Question 2: Analyze an Environmental Problem and Propose a Solution — 10 points

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

- 50 m^2

(b) Based on the information provided, **identify** the type of survivorship curve exhibited by the darkling beetle. — **1 point**

- Type III

(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. — **1 point**

Accept one of the following:

- Darkling beetles reproduce quickly, which allows for a large amount of protein to be produced in a short period of time.
- Darkling beetles have many offspring, which allows for a large amount of protein to be produced in a short period of time.

(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. — **1 point**

Accept one of the following:

- Chicken production has a lower global warming potential than pork production, so it would cause less environmental damage because chicken production releases less greenhouse gas.
- Chicken production has a lower land use than pork production, so it would cause less environmental damage because there would be less deforestation/habitat destruction/soil erosion/fossil fuel use.

(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. — **1 point**

Accept one of the following:

- Beef has a larger impact because methane has a high global warming potential.
- Beef has a larger impact because methane is a greenhouse gas.
- Beef requires more land use, which results in loss of forests/habitat/grasslands leading to release of CO_2/reduction in carbon storage.

(f) **Describe** how water quality can be altered by cattle grazing that occurs near a stream or river. **1 point**

Accept one of the following:

- Cattle cause erosion, which increases sedimentation/turbidity in water.
- Cattle feces can add nutrients/nitrogen/phosphorus to waterways.
- Cattle feces may contaminate waterways with bacteria.

(g) **Propose** a solution to reduce the negative impacts on waterways that result from cattle grazing, while still allowing cattle to graze. **1 point**

Accept one of the following:

- Practice rotational grazing/alternate grazing parcels.
- Eat a diet with less meat/beef.
- Fence/barricade the riparian zone.
- Provide other water sources for the cattle.

(h) Crop production can cause soil erosion. **Describe** a sustainable agricultural practice used to reduce soil erosion. **1 point**

Accept one of the following:

- Switch crops to perennial plants.
- Plant crops on terraces.
- Implement contour plowing/farming.
- Use no-till farming/cover crops.

(i) **Justify** the use of the sustainable practice described in part (h) by describing an additional advantage, other than the reduction of soil erosion. **1 point**

Accept one of the following:

Solution proposed in (h)	Justification of solution with additional advantage other than the reduction of soil erosion
Switch to perennial plants	• Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils.
Plant crops on terraces	• Allows areas to be farmed that are otherwise too steep. • Sediments and other contaminants settle out behind the terrace ridge reducing the amount of soil that runs off. • Increases groundwater absorption.
Implement contour plowing/farming	• Allows areas to be farmed that are otherwise too steep. • Increases groundwater absorption.
Use no-till farming/cover crops	• Reduces the use of fossil fuels. • Reduces the cost of farming. • Increases/maintains carbon storage in soils. • Preserves habitats for organisms in soils. • Cover crops can be used as green manure.

(j) Crop production around the world is affected by climate change. **Describe** how crop production could be negatively affected by climate change. **1 point**

Accept one of the following:

- Crop production/yields could decrease because of:
  - Increased drought
  - Increased flooding
  - Increased insect infestation from warmer temperatures
  - Increased temperature
  - Changes in seasonal rain patterns (or temperatures)
  - Expansion of geographic range of invasive pests/species
  - Climate may be outside range of tolerance of crops

Total for question 2 10 points

Question 1: Design an Investigation — 10 points

(a) **Identify** the ecological change over time illustrated in the diagram. **1 point**

- Primary Succession

(b) **Identify** the stage in which pioneer species first appear. **1 point**

- II/2

(c) **Describe** how soil forms from stage II to stage III. **1 point**

Accept one of the following:

- Wind/rain/weather can erode the rock/parent material.
- Wind/rain can break down rocks.
- Pioneer species (lichen/algae/fungi) die off adding small amounts of organic material.
- Pioneer species (lichens/algae/fungi) help break down rocks.

(d) **Identify** a cultural ecosystem service that may be provided by a mature forest. **1 point**

Accept one of the following:

- Recreation
- Aesthetic enjoyment
- Spiritual use
- Ecotourism
- Education

(e) **Identify** a testable hypothesis being investigated by the researchers. **1 point**

Accept one of the following:

- The removal of trees/clear-cutting will lead to an increase/decrease in water quality (temperature/turbidity/dissolved oxygen).
- The removal of trees/clear-cutting will have no effect on water quality (temperature/turbidity/dissolved oxygen).
- Water quality (temperature/turbidity/dissolved oxygen) will increase/decrease between stations.
- Water quality (temperature/turbidity/dissolved oxygen) will not change between stations.

(f) **Identify** the independent variable in the experiment. **1 point**

Accept one of the following:

- Presence or absence of clear-cutting
- Intact or clearcut forest
- Location of stream monitoring stations

(g) **Describe** the purpose of forest A in the experiment. **1 point**

Accept one of the following:

- Forest A/A/It is included so the researchers can compare the temperature/turbidity/water quality in clear-cut areas (forest B) to intact areas.
- Forest A/A/It acts as a control so researchers can compare intact areas/Forest A to clear-cut areas/Forest B.

(h) **Explain** why the water temperature might change because of clear-cutting trees in forest B. **1 point**

Accept one of the following:

- Water temperature will increase because there will be no/fewer trees to block the sunlight.
- Water temperature will increase because there will be additional sediment from erosion.
- Water temperature will increase because more sunlight will reach the water surface.

(i) **Explain** why an indicator of water quality other than temperature could be altered by the golf course in forest B. **1 point**

Accept one of the following:

- There could be a decrease in dissolved oxygen because fertilizer runoff leads to algal blooms/eutrophication.
- There could be a decrease in sedimentation/turbidity because the grass will decrease erosion compared to the clear-cut land.
- There could be an increase in nitrates/phosphates due to fertilizer runoff resulting in algal growth/bloom.

(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. **1 point**

Accept one of the following:

- Aquatic organisms would die off from a lack of oxygen created by the decomposition of algae/eutrophication.
- Aquatic organisms would survive at a higher rate because there is less sediment to suffocate them/clog their gills.
- Aquatic organisms would die off due to increased toxicity from pesticide runoff.

Total for question 1 10 points

Question 2: Analyze an Environmental Problem and Propose a Solution — 10 points

(a) Based on the data in the graph, **identify** the year with the highest percentage of forest. **1 point**

- 1700

(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. **1 point**

Accept one of the following:

- The percentage/amount of wild grasslands has decreased, and the percentage/amount of grazing (land) has increased.
- The two variables have an inverse relationship.

(c) **Identify** an environmental problem associated with overgrazing by livestock. **1 point**

Accept one of the following:

- Loss of vegetation
- Soil erosion
- Desertification
- Sedimentation/turbidity in waterways
- Soil compaction

(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. **1 point**

- The hypothesis is refuted/disproved/not supported. The percentage of forest has decreased, so the amount of photosynthesis/carbon sequestration has decreased.

(e) **Describe** a water-related environmental problem associated with urbanization. **1 point**

Accept one of the following:

- Increased runoff/flooding because urban areas have more impermeable surfaces.
- Decreased groundwater/saltwater intrusion because urban areas have many people/groundwater is overused.
- Increased water pollution because precipitation/runoff can carry contaminants/pollutants/waste.
- Destruction of aquatic habitats from increased development/land use changes.

(f) **Describe** a potential response to mitigate the environmental problem identified in part (e). **1 point**

Accept one of the following:

Environmental problem identified in part (e)	Potential response to mitigate environmental problem
Increased runoff/flooding	• Use permeable road/parking lot materials. • Set aside green spaces/parks/conservation areas. • Construct green roofs/rain gardens/storm water retention ponds/basins.
Decreased groundwater/saltwater intrusion	• Use permeable road/parking lot materials. • Establish groundwater conservation/management plans. • Set aside green spaces/parks/conservation areas in recharge zones. • Construct green roofs/rain gardens/storm water retention ponds/basins.
Increased water pollution	• Encourage walking/biking or other methods of transportation. • Reduce use of home pesticides/fertilizers. • Reduce use of road salts/de-icing chemicals • Pick up trash and litter along waterways. • Dispose of toxic chemicals (for example, used oil and household cleaners).
Destruction of aquatic habitats from increased development/land use changes	• Create conservation areas/preserves/wetlands to protect aquatic habitats. • Restore degraded aquatic habitats.

(g) **Explain** why there are fewer bobcats present on the farmland now compared to several decades ago. **1 point**

Accept one of the following:

- Loss of forest habitat has led to a decrease in resources/food/shelter/ mates/migration.
- Trapping/hunting has reduced the bobcat population.

(h) **Describe** a disadvantage of introducing only a small population of bobcats. **1 point**

Accept one of the following:

- Small populations have lower genetic diversity.
- Genetic bottlenecks can lead to inbreeding/passing on negative traits.
- Small populations are more vulnerable to diseases/disturbances like wildfire.
- Small populations do not control small mammals/pests as well as large populations.
- Small populations are less likely to survive.

(i) **Propose** a solution to improve the chances that the bobcat reintroductions will be successful in reestablishing wild populations. **1 point**

Accept one of the following:

- Increase connectivity/build habitat corridors (so bobcats can safely mate/find food/build dens).
- Restore/reforest/preserve areas of bobcat habitat.

(j) **Justify** the solution proposed in part (i) by describing an additional advantage, other than reestablishing the bobcat population near the farms. **1 point**

Accept one of the following:

Solution proposed in part (i)	Justification of the proposed solution by stating an advantage
Increase connectivity/build habitat corridors (so that bobcats can safely mate/find food/build dens)	• Habitat corridors can be used by other species. • Habitat corridors would increase biodiversity/population of other species. • Habitat corridors can attract other species that might be beneficial for farmers (such as predators of pests and/or pollinator species). • Habitat corridors could help decrease road kills/the frequency of car accidents with wildlife.
Restore/reforest/preserve areas of bobcat habitat	• Restored habitat can be used by other species. • Restoration/reforestation/preservation could increase diversity/improve air quality/improve water quality. • An increase in the number of trees will improve aesthetic value/enhance tourism/reduce erosion/serve as a carbon sink.

Total for question 2 **10 points**

Question 1: Design an Investigation — 10 points

(a) **Identify** the control group in this experiment. **1 point**

Accept one of the following:

- Plot D
- Unmodified beans

(b) **Identify** the scientific question for the investigation. **1 point**

Accept one of the following:

- Will genetically modified green beans have higher crop yields than unmodified green beans?
- Is there a difference between the crop yields of genetically modified and unmodified green beans?
- Does genetically modifying green beans affect crop yield?

(c) Researchers repeated the experiment modifying the length of time for the spray irrigation to 20 minutes per day. **Explain** how the results of the experiment could be altered with this modification. **1 point**

Accept one of the following:

- With less water, there will be lower crop yield/fewer green beans harvested in all plots.
- The genetically modified beans will remain similar in yield because they are resistant to drought/need less water, but the unmodified beans will decrease in crop yield because they will receive less water.

(d) Based on the data in the table, **identify** the plot with the lowest soil temperature. **1 point**

Accept one of the following:

- Plot D
- The unmodified green beans

(e) **Describe** how sediment runoff and fertilizer runoff compare between the unmodified green beans and the genetically modified green beans. **1 point**

Accept one of the following:

- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are lower with the genetically modified beans.
- Both types of runoff/Sediment and fertilizer (phosphorus/nitrogen) runoff are higher with the unmodified beans.

(f) The Type 2 GMO beans in Plot B were developed to grow more quickly than the unmodified beans in Plot D. Researchers have hypothesized that the Type 2 beans would use fertilizer more completely than the other varieties. Based on the data in the table and the experimental design, **explain** whether the researchers' hypothesis was supported or refuted. **1 point**

Accept one of the following:

- The hypothesis is supported because there is less fertilizer (phosphorus/nitrogen) in the runoff from plot B, so the beans in plot B are absorbing/taking up more fertilizer (phosphorus/nitrogen).
- The hypothesis is supported because there is more fertilizer (phosphorus/nitrogen) in the runoff from plot D, so the beans in plot D are absorbing/taking up less fertilizer (phosphorus/nitrogen).
- The hypothesis is supported because the plants in plot B were able to produce more beans given the same amount of fertilizer.

(g) **Describe** the ecological process that occurred on the plots after the crops were burned. **1 point**

Accept one of the following:

- Fast growing/early successional organisms returned to/colonized the soil after the fire/major disturbance.
- Secondary succession occurred where plants recolonize a habitat after the fields were burned/after a major disturbance.

(h) After each flooding event, the plot with twice the plant diversity returned to its prior level of biodiversity more quickly than the other plots did. **Explain** why a community with more plant diversity will recover more quickly from the flooding. **1 point**

Accept one of the following:

- The plot with higher diversity/richness has more species/organisms, so the floods harm a smaller proportion of the species/organisms.
- The plot with higher diversity/richness has more connections between organisms, so the floods disrupt a smaller percentage of the connections between organisms.
- The plot with higher genetic diversity within species may have more flood tolerant individuals that will survive a flood.

(i) After the last flooding event, a beetle not previously known in the area appeared in one of the plots with less plant diversity. Over a period of a few months, the new beetle population increased, whereas the existing beetle species in the plot had declining populations. **Explain** why the new beetle species could be better able to successfully populate this plot than the existing beetle species could. **1 point**

Accept one of the following:

- The new beetle is a generalist/r-selected species and could more quickly populate the area/outcompete the existing/native beetle species.
- The flooding of the plot caused a natural disruption to the existing community, eliminating species/natural predators and opening niches for the new/invasive beetle.
- Low diversity communities are susceptible to disruption and can't recover allowing the new/nonnative beetle species to invade
- The new beetle is an invasive species that can live outside its normal environment and threaten native species

(j) **Describe** one realistic method to prevent the new beetle from spreading beyond the experimental plot. **1 point**

Accept one of the following:

- Remove beetles by trapping/physical removal to reduce their population size.
- Apply a chemical/pesticide to kill beetles.
- Add a predator/parasite/pathogen/biological control that harms beetles.

Total for question 1 10 points

Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 10 points

(a) **Describe** one environmental problem associated with the release of methane into the atmosphere. **1 point**

Accept one of the following:

- It traps heat effectively leading to climate change/global warming.
- The greenhouse effect is enhanced, increasing global temperatures/warming.
- It is a greenhouse gas, which leads to climate change/global warming.
- It is a greenhouse gas, which leads to melting ice/rising sea levels.

(b) **Describe** one factor that could affect the decomposition of the solid waste in a landfill. **1 point**

Accept one of the following:

- The amount of/percentage of organic material in the solid waste.
- The amount of/percentage of non-degradable material in the solid waste.
- Conditions of the landfill (such as concentration of oxygen, population of microbes/decomposers, temperature, moisture).
- Environmental conditions of the area (such as temperature, amount of rainfall, climate, weather, etc.).

(c) **Propose** a solution to decrease the amount of methane released from landfills into the atmosphere. **1 point**

Accept one of the following:

- Incinerate waste.
- Compost waste.
- Recycle/reuse non-synthetic organic waste (paper, textiles).
- Install/Use methane collection systems.
- Burn off/Combust the methane coming from the landfill.

(d) **Justify** the solution proposed in part (c) by describing an additional advantage, other than decreasing the amount of methane released from landfills. **1 point**

Accept one of the following:

Solution proposed in part (c)	Justification of solution with additional advantage
Incinerate waste.	• Extends the lifetime of the landfill. • Reduces the amount of waste going to the landfill. • Can be used to generate electricity/heat. • Can generate income. • Reduces land area needed for landfills.
Compost waste.	• Extends the lifetime of the landfill. • Produces effective, inexpensive fertilizer. • Reduces land area needed for landfills.
Recycle/Reuse non-synthetic organic waste (paper, textiles, etc.).	• Reduces land needed for landfills. • Reduces energy/resources needed for new products. • Reduces trees cut for new paper.
Install/Use methane collection systems. Burn off/Combust the methane coming from the landfill.	• Can be used to generate electricity. • Can be used to heat buildings. • Can generate income. • Can be used as fuel. • Reduces the need for other energy sources.

(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 one year. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of methane released in one year:

Accept one of the following:

- $\frac{150 \text{ L methane per day}}{\text{cow}} \times 31{,}200{,}000 \text{ cows (cattle)} \times \frac{365 \text{ days}}{1 \text{ year}}$
- $31{,}200{,}000 \times \frac{150 \text{ L}}{\text{cow}} \times 365 \text{ days}$
- $150 \times 31{,}200{,}000 \times 365$

One point for the correct calculation of the amount of methane released in one year: **1 point**

Accept one of the following:

- 1,708,200,000,000 L
- 1.7×10^{12} L

Total for part (e) 2 points

(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 pasture that would be needed to support all beef cattle raised in the United States for one day. **Show** your work. **1 point**

One point for the correct setup to calculate the number of hectares of pasture to support cattle:

Accept one of the following:

- $\frac{11.8 \text{ kg}}{\text{cow}} \times \frac{1 \text{ ha}}{26.2 \text{ kg}} \times 31{,}200{,}000 \text{ cows (cattle)}$
- $31{,}200{,}000 \times \frac{11.8 \text{ kg}}{26.2 \text{ kg}}$
- $\frac{11.8}{26.2} \times 31{,}200{,}000$

One point for the correct calculation of the number of hectares of pasture to support cattle: **1 point**

Accept one of the following:

- 14,051,908
- 1.4×10^{7}
- 14.1 million

Total for part (f) 2 points

(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 fed if 150 hectares of land was used to grow corn instead of raising beef cattle. **Show** your work. **1 point**

One point for the correct setup to calculate the change in the number of people:

Accept one of the following:

- $\frac{(30{,}400{,}000 \text{ kcal} - 2{,}700{,}000 \text{ kcal})}{1 \text{ ha}} \times \frac{1 \text{ person}}{2{,}250 \text{ kcal}} \times 150 \text{ ha}$
- $(30{,}400{,}000 - 2{,}700{,}000) \times \frac{1 \text{ person}}{2{,}250 \text{ kcal}} \times 150$
- $\left(\frac{30{,}400{,}000}{2{,}250} \times 150\right) - \left(\frac{2{,}700{,}000}{2{,}250} \times 150\right)$
- $\frac{(30{,}400{,}000 - 2{,}700{,}000)}{2{,}250} \times 150$

One point for the correct calculation of the change in the number of people: **1 point**

Accept one of the following:

- 1,846,667
- 1.8×10^6

Total for part (g) 2 points

Total for question 3 10 points

Question 1: Design an Investigation — 10 points

(a) (i) **Identify** the area with the greatest nest success rate, based on the information in the diagram. **1 point**

Accept one of the following:

- Area A
- Site/area upstream from the factory

(ii) **Identify** the dependent variable in the study. **1 point**

- Turtle nesting success

(iii) Based on the information provided, **identify** a likely scientific question for the study. **1 point**

Accept one of the following:

- Does mercury content in the turtle's habitat affect common snapping turtle nest success?
- Does mercury content in the turtle's habitat affect the location/site of common snapping turtle nests?

(iv) **Describe** why researchers measured mercury levels in locations upstream from the factory. **1 point**

Accept one of the following:

- The upstream locations acted as a control group in the study.
- The site was used to compare with the high mercury turtle nests downstream.

(v) There are plans to remove trees and other vegetation along the riverbank. **Explain** how this modification could affect the location and number of successful turtle nests in Area B. **1 point**

Accept one of the following:

- With more open area closer to the river, turtles don't have to travel as far to build nests, leading to exposure to higher levels of mercury near the river, decreasing the number of successful nests.
- With less vegetation to remove the mercury/heavy metals/endocrine disruptors/pesticides, there will be increased concentrations in the soil, decreasing the number of successful nests.
- Soil erosion along the stream would increase, which would make it more difficult for turtles to build nests there and decrease the number of successful nests.
- With less vegetation and reduced shade, the soil temperature will increase/moisture will decrease, decreasing the number of successful nests.

Total for part (a) 5 points

(b) (i) **Describe** how a persistent pollutant, such as mercury, can negatively affect an organism. **1 point**

Accept one of the following:

- The mercury/persistent pollutant could bioaccumulate in the tissues of organisms because the pollutants do not easily break down and can accumulate over time.
- Mercury is a neurotoxin, which can disrupt an animal's nervous system/neuron functioning.
- The mercury/persistent pollutant disrupts regular functioning of an animal's brain/kidneys/liver/immune system/reproductive system and can lead to death.

(ii) **Describe** how a persistent pollutant, such as mercury, can negatively affect an ecosystem. **1 point**

Accept one of the following:

- A toxin can biomagnify in the food chain impacting top predators that will have a very high concentration of the pollutant.
- The death of top predators in a food chain leads to a trophic cascade.
- Reproductive success of individual organisms can decrease from exposure to the pollutant, altering the ecosystem's food webs/trophic levels and decreasing its stability/resulting in a decline in biodiversity.

(iii) Researchers measured methylmercury in a location downstream from the factory. **1 point**
Explain how methylmercury could be present in the stream.

- Mercury is likely released into the stream by the factory as a waste product. Bacteria/microorganisms in the water/sediments then convert the mercury into methylmercury.

(iv) Researchers claimed that the soil nearest to the river has higher levels of mercury than the field has, and those elevated levels have affected the nesting success for turtles. **1 point**
Explain how the pattern shown in the diagram supports or refutes this claim.

Accept one of the following:

- The nests near the river in Area B where there is mercury are not successful, but the nests further away are successful. This supports the claim that the high concentration in the soil negatively affects the nesting success.
- There are fewer total nests/successful nests in Area B closer to the river than in Area A indicating that the mercury in the soil has negatively affected the nesting success. This supports the claim.

Total for part (b) **4 points**

(c) The turtle study was conducted in an agricultural area. **Describe** how a specific agricultural practice changes the soil in an area. **1 point**

Accept one of the following:

- Tilling/plowing softens/loosens soils and/or removes organic matter or leads to erosion.
- Monocropping removes nutrients and/or moisture from soil.
- Use of synthetic fertilizers disrupts the soil chemistry in areas used for agriculture.
- Irrigation can lead to waterlogging, erosion, and/or salinization of soils.
- Slash and burn removes vegetation and upper organic layers of the soil/adds nutrients to the soil.
- Use of industrialized machinery (harvesters, plows, planters) compacts soil.
- Use of polycultures/cover cropping with nitrogen-fixing plants can add nutrients to soil.
- Use of manure/organic fertilizer can increase moisture content of the soils.

Total for part (c) 1 point

Total for question 1 10 points

Question 1: Design an Investigation — 10 points

(a) (i) **Identify** the land use that covers the least amount of area in the Mississippi River watershed, based on the diagram. **1 point**

- Urban

(ii) **Describe** one way that land use practice at location X in the diagram could contribute to the dead zone in the Gulf of Mexico. **1 point**

Accept one of the following:

- Fertilizer used on croplands is washed into the streams and rivers in the watershed and feeds the growth of algae once it reaches the Gulf.
- Concentrated animal feeding operations generate large amounts of organic wastes that can move into streams and rivers, feeding the growth of algae once it reaches the Gulf.
- Treated or untreated (overflows) sewage released from wastewater treatment plants feeds the growth of algae once it reaches the Gulf.

(iii) **Describe** one way that urban areas in the Mississippi River watershed could contribute to the dead zone in the Gulf of Mexico. **1 point**

Accept one of the following:

- Wastewater treatment facilities in urban areas may release nutrients in treated wastewater and/or overflows, with this effluent flowing into the Gulf.
- Impervious surfaces in urban areas can increase the movement/runoff of lawn fertilizers or high-phosphate detergents that move onto pavement areas and flow into the Gulf.

Total for part (a) **3 points**

(b) (i) **Describe** how a dead zone affects marine organisms living in the Gulf of Mexico. **1 point**

Accept one of the following:

- Many organisms are forced to migrate or will die as a result of low dissolved oxygen levels in the water.
- Many organisms are forced to migrate or will die as a result of algal blooms that block sunlight from reaching underwater plants (submerged aquatic vegetation).

(ii) **Describe** one economic effect on communities along the Gulf of Mexico that can result from the presence of the dead zone. **1 point**

Accept one of the following:

- Decreased fish catch/decreased income for fishing industry
- Decreased tourism/lower tourism revenues
- Increased fuel costs for fishing vessels that need to travel farther to locate fish, therefore there will be a decrease in income/profits for fishing industry
- Increased costs for consumers as a result of a limited supply of fish

(iii) **Describe** one factor that causes the area of the dead zone in the Gulf of Mexico to increase during the summer months. **1 point**

Accept one of the following:

- Increased runoff of nitrates/phosphates/potassium from fertilizer used during the growing season leads to increased algal growth in the summer months.
- Increased precipitation/snowmelt/water volume carries more fertilizer runoff from urban or agricultural areas leading to increased algal growth.
- Higher water temperatures in the summer decrease the concentration of dissolved oxygen as warm water does not hold as much dissolved oxygen as cold water.
- Increased runoff of fertilizer or high-phosphate detergents used in urban areas leads to increased algal growth in the summer months.

Total for part (b) **3 points**

(c) (i) **Identify** a testable hypothesis for the study. **1 point**

Accept one of the following:

- If riparian buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will be lower than areas without riparian buffers.
- If riparian buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will be higher than areas without riparian buffers.
- If riparian buffers are present in agricultural areas, then the level of nitrates/phosphates/nutrients downstream will remain the same in areas with and without riparian buffers.

(ii) **Describe** a control that the researchers could use in the study. **1 point**

- Stream sites that are 100 meters downstream from areas without riparian buffer zones

(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. **1 point**

Accept one of the following:

- Turbidity
- Total suspended solids (TSS)
- Dissolved oxygen
- Water temperature
- Fecal coliform
- Conductivity
- pH
- Biological oxygen demand (BOD)

(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. **1 point**

Accept one of the following:

- There would be a decline in water quality from increased nutrients/increased coliform bacteria in the runoff because there is animal waste in the areas near concentrated animal feeding operations that are high in nutrients/coliform bacteria.
- There would be a decline in water quality from increased turbidity/increased total suspended solids in the streams near the concentrated animal feeding operations because particles from animal wastes enter the stream/there is increased disruption of the stream bed from animals in the water.
- There would be a decline in water quality from increased water temperature because the increased turbidity/suspended solids in streams near the concentrated animal feeding operations absorb sunlight/heat.
- There would be a decline in water quality from increased conductivity because there is increased water temperature/increase dissolved salts in streams near concentrated animal feeding operations.
- There would be a decline in water quality from antibiotics/veterinary drugs in runoff near the concentrated animal feeding operations because antibiotics/drugs are used in livestock operations but not to grow crops.

Total for part (c) 4 points

Total for question 1 10 points

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

(a) (i) Based on the data in the graph, **identify** the habitat type with the greatest number of lizards. **1 point**

- Clearings, Gardens

(ii) Based on the data in the graph, **describe** the relationship between the lizard numbers observed on islands with and without mongoose populations. **1 point**

Accept one of the following:

- 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 where mongooses are present.
- The relationship between lizard number counted and mongoose population is an inverse relationship.

Total for part (a) **2 points**

(b) Based on the theory of island biogeography, **describe** the characteristics of an island with the greatest species diversity. **1 point**

- A large island that is located near the mainland will contain the greatest species diversity.

Total for part (b) **1 point**

(c) (i) **Describe** one environmental problem caused by invasive animal species. **1 point**

Accept one of the following:

- Invasive species outcompete native species for resources, causing food web disruptions/trophic cascades/habitat loss.
- Invasive species outcompete/prey on native organisms, decreasing biodiversity/ reducing population size of native species.

(ii) Invasive species are often pests. **Make a claim** that proposes one way to control pest species. **1 point**

Accept one of the following:

- Introduce biological controls, like natural predators of the species, to reduce the number of pests.
- Use chemical controls, such as pesticides, to kill off pests.
- Use manual/mechanical methods to remove plant species.
- Trap/hunt animal species and kill/remove them from the area.

(iii) **Justify** the solution proposed in (c)(ii) by providing an additional benefit of the solution. **1 point**

Accept one of the following:

Solution proposed in (c)(ii)	Justification of solution with additional benefit
Introduce biological controls like natural predators of the species to reduce the number of pests	• Method least likely to harm other species because the pest species can be specifically targeted • Harmful synthetic chemicals are not introduced into the environment
Use chemical controls, such as pesticides, to kill off pests	• Quick/efficient method to reduce/eliminate pest species
Use manual/mechanical methods to remove plant species	• Method least likely to harm other species because the pest species can be specifically targeted • Harmful synthetic chemicals are not introduced into the environment • Financial gain from selling killed pest organisms
Trap/hunt animal species and kill/remove them from the area	• Method least likely to harm other species because the pest species can be specifically targeted • Harmful synthetic chemicals are not introduced into the environment • Financial gain from selling killed pest organisms

Total for part (c) **3 points**

(d) (i) **Identify** a provisioning ecosystem service provided by primary forests. **1 point**

Accept one of the following:

- Timber/lumber/wood
- Medicine
- Food

(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. **1 point**

Accept one of the following:

- The cleared land is preferred habitat for the lizards, which led to increased numbers of lizards in the sugar cane fields compared to the forests.
- The cleared land has fewer predators, which led to increased numbers of lizards counted in the sugar cane fields compared to the forests.
- The cleared land has more food for the lizards, which led to increased numbers of lizards in the sugar cane fields compared to the forests.

(iii) The long-term use of monocultures in commercial sugarcane farming is one cause of the ecological damage. **Describe** one problem associated with monocultures. **1 point**

Accept one of the following:

- Decreased genetic diversity of monoculture species
- Decreased species diversity
- Increased susceptibility of monoculture to disease/pests
- Depletion of nutrients from soil
- Increased use of irrigation water/fertilizer/pesticide

Total for part (d) **3 points**

(e) **Describe** an advantage of crop rotation using legumes on soil fertility. **1 point**

Accept one of the following:

- Improved nitrogen fixation in the soil
- Less nitrogen-based fertilizers required

Total for part (e) **1 point**

Total for question 2 **10 points**

Question 1: Design an Investigation — 10 points

(a) (i) **Identify** the scientific question that resulted in the data presented in the graph. **1 point**

Accept one of the following:

- What is the relationship between slope and annual erosion rate for four different land use types?
- Does crop rotation/tilling/not tilling/using cover crops on various slopes increase/decrease/change erosion rates?

(ii) **Identify** the agricultural practice that could be used on a 15% slope without leading to a higher than tolerable loss of soil. **1 point**

- Crop rotation

(iii) **Describe** the effect of adding a cover crop compared to using the no-till method. **1 point**

Accept one of the following:

- Adding a cover crop reduces the annual rate of soil erosion compared to using the no-till method.
- Adding a cover crop allows planting on greater sloped land before reaching tolerable loss as compared for the no-till method.

(iv) **Identify** one natural mechanism of soil erosion. **1 point**

Accept one of the following:

- Moving/flowing water
- Rainfall
- Wind

Total for part (a) **4 points**

(b) (i) **Identify** the dependent variable stated in the hypothesis. **1 point**

Accept one of the following:

- The amount of sediment discharge
- The amount of sediment run-off

(ii) **Describe** one way to add a control to improve the design of the study. **1 point**

Accept one of the following:

- Add a plot that is bare/does not have straw bales or grass (no ground cover).
- Measure sediment discharge/runoff prior to placing straw bales or planting grass compared to discharge after the bales/grass are in place (pre-/post-tests).

(iii) **Identify** one variable that was not discussed that could affect the results of the study. **1 point**

Accept one of the following:

- Slope of the plots
- Amount of rainfall
- Composition of the roads
- Distance of the plots from road/stream
- Size of the plots
- Type of soil at the plots
- When the data are collected at the plots (how quickly after rainfall)

(iv) Based on the data in the table above, **make a claim** about the stated hypothesis. **1 point**

Accept one of the following:

- The stated hypothesis is rejected as more sediment resulted from straw bale plots (plot A) than grass planted plots (plot B).
- The data in the table shows that the grass is more effective at reducing sediment runoff. The hypothesis should be rejected.

Total for part (b) 4 points

(c) (i) **Describe** the type of survivorship curve expected for these fish species. **1 point**

Accept one of the following:

- Low survival rate in early life, followed by increased chances of survival as the organism matures.
- Most offspring die at a very young age and few reach maturity.

(ii) **Explain** why the input of sediment to a stream can negatively affect reproduction of fish that lay their eggs in the gravel of the streambed. **1 point**

Accept one of the following:

- Sediment can cover/bury eggs, which reduces the amount of oxygen, causing them to die.
- Sediment takes away usable habitat/space resulting in fewer areas for them to lay eggs causing fewer eggs to survive.
- Sediments can carry toxic/poisonous chemicals, which can negatively impact the eggs and decrease egg survival.
- An increase in sediment can increase the water temperature and result in less dissolved oxygen/too warm water, which can decrease the viability of the eggs that have already been laid.
- Sediment can increase water turbidity, which decreases fish navigation/ability to forage/efficiency of oxygen use which decreases the amount of eggs laid.

Total for part (c) 2 points

Total for question 1 10 points

AP® Environmental Science 2016 Scoring Guidelines

2016 SCORING GUIDELINES

Question 1

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

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

(1 point for a correct explanation for why diseases seldom cause extinction)

- Genetic diversity in wild populations enables some resistant organisms to survive and reproduce.
- Disease organisms often co-evolve with their hosts, allowing the host to evolve adaptations that resist the disease.
- Disease organisms/pathogens that cause the extinction of their host population jeopardize their own survival.
- Initial deaths thin (reduce density of) populations and make the disease less likely to spread.

(b) 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.

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

(2 points: 1 point for each description of a threat. Only the first two descriptions can earn a point.)

- Difficulty finding mates when populations are small, widely dispersed, or have a skewed sex ratio
- Competition from other species with a similar niche (e.g., nesting sites, food)
- Problems associated with a reduction of genetic diversity (small gene pool, lack of hybrid vigor, diseases that affect one will affect all members of the population, bottle-neck, etc.)
- Susceptibility to reduced fitness as a result of decreased protection by the group (e.g., not enough individuals to create heat, less protection by group members, increase in probability of becoming prey without the advantage conferred by group size)
- Increased vulnerability to environmental disturbances (need to name specific disturbance)

(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.

(1 point for a correct discussion of a correct aspect of bat biology that might slow their recovery)

- Low fecundity/ few babies per year
- Long generation times in bats
- Advanced age at first reproduction
- Increased parental care

(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.

(2 points: 1 point for each correct description. Only the first two descriptions can earn a point.)

2016 SCORING GUIDELINES

Question 1 (continued)

- Increase in bat food sources.
- Increase in West Nile and other insect-borne diseases
- Decrease in the spread of rabies
- Decrease in fungus that causes WNS
- Decrease in bat guano (tied to organism)
- Decline in plants pollinated or dispersed by bats
- Decline in bat predators due to decreased food supply.
- Increase in numbers of animals with similar food and habitat needs
- Causes a trophic cascade

(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.

(2 points: 1 point for each correct ecosystem service with an explanation of how the service benefits human society)

Acceptable responses may include the following:

Ecosystem Service	Benefit to Humans
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 (e.g. specify shade, temperature moderation, etc.)	Animals or plants desired by humans for fishing, hunting, food
Biodiversity	Food, medicine, gene diversity, breeding stock
Carbon sink (sequestering)	Slows climate change
Aesthetics/cultural/social	Connection with nature (inspiration for art, music, poetry, etc.), research, education, recreation, tourism

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.

(e) **Provide** a likely reason for the increase in emerging infectious diseases affecting human populations. Include an explanation for the reason you provided.

(2 points: 1 point for a correct reason for the increase in emerging infectious diseases. 1 point for a correct explanation of how the reason likely increases the emerging diseases affecting human populations.)

Acceptable responses may include the following:

2016 SCORING GUIDELINES

Question 1 (continued)

Reason for Increase	Explanation
Climate change, global warming	Allows pathogens and disease vectors to survive in places that were 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 rodents, etc; 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	Increase human susceptibility to disease, reduce herd immunity
Antibiotic resistance	New disease strains evolve
Decrease in medical care/public health	Poverty, war, migration, human behavior (refusing to use condoms/sharing needles/refusing aid)

SCORING GUIDELINES

Question 2

Use the data below to respond to the following. For each calculation, show all your work.

Calculate the weight (in tons) of rock waste produced globally each year when iron ore is converted to pig iron.

(1 point for the correct answer with work shown)

1.6 billion tons of iron ore – 1.2 billion tons of pig iron = 0.4 billion tons of waste

OR

$1.6 \times 10^9 - 1.2 \times 10^9 = 4 \times 10^8$

Calculate the weight (in tons) of pig iron that could be produced if all of the estimated global iron ore reserves were used for pig iron production.

(2 points: 1 point for the correct setup and 1 point for the correct answer)

$\frac{1.2 \text{ billion tons pig iron}}{1.6 \text{ billion tons iron ore}} \times 800 \text{ billion tons iron ore} = 600 \text{ billion tons iron}$

OR

$\frac{1.2}{1.6} = 0.75 \qquad 0.75 \times 800 \text{ billion} = 600 \text{ billion} \qquad \textbf{OR} \qquad \frac{1.2}{1.6} = \frac{x}{800}$

OR

$\frac{1.2 \times 10^9}{1.6 \times 10^9} \times 8.0 \times 10^{11} = 6.0 \times 10^{11}$

Calculate the weight (in tons) of the current global iron ore reserves that would be used to make steel if the current trends continue.

(1 point for the correct answer with work shown)

0.95×800 billion tons of iron = 760 billion tons iron ore used to make steel

OR

$0.95 \times 800 = 760$ billion

OR

$9.5 \times 10^{-1} \times 8 \times 10^{11} = 7.6 \times 10^{11}$

Calculate the weight (in tons) of coal that is conserved each year in North America by recycling steel.

(1 point for a correct answer with work shown)

$\frac{0.7 \text{ fewer tons coal used}}{1 \text{ ton steel recycled}} \times 80 \text{ million tons steel recycled} = 56 \text{ million tons coal saved per year in North America}$

OR

$0.7 \times 80 = 56$ million

OR

$7.0 \times 10^{-1} \times 8.0 \times 10^7 = 5.6 \times 10^7$

SCORING GUIDELINES

Question 2 (continued)

Describe TWO environmental problems that are associated with abandoned coal mine sites.

(2 points: 1 point for each correct description of an environmental problem. Only the first two descriptions can earn a point.)

- Subsidence/sinkholes as shafts collapse
- Habitat destruction/slow to recover
- Stream/water quality degradation
- Acid mine drainage
- Heavy metal runoff
- Tailings alter landscape and drainage patterns
- Increased soil erosion
- Particulate/dust pollution
- Animals fall in
- Methane release
- Underground fires difficult to extinguish

Describe one method that can be used to mitigate one of the problems you identified in part (c).

(1 point for a correct description of a mitigation method for one of the two environmental problems described in part (c))

- Plant trees or other plants to restore cover/reduce erosion
- Fill in/fence off abandoned shafts to stop subsidence or reduce access
- Prevent acid mine drainage and leaching from sites using retaining ponds, berms, other BMPs
- Treat acid mine drainage with limestone
- Return tailings to excavation sites
- Recontour the land
- Place gravel on surface to reduce wind erosion

Discuss one reason why surface coal mining is generally less expensive than subsurface mining.

(2 points for correct identification of a reason linked with a discussion of why surface mining is less expensive)

Reason	Economic Discussion
Wages	Fewer workers needed above ground Workers paid less above ground
Healthcare	Workman's compensation Insurance
Safety	Increased likelihood below ground of o severe accidents o death o black lung
Legal costs	Lawsuits from injuries, accidents, rescues

SCORING GUIDELINES

Question 3

Municipal solid waste (MSW) is the trash collected from households and businesses.

(a) Use the data provided in the graph to respond to the following.

(i) **Explain** one probable cause (other than increased composting) for the change in per capita waste generation from 2000 to 2012.

(1 point for a correct explanation for the change in per capita generation from 2000 - 2012)

- People or businesses practicing one of the following: refuse, reduce, reuse, recycle, or repurpose.
- Lighter materials contribute to less MSW creation (e.g. plastic bottles not glass bottles)
- Less material used in products (newspapers smaller, aluminum cans less massive)
- Technology reduces waste generation (e.g., reading magazines online → less paper)
- Economic recession → less consumption → less MSW produced

(ii) **Calculate** the percent increase in total MSW generation from 1980 to 2012.

(1 point for the correct answer with work shown)

$$\frac{(250 \text{ million tons} - 150 \text{ million tons})}{150 \text{ million tons}} \times 100 = 66\% \text{ to } 67\%$$

(b) Two ways of managing MSW are incineration and disposal in landfills.

(i) **Identify** one disadvantage of waste incineration.

(1 point for a correct identification of a disadvantage of waste incineration)

- Specific air pollutant (e.g., CO, CO_2, dioxin, halogens, particulates, SO_x, NO_x)
- Ash disposal necessary
- Incinerator is expensive to construct and/or operate
- MSW supply and quality may be limited requiring additional fuel
- Reduced quality of life and property value due to incinerator and supply trucks

(ii) **Identify** one disadvantage of waste disposal in landfills.

(1 point for a correct identification of a disadvantage of waste disposal in landfills)

- Ground water, surface water, or soil contamination through some transport mechanism
- Reduced quality of life and property value due to landfill and supply trucks
- Release of methane or CO
- Odor source
- Attracts vermin
- Habitat destruction
- Preclusion of other land uses
- Explosion/seepage hazard from methane produced

SCORING GUIDELINES

Question 3 (continued)

Trash incineration is one way to generate electricity from MSW. Electricity can also be generated from waste buried in landfills.

Describe the specific steps of a process use to produce electricity from waste buried in a landfill
(3 points – 1 point for each step in the process of generating electricity from landfill gas)

Step	Description of Step
Acquire fuel (chemical energy)	Methane collected or gathered
Use fuel (chemical → mechanical)	Fuel is combusted to produce steam or hot air
Generate electricity (mechanical → electricity)	Steam or hot air spins/turns/rotates a turbine/generator to generate/produce electricity

(d) Many landfills do not accept used tires. As a result, the tires are often dumped in poorly regulated piles. **Describe** one human health problem associated with piles of discarded tires.
(1 point for a correct description of a human health problem associated with piles of discarded tires)

- Discarded tires provide habitat for mosquitoes/pests that can be disease vectors.
- Tires may catch fire and release air pollutants that cause respiratory issues in humans.

(e) Composting is one way to reduce the amount of waste that enters a landfill.

(i) Other than reducing the volume of waste, **identify** one advantage of composting.
(1 point for a correct identification of an advantage of composting)

- The resulting compost can be used or sold as fertilizer or soil amendments.
- Municipal composting facilities may provide jobs.
- MSW may emit less foul odor if organic material is composted.
- Tipping fees and trash removal costs may be reduced due to removal of dense compostable material.

(ii) **Identify** one disadvantage of composting.
(1 point for a correct identification of a disadvantage of composting)

- Compost may attract undesirable animals (vermin).
- Compost may emit foul odors or spontaneously combust.
- Nutrients released from decomposing organic matter may run off into surface waters and cause water quality problems.
- Compost may release methane.
- Composting organic material requires a great investment of time and labor by humans.

2016 SCORING GUIDELINES

Question 4

Soil is a complex mixture of living organisms and organic material, along with minerals and other abiotic components. Soils help sustain life and provide ecosystem functions.

(a) **Describe** how TWO climate factors affect the rate of soil formation.

(2 points: 1 point for each correct description of how a climate factor affects the rate of soil formation. Only the first two descriptions can earn a point.)

Climate Factor		Effect
Temperature	High	Increases rates of biological activity (decomposition) and chemical activity – inceases rates of soil formation
	Low	Decreases rates of biological activity (decomposition) – decreases rates of soil formation Increases the rate of weathering (frozen water expands, breaking rock) – increases the rate of soil formation
Precipitation/ Humidity	High	Increases biological activity and weathering – increases the rate of soil formation Increases erosion, runoff – decreases the rate of soil formation
	Low	Decreases biological activity and weathering – decreases the rate of soil formation
Wind		Can carry in particles – increases rates of accumulation Can hasten rates of soil erosion – decreases rates of accumulation

(Note: No point earned for merely identifying a climate factor.)

(b) As soils form, distinct layers known as horizons develop over time. One of these is the A horizon.
(i) **Identify** one specific biotic component of the A horizon.
(ii) **Identify** one abiotic component of the A horizon.

(2 points: 1 point for a correct identification of a specific biotic factor and 1 point for a correct identification of an abiotic factor.)

	Examples of components include:
Biotic	Humus, microorganisms, bacteria, earthworms, macroinvertebrates, roots, fungi, beetles, decomposers, insects
Abiotic	Sand, silt, clay, water, air, nutrients (N,P, K compounds), decomposing parent material, minerals, rocks, pebbles

2016 SCORING GUIDELINES

Question 4 (continued)

(c) Nitrate levels exceeding the United States Environmental Protection Agency's primary drinking water standard have been found in the groundwater of areas with intensive agriculture.

(i) **Identify** one agricultural practice that can lead to elevated nitrate levels in groundwater.

(1 point for a correct agricultural practice that leads to elevated nitrate levels in groundwater.)

- Application of fertilizer
- Improper sealing of feedlots
- Improper construction or maintenance of animal waste lagoons

(ii) **Describe** how the practice you identified in (c)(i) leads to elevated nitrate levels in ground water.

(1 point for a correct description linked to the practice identified in part (c)(i).)

- Nitrates infiltrate/percolate/seep into ground water.
- Nitrates entering surface waters that recharge aquifers (must connect surface with ground water).

(d) Acid deposition has affected soil quality in many parts of the northeastern United States.

(i) **Explain** one way acid deposition onto soil can affect plant health.

(1 point for a correct explanation of one way acid deposition onto soil can affect plant health.)

- Increased soil acidity may be outside of the optimal range of tolerance for the plant, resulting in poor plant growth or death.
- Acid can leach cations/metal ions/nutrients from soil, making them less available to plants, thus decreasing growth.
- Aluminum is released and can be toxic to plants.
- Acid can diminish the ability of soil to buffer, leading to poor plant growth.
- Increased soil acidity can damage plant root systems, stressing plants.
- Sulfur and nitrogen from acid deposition can build up to levels toxic to plants (or can fertilize the soils).

(ii) **Describe** one method for remediating soil affected by acid deposition.

(1 point for a correct description of a method of remediation.)

- Add crushed limestone / lime / marble dust / bone meal / crushed egg shells or oyster shells

(e) Climate change is causing far-reaching ecosystem changes, including soil degradation in many of the world's biomes. **Describe** TWO ways that climate change can degrade soil.

(2 points: 1 point for each correct description of how a change in climate has resulted in soil degradation.)

- Increased global temperatures and decreased precipitation cause desertification.
- Increased temperatures lead to increased evaporation of irrigation water, resulting in soil salinization.
- Increased erosion and/or leaching can result from increased precipitation in certain areas.
- Increased temperature can lead to faster breakdown of organic matter (less organic matter in the soil).
- Increased temperatures and shifting climatic belts result in longer growing seasons, which can deplete nutrients from the soil.
- Rising sea levels can result in flooding of coastal areas, leading to salinization of soil and increased soil erosion.
- Increased temperatures can lead to soil desiccation.