the production of 1 kilogram of beef protein has a different impact on global warming than the production of 1 kilogram of protein from any of the other animals studied would have.
Agricultural practices can have negative impacts on rivers and streams.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(f) Describe how water quality can be altered by cattle grazing that occurs near a stream or river.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(g) Propose a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(h) Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(i) Justify the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion.

Question 2

2024 Set 1 ▪ Q2

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Question 2

(j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change.

Solution 2

(a)

Mark scheme

- 50 m^2 of land is required to produce 1 kilogram of chicken protein (read from the graph).

Solution 2

(b)

Mark scheme

- The darkling beetle exhibits a Type III survivorship curve (high mortality early in life, few survivors reach old age — consistent with an r-selected species).

Solution 2

(c)

Mark scheme

- Darkling beetles are r-selected and reproduce quickly with many offspring, which allows a large amount of protein (mealworm biomass) to be produced in a short period of time — an advantage for feeding a rapidly growing human population.

Solution 2

(d)

Mark scheme

- Producing 1 kg of chicken protein causes less environmental damage than producing 1 kg of pork protein: chicken production has a lower global warming potential (releases less greenhouse gas) than pork, and/or chicken has lower land use than pork, so it causes less deforestation/habitat destruction/soil erosion/fossil fuel use.

Solution 2

(e)

Mark scheme

- Beef production has a larger impact on global warming than the other animals studied because cattle emit methane from digestive (enteric) fermentation, and methane is a greenhouse gas with a high global warming potential; beef also requires much more land use, which causes loss of forests/habitat/grasslands and releases stored CO2 (reducing carbon storage).

Solution 2

(f)

Mark scheme

- Cattle grazing near a stream or river can alter water quality by: causing erosion that increases sedimentation/turbidity in the water; adding nutrients (nitrogen/phosphorus) to waterways via feces; and/or contaminating waterways with bacteria from feces.

Solution 2

(g)

Mark scheme

- A solution that reduces waterway damage while still allowing grazing: practice rotational grazing (alternate grazing parcels so land can recover); reduce dietary reliance on meat/beef; fence/barricade the riparian zone to keep cattle out of the waterway; or provide alternative water sources for the cattle away from the stream.

Solution 2

(h)

Mark scheme

- A sustainable agricultural practice to reduce soil erosion: switch crops to perennial plants; plant crops on terraces; implement contour plowing/farming; or use no-till farming/cover crops.

Solution 2

(i)

Mark scheme

- Justify the practice named in part (h) with an advantage beyond reduced erosion. Matching the scoring table: perennial crops or no-till/cover crops $\rightarrow$ reduce fossil fuel use, reduce farming costs, increase/maintain soil carbon storage, and preserve soil habitat for organisms (cover crops can also serve as green manure); terracing or contour plowing $\rightarrow$ allows otherwise-too-steep areas to be farmed and increases groundwater absorption (terracing also lets sediment/contaminants settle out behind the ridge, further reducing runoff).

Solution 2

(j)

Mark scheme

- Climate change could negatively affect crop production/yields through: increased drought; increased flooding; increased insect infestation due to warmer temperatures; increased temperature generally; changes in seasonal rain patterns; expansion of the geographic range of invasive pests/species; or climate conditions moving outside crops' range of tolerance.

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

- 1900: Forest 49%, Crops 8%, Grazing 16%, Wild grasslands 27%, Built-up land negligible.
- 1950: Forest 45%, Crops 12%, Grazing 31%, Wild grasslands 12%, Built-up land small sliver.
- 2000: Forest 39%, Crops 15%, Grazing 32%, Wild grasslands 13%, Built-up land small sliver.
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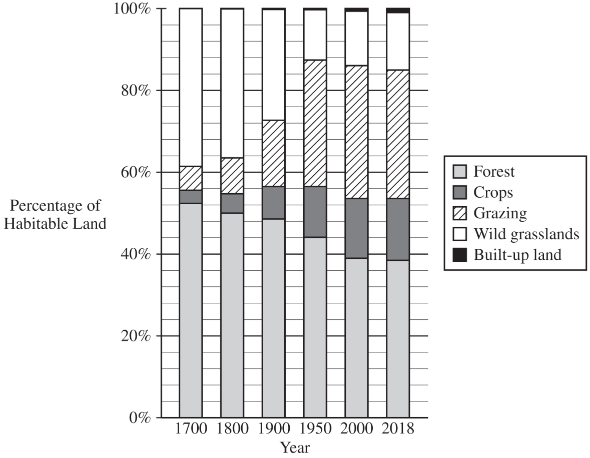
(a) Based on the data in the graph, identify the year with the highest percentage of forest.

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

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

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

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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

Question 2

2024 Set 2 ▪ Q2

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

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2024 Set 2 ▪ Q2

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

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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.

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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.

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2024 Set 2 ▪ Q2

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Question 2

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- 1950: Forest 45%, Crops 12%, Grazing 31%, Wild grasslands 12%, Built-up land small sliver.
- 2000: Forest 39%, Crops 15%, Grazing 32%, Wild grasslands 13%, Built-up land small sliver.
- 2018: Forest 38%, Crops 15%, Grazing 33%, Wild grasslands 13%, Built-up land small sliver.]

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

Question 2

2024 Set 2 ▪ Q2

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

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

Question 2

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

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

Solution 2

(a)

Mark scheme

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

Solution 2

(b)

Mark scheme

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

Solution 2

(c)

Mark scheme

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

Solution 2

(d)

Mark scheme

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

Solution 2

(e)

Mark scheme

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

Solution 2

(f) Mark scheme

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

Solution 2

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

Solution 2

(g)

Mark scheme

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

Solution 2

(h)

Mark scheme

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

Solution 2

(i)

Mark scheme

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

Solution 2

(j) Mark scheme

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

Question 3

2023 Set 2 ▪ Q3

Human activities generate large amounts of solid waste, including organic waste. The decomposition of organic waste in landfills can result in the release of methane into the atmosphere.

There are biological and physical factors that can affect the decomposition of the solid waste in a landfill and the release of methane in the atmosphere.

Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(a) Describe one environmental problem associated with the release of methane into the atmosphere.

Question 3

2023 Set 2 ▪ Q3

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Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

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(b) Describe one factor that could affect the decomposition of the solid waste in a landfill.

Question 3

2023 Set 2 ▪ Q3

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Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

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(c) Propose a solution to decrease the amount of methane released from landfills into the atmosphere.

Question 3

2023 Set 2 ▪ Q3

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Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(d) Justify the solution proposed in part (c) by describing an additional advantage, other than decreasing the amount of methane released from landfills.

Question 3

2023 Set 2 ▪ Q3

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Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(e) The average cow releases 150 liters of methane per day. **Calculate** the amount of methane that was released by all beef cattle raised in the United States in 2021. **Show** your work.

Question 3

2023 Set 2 ▪ Q3

Human activities generate large amounts of solid waste, including organic waste. The decomposition of organic waste in landfills can result in the release of methane into the atmosphere.

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Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(f) A typical beef cow needs 11.8 kilograms of food per day, and each hectare of cattle pasture produces 26.2 kilograms of grasses. **Calculate** the number of hectares of

Question 3

pasture that would be needed to support all beef cattle raised in the United States for one day. **Show** your work.

Question 3

2023 Set 2 ▪ Q3

Human activities generate large amounts of solid waste, including organic waste. The decomposition of organic waste in landfills can result in the release of methane into the atmosphere.

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Another anthropogenic activity that releases methane is raising beef cattle. In 2021, 31.2 million beef cattle were raised in the United States.

Another environmental concern with raising beef cattle for food is that it is not as efficient as growing crops for food.

(g) The average American consumes 2,250 kilocalories of food per day. Beef cattle can produce 2.7 million kilocalories per hectare of land. Corn can produce 30.4 million kilocalories per hectare of land. **Calculate** how many more American people could be

Question 3

fed if 150 hectares of land was used to grow corn instead of raising beef cattle. **Show** your work.

Solution 3

(a)

Mark scheme

- One environmental problem, e.g.: methane traps heat effectively, enhancing the greenhouse effect and leading to climate change/global warming — which can in turn cause melting ice and rising sea levels.

Solution 3

(b)

Mark scheme

- One factor, e.g.: the amount/percentage of organic material in the solid waste; the amount/percentage of non-degradable material in the waste; landfill conditions such as oxygen concentration, population of microbes/decomposers, temperature, or moisture; or environmental conditions of the area such as temperature, rainfall, climate, or weather.

Solution 3

(c)

Mark scheme

- A solution such as: incinerating waste; composting waste; recycling/reusing non-synthetic organic waste (paper, textiles); installing/using methane collection systems; or burning off/combusting the methane coming from the landfill.

Solution 3

(d) Mark scheme

- An additional advantage matching the solution proposed in (c). Incinerating waste: extends the landfill's lifetime, reduces the amount of waste going to the landfill, can be used to generate electricity/heat or income, or reduces land area needed for landfills. Composting waste: extends the landfill's lifetime, produces effective inexpensive fertilizer, or reduces land area needed for landfills. Recycling/reusing organic waste: reduces land needed for landfills, reduces energy/resources needed for new products, or reduces trees cut for new paper. Installing methane collection / burning off methane: can be used to generate electricity, can be used to heat buildings, can generate income, can be used as fuel, or reduces the need for other energy sources.

Solution 3

(e)

Mark scheme

- Setup (1 pt): 150 L methane/day/cow $\times$ 31,200,000 cows (cattle) $\times$ 365 days/year. Calculation (1 pt): 150 $\times$ 31,200,000 $\times$ 365 $=$ 1,708,200,000,000 L (1.7 $\times$ 10^12 L) of methane released by all beef cattle raised in the United States in one year.

Solution 3

(f)

Mark scheme

- Setup (1 pt): (11.8 kg food/day/cow ÷ 26.2 kg grass produced/ha) × 31,200,000 cows (cattle). Calculation (1 pt): (11.8/26.2) × 31,200,000 14,051,908 hectares (1.4 × 10ˆ7 ha, or 14.1 million hectares) of pasture needed to support all beef cattle raised in the United States for one day.

Solution 3

(g)

Mark scheme

- Setup (1 pt): [(30,400,000 kcal/ha − 2,700,000 kcal/ha) ÷ 2,250 kcal/person] × 150 ha — the extra kcal/ha produced by growing corn instead of raising beef cattle, converted to people fed, for 150 hectares. Calculation (1 pt): (27,700,000/2,250) × 150 = 1,846,667 additional people (1.8 × 10^6) could be fed if 150 hectares were used to grow corn instead of raising beef cattle.

Question 1

2022 Set 2 ▪ Q1

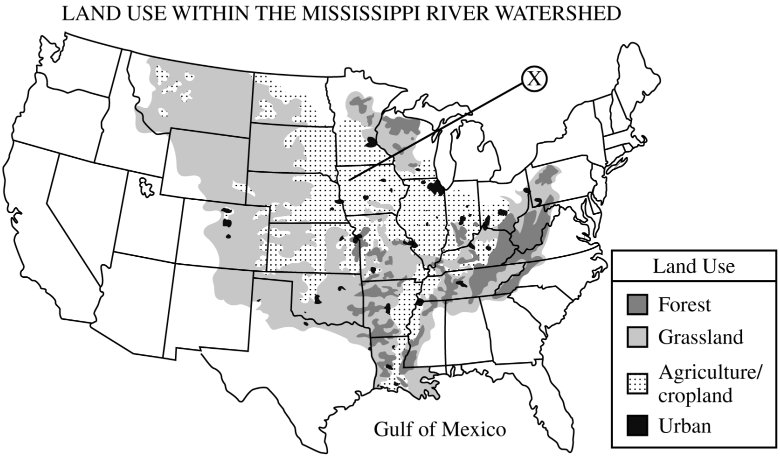
The dead zone in the Gulf of Mexico occurs every summer when winter snow melts and spring rain flows into the Mississippi River. Recent studies have shown that both the total area covered by algae and the depth of the algal mass in the dead zone are increasing.

[Map titled "LAND USE WITHIN THE MISSISSIPPI RIVER WATERSHED": a map of the continental United States showing the Mississippi River watershed shaded by land use type, with the Gulf of Mexico labeled at the bottom. A point labeled "X" is marked in the upper-central part of the watershed (near the Great Lakes region), connected by a line from the map. Legend "Land Use": Forest (dark gray shading), Grassland (light gray shading), Agriculture/cropland (dotted/stippled shading), Urban (solid black shading, scattered small patches throughout the watershed, especially clustered in the east and around the Great Lakes).]

Question 1

(a)(i) Various land use practices can have different effects on the waters that surround a dead zone.
Identify the land use that covers the least amount of area in the Mississippi River watershed, based on the diagram.
(a)(ii) Describe one way that the land use practice at location X in the diagram could contribute to the dead zone in the Gulf of Mexico.
(a)(iii) Describe one way that urban areas in the Mississippi River watershed could contribute to the dead zone in the Gulf of Mexico.

Question 1


LAND USE WITHIN THE MISSISSIPPI RIVER WATERSHED
X
Gulf of Mexico
Land Use
Forest
Grassland
Agriculture/ cropland
Urban

Question 1

2022 Set 2 ▪ Q1

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Question 1

(b)(i) The dead zone in the Gulf of Mexico has both economic and environmental effects for coastal communities.
Describe how a dead zone affects marine organisms living in the Gulf of Mexico.
(b)(ii) Describe one economic effect on communities along the Gulf of Mexico that can result from the presence of the dead zone.
(b)(iii) Describe one factor that causes the area of the dead zone in the Gulf of Mexico to increase in the summer months.

Question 1

2022 Set 2 ▪ Q1

The dead zone in the Gulf of Mexico occurs every summer when winter snow melts and spring rain flows into the Mississippi River. Recent studies have shown that both the total area covered by algae and the depth of the algal mass in the dead zone are increasing.

[Map titled "LAND USE WITHIN THE MISSISSIPPI RIVER WATERSHED": a map of the continental United States showing the Mississippi River watershed shaded by land use type, with the Gulf of Mexico labeled at the bottom. A point labeled "X" is marked in the upper-central part of the watershed (near the Great Lakes region), connected by a line from the map. Legend "Land Use": Forest (dark gray shading), Grassland (light gray shading), Agriculture/cropland (dotted/stippled shading), Urban (solid black shading, scattered small patches throughout the watershed, especially clustered in the east and around the Great Lakes).]

Question 1

(c)(i) Researchers want to examine the effect of riparian vegetation buffers on water quality in streams in agricultural areas. Researchers will measure the water nutrient concentrations over the course of one year. The study sites are located 100 meters downstream from areas either with or without riparian vegetation buffers.
Identify a testable hypothesis for the study.
(c)(ii) Describe a control that the researchers could use in the study.
(c)(iii) Identify one water quality test, other than measuring nitrates or phosphates, that the researchers could use to evaluate how riparian vegetation buffers affect water quality.
(c)(iv) During the investigation, researchers discovered that some of the land next to one of the streams with a riparian vegetation buffer is going to be converted from cornfields into a large-scale concentrated animal feeding operation. **Explain** one way that this change in land use could alter the results of the study.

Solution 1

(a)(i)

Mark scheme

- Urban — urban land use covers the least area of the Mississippi River watershed shown in the diagram.

Solution 1

(a)(ii)

Mark scheme

- Any one way land use at location X could contribute to the dead zone: fertilizer applied to croplands washes into streams/rivers and feeds algae growth once it reaches the Gulf; concentrated animal feeding operations (CAFOs) generate large amounts of organic waste that moves into streams and rivers, feeding algae growth in the Gulf; treated or untreated (overflow) sewage released from wastewater treatment plants feeds algae growth in the Gulf.

Solution 1

(a)(iii)

Mark scheme

- Any one way urban areas could contribute to the dead zone: wastewater treatment facilities in urban areas may release nutrients in treated wastewater and/or overflows that flow into the Gulf; impervious surfaces in urban areas increase runoff of lawn fertilizers or high-phosphate detergents that move onto pavement and flow into the Gulf.

Solution 1

(b)(i)

Mark scheme

- Any one effect: many organisms are forced to migrate or die because of low dissolved oxygen levels in the water (hypoxia); many organisms are forced to migrate or die because algal blooms block sunlight from reaching submerged aquatic vegetation.

Solution 1

(b)(ii)

Mark scheme

- Any one economic effect: decreased fish catch / decreased income for the fishing industry; decreased tourism / lower tourism revenues; increased fuel costs for fishing vessels that must travel farther to find fish, decreasing income/profits; increased costs for consumers due to a limited supply of fish.

Solution 1

(b)(iii)

Mark scheme

- Any one factor: increased runoff of nitrates/phosphates/potassium from fertilizer used during the growing season increases algal growth in summer; increased precipitation/snowmelt/water volume carries more fertilizer runoff from urban or agricultural areas, increasing algal growth; higher water temperatures in summer decrease dissolved oxygen concentration (warm water holds less DO than cold water); increased runoff of fertilizer or high-phosphate detergents used in urban areas increases algal growth in summer.

Solution 1

(c)(i)

Mark scheme

- Any testable hypothesis of the form: if riparian vegetation buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will be lower (or higher, or the same) than in areas without riparian buffers.

(c)(ii)

Mark scheme

- The control is stream sites located 100 meters downstream from areas WITHOUT riparian vegetation buffer zones.

Solution 1

(c)(iii)

Mark scheme

- Any one water quality test other than nitrates or phosphates: turbidity; total suspended solids (TSS); dissolved oxygen; water temperature; fecal coliform; conductivity; pH; biological oxygen demand (BOD).

Solution 1

(c)(iv) Mark scheme

- Any one explanation: water quality would decline from increased nutrients/coliform bacteria in runoff because animal waste near the new CAFO is high in nutrients/coliform bacteria; water quality would decline from increased turbidity/total suspended solids because particles from animal waste enter the stream / streambed disruption increases; water quality would decline from increased water temperature because the increased turbidity/suspended solids absorb more sunlight/heat; water quality would decline from increased conductivity because of increased water temperature/dissolved salts near the CAFO; water quality would decline from antibiotics/veterinary drugs present in runoff from livestock operations (not used on the original cornfield crop). This

Solution 1

confounds the study because conditions change at the riparian-buffer site independent of the buffer treatment itself.