

**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
- $1.7 \times 10^{12} \text{ L}$

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

2018



AP Environmental Science

Scoring Guidelines

2018 SCORING GUIDELINES

Question 1

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

- (a) The students want to reduce the school's carbon footprint.

- (i) **Define** carbon footprint.

(1 point for correct definition of carbon footprint)

- The amount of carbon dioxide and/or other carbon compounds released to the environment by a product, process, or activity
- A measurement of the amount of carbon released by human activities

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

(1 point for correct identification of a way the school's heating system is adding to its carbon footprint)

- The burning/combustion of fossil fuels releases carbon dioxide
- The incomplete combustion of fossil fuels releases carbon monoxide

- (iii) **Describe** one realistic way to reduce the contributions of the heating system to the school's carbon footprint

(1 point for correct description of a realistic way to reduce the contributions of the heating system)

- Switch to renewables (solar, wind, etc.)/switch to a more efficient fossil fuel (natural gas, propane)/switch to a provider that uses nuclear energy.
- Decrease the temperature/thermostat in the school during the winter/program thermostat to lower energy consumption during certain times.
- Purchase credits through environmental agencies for carbon-offsetting projects.
- Increase insulation or implement other efficiency/design methods to reduce energy demand (green roof, double paned glass, south-facing windows for passive solar heating, change air filters, etc.).

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

(2 points; 1 point for each correct identification of an environmental benefit of a green roof)

- Insulation/reduced use of fossil fuels for heating and/or cooling
- Habitat for wildlife and/or plants/increases biodiversity
- Area to grow crops/production of food locally
- Reduction in the number of heat islands in the environment/urban heat island mitigation
- Photosynthesis/carbon capture/ CO_2 storage/oxygen release
- Stormwater treatment/runoff reduction
- Filters particulates, VOCs, O_3 from air

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Question 1 (continued)

- (c) **Describe** TWO practices the cafeteria's food service could use to decrease the environmental impacts of Fremont High School.

(2 points; 1 point for each correct description of a practice that decreases the environmental impact of the school)

- Offer more vegetarian options/serve fewer animal products, etc. to reduce impact from meat production.
- Use some locally sourced food to reduce transportation.
- Grow food at the school to reduce transportation.
- Compost food waste to reduce the amount disposed in landfills.
- Donate leftover food to reduce food waste.
- Use energy-friendly practices (LED lighting, serve more cold-cut sandwiches, etc.) to decrease energy use.
- Purchase bulk packaged items to reduce material waste.
- Use recyclable food containers/don't use disposable straws/food containers/trays to reduce material waste.
- Install a water fountain/stop selling single-serving water bottles to reduce material waste.
- Use reusable take-out containers/offer savings or credit for reusing containers to reduce material waste.
- Allow students to choose appropriate portions to reduce food waste.
- Purchase organic foods to reduce pesticide use.
- Use gray water to irrigate landscaping to reduce potable water use.

- (d) **Discuss** TWO benefits of using native plants for landscaping at Fremont High School.

(2 points; 1 point for each correct discussion of benefits of using native plants)

- Native plants require less pesticides because they are better adapted to their environment.
- Native plants require less fertilizer because they are better adapted to their environment.
- Native plants require less irrigation water because they are better adapted to their environment.
- Native plants increase biodiversity by providing native habitat areas.
- Native plants support native food webs/native food production by providing native habitat areas.
- Native plants reduce the amount of land available for the establishment/spread of invasive species.
- Native plants save the school money by requiring less water/fertilizer/pesticides/upkeep.

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Question 1 (continued)

- (e) During the renovation, the carpeting must be replaced. **Discuss** one environmental benefit of using flooring made of plant material, such as cork or bamboo, instead of carpet made of synthetic fibers.

(1 point for correct discussion of benefits of using flooring made of plant material)

- Plant-based material is more easily compostable/is biodegradable/can be reused/repurposed, unlike carpet.
- Plant-based material is from a renewable resource making it more sustainable than carpet. Plant-based material is a carbon sink/reservoir, so growing plant materials removes CO₂ from the atmosphere, unlike carpet.
- Plant-based materials require less fossil fuels/toxic chemicals for production than synthetic fibers found in carpets.
- Plant-based materials produce less indoor pollutants (off-gas pollutants/VOCs/release toxins) than carpet.
- Plant-based materials harbor fewer pathogenic vectors/diseases/allergens (fleas, ticks, dust mites, mold spores, etc.) than carpets.
- Plant-based material when cultivated provides habitat for native species.

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Question 2

An offshore wind farm project using turbines to generate electricity is to be built along the Atlantic coast of the United States. It will be located about 13 km from the coast in water with an average depth of 10 m.

- (a) **Describe** one environmental benefit associated with an offshore wind project.

(1 point for correct description of an environmental benefit associated with an offshore wind project)

- Reduced environmental damage from decreased reliance on fossil fuels, such as:
 - Less habitat/ecosystem destruction due to less exploration and extraction (less mining or drilling, etc.)
 - Less air/soil/water pollution (less exhaust emissions, pipeline leaks, tanker leaks) due to less transportation of fossil fuels
 - Less air pollution (no/fewer particulates, VOCs, NO_x, SO_x, CO₂, or greenhouse gases) due to less fossil fuel combustion
- Reduced environmental damage from decreased reliance on nuclear power, such as:
 - No risk of radioactive releases with accidents
 - No hazardous/radioactive wastes to store
 - Less exploration/ extraction/processing for uranium ore
- Increased aquatic habitat/artificial reefs for barnacles, sponges, other invertebrates, fish

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Question 2 (continued)

- (b) **Identify and describe** one potential economic effect of an offshore wind project.

(2 points; 1 point for correct identification of a potential economic effect and 1 point for correct description of an identified economic effect. The description point cannot be earned without correct identification of a potential economic effect.)

Identify one potential economic effect	Describe one potential economic effect
Job creation (+)	Jobs will be created in construction, operation, maintenance, etc.
Additional income (+)	- Local municipalities receive more taxes (income, sales, property) paid by utility and workers - Wind power company will make money/profits in the long run
Decreased electricity costs (+)	Electrical production costs will be lower, which will reduce electricity rates for consumers
Less reliance on foreign energy resources (+)	Transportation costs to deliver fuels will be reduced
High initial construction/ high maintenance costs (-)	- Local taxes/fees/rates will increase to support construction costs associated with building of facility - Parts and personnel must be transported off-shore for construction, repairs and maintenance
Decreased property value (-)	Property values will decrease in coastal areas due to unfavorable aesthetics
Loss of income (-)	- Turbines negatively affect the aesthetics, which negatively impacts tourism, fishing, whale watching, etc. - Local fishing opportunities will be disrupted - Less revenue for fossil fuel companies as demand decreases
Job loss (-)	Jobs will be lost in the traditional energy production sectors (coal, nuclear)
Subsidies cost (-)	State subsidies to offset cost of building offshore and transmission lines to coast will increase; costs may be recovered with increased taxes

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Question 2 (continued)

- (c) **Describe** one additional way, other than wind power, that oceans can provide renewable energy for the generation of electricity.

(1 point for correct description of energy source from ocean)

- Use of tidal movement/currents to turn turbines
- Utilize a device designed to capture energy from wave motion
- Harness the solar energy absorbed by the oceans/use natural thermal gradient in tropical and temperate oceans to create electricity (OTEC — Ocean Thermal Energy Conversion)
- Harvest algae and convert to biofuel

The project will consist of 200 wind turbines, each with a capacity of 4 megawatts (MW). Each turbine costs \$1.2 million to build. Electrical demand in the area to be served by the project is expected to be 2.0×10^6 MWh per year.

- (d) **Calculate** how much electricity (in MWh) the wind project needs to generate per year in order to provide 80% of the annual electrical demand in the service area. Show all work.

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

$$(0.80) \times (2.0 \times 10^6 \text{ MWh}) = 1.6 \times 10^6 \text{ MWh}$$

- (e) Customers in the service area pay \$0.20/kWh for electricity. **Calculate** how much revenue will be produced if the wind turbines provide 80% of the annual electrical demand in the service area. Show all work.

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

$$1.6 \times 10^6 \text{ MWh} \times \frac{\$(2 \times 10^{-1})}{\text{kWh}} \times \frac{1 \times 10^3 \text{ kWh}}{1 \text{ MWh}} = \$3.2 \times 10^8 = \$320,000,000 = \$320 \text{ million}$$

- (f) Assuming all turbines are operating, **calculate** how many hours the wind turbines must operate to provide 80% of the annual electrical demand in the service area. Show all work.

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

$$1.6 \times 10^6 \text{ MWh} \times \frac{1 \text{ turbine}}{4 \text{ MW}} \times \frac{1}{2 \times 10^2 \text{ turbines}} = 2 \times 10^3 \text{ hr} = 2,000 \text{ hours}$$

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Question 3

An Arctic food web includes the following organisms.

- (a) Refer to the diagram above to complete the following table.

(3 points; 1 point for correct identification of each organism in the table)

	Organism from Arctic food web
(i) Identify a primary producer	Diatom (phytoplankton)
(ii) Identify a primary consumer	Krill (zooplankton)
(iii) Identify a secondary consumer	Cod or seal

- (b) Other than showing which organisms are consumed by others, **describe** what is indicated by the direction of the arrows in the diagram.

(1 point for correct description of what is indicated by the direction of the arrows)

- Shows the flow of energy among trophic levels
- Shows the flow of matter through trophic levels

As the amount of sea ice has decreased, larger expanses of the Arctic Ocean are now completely free of sea ice for several weeks each summer. Ringed seals, the preferred prey of polar bears, come to holes in the sea ice to breathe.

- (c) **Describe** how the change in sea ice habitat is affecting polar bears' ability to hunt and feed.

(1 point for correct description of how the change in sea ice habitat affects ability to hunt and feed)

- Decreasing area of hunting ground (area of ice used for hauling out/fewer seal breathing holes/seals are a less available food source because of more open water) makes it more difficult for polar bears to get food
- Increasing area/distance between hunting ground means the polar bears have to exert more energy to swim to find food/physical exhaustion from swimming results in less energy available for hunting
- Increasing physiological stress (dehydration, exhaustion, cub mortality, etc.) because polar bears are not physiologically adapted to warmer temperatures
- Increasing the time between successful kills results in bears spending more time waiting/hunting for prey

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Question 3 (continued)

- (d) **Explain** how melting sea ice leads to a feedback loop that increases Arctic warming.

(2 points; 1 point for correct explanation of the connection between melting ice and the increased absorption of sun's energy and 1 point for correct explanation that increased absorption of sun's energy leads to increased melting of ice. For the second point the student must complete the positive feedback loop.)

- Melting of sea ice leads to a decrease in albedo, or reflectivity, leads to water surfaces absorbing more of the sun's energy.

AND

- Increasing absorption of sun's energy warms the water surface further, which leads to further ice melt (completes positive feedback loop).

- (e) Many species, including some whales and birds, will travel thousands of kilometers during annual migrations.

- (i) **Provide** one reason a species may migrate a long distance.

(1 point for a correct reason why a species may migrate a long distance)

- Limited food/water supply leads to migration to locations with more food/water supply
- Food supply migrates and species follow prey
- More hospitable climate during certain seasons
- Availability of mates/breeding/birthing occurs in different location
- Protection of offspring from predators

2018 SCORING GUIDELINES

Question 3 (continued)

- (ii) The North Atlantic right whale migrates between subtropical and polar waters annually. Nearly 50 percent of right whale deaths are due to human activities. **Describe** one commercial activity, other than whaling, that may result in the death of right whales.

(1 point for correct description of one commercial activity, other than whaling)

- (iii) **Describe** one strategy that could reasonably be implemented to decrease right whale deaths caused by the commercial activity you described in part (ii).

(1 point for correct strategy linked to activity in (ii))

Description of commercial activity	Description of one strategy
• Fishing nets entangle whales as by-catch. • Fishing gear can accidentally trap.	• Require change of fishing method (location, timing, or materials) that traps whales to reduce the number of whales trapped in nets/gear • Fines for discarded fishing gear (long-line gear, ropes for hauling pots up, etc.) so less gear is discarded reducing the number of whales trapped in gear
• Ships and whales use the same channels, which can increase number of ship strikes.	• Improved navigational technology to spot whales that are close to ships in order to avoid collisions • Increased education of ship captains and crews about whale habitat/migration routes/feeding behaviors in order to reduce ship collisions with whales • Expansion of low-speed navigational zones around ports to reduce ship collisions with whales
• Noise pollution from seismic surveys/sonar/engine noise can disrupt a whale's internal navigational system.	• Reduction of seismic survey activity/sonar use in coastal areas to reduce exposure to noise pollution • Installation of quieter motors to reduce or eliminate noise pollution

2018 SCORING GUIDELINES

Question 4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(a) Air pollutants are released during the burning of biomass indoors for cooking and heating.

- (i) **Identify** TWO air pollutants released during the burning of biomass indoors for cooking and heating.

(2 points; 1 point for each correct identification of an air pollutant released during the burning of biomass)

- (ii) **Identify** a specific human respiratory illness that one of the pollutants you identified may cause.

(1 point for correct identification of a specific respiratory illness linked to identified pollutant)

Identification of TWO air pollutants	Identification of a specific human respiratory illness linked to identified pollutant
- Carbon monoxide (CO) - Particulate matter (PM)	- CO poisoning - Asthma - Chronic obstructive pulmonary disease (COPD) - Emphysema - Bronchitis - Lung cancer
Nitrogen oxides (NO_x)	- Pneumonia - Asthma
Sulfur oxides (SO_x)	- Bronchitis - Emphysema - Asthma
Trace metals, such as lead, mercury, arsenic, and cadmium	Bronchitis
Methane (CH₄)	Bronchitis
Volatile organic compounds (VOCs)	Asthma

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Question 4 (continued)

- (b) **Identify** one realistic approach, other than banning the practice of burning biomass indoors, which could be used to reduce the impact of biomass combustion indoors on human respiratory health. **Describe** how this approach could reduce the incidence of respiratory illness.

(2 points; 1 point for correct identification of a realistic approach to reducing the impact and 1 point for correct description of reduction of illness linked to identified approach)

Identify one realistic approach	Describe how this approach would reduce the incidence of respiratory illness
Ventilate through structural change (chimney construction, opening windows and doors)	Removes some or all of the air pollution from indoors/transfers pollutants out of the home, leading to less respiratory illness
Switch to cleaner-burning/more efficient cooking stove	Requires less fuel to be burned releasing fewer air pollutants into the home, leading to less respiratory illness
Switch to a different energy source (solar, natural gas, biogas, electric)	Produces less or no indoor air pollutants, leading to less respiratory illness
Cook outdoors	Move the source of the air pollutant outside/leads to less or no concentrated air pollution inside, leading to less respiratory illness

In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.

- (c) **Discuss** one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

(1 point for correct discussion of why children under the age of five are at a greater risk)

- Children have an underdeveloped or less-developed immune systems leading to a greater risk of illness following exposure.
- Children have a lower body mass leading to a higher relative dose of air pollution.
- Children spend more time indoors leading to higher exposure to air pollution.
- Children have smaller respiratory systems (narrow airways) so mild inflammation may cause more severe respiratory distress.

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Question 4 (continued)

In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

- asbestos
- radon
- mold

(d) Choose TWO of the three common indoor air pollutants (asbestos, radon, or mold) listed above and complete the following table.

(i) **Identify** a source for each indoor air pollutant

(2 points; 1 point for correct identification of a source of each indoor air pollutant chosen)

(ii) **Describe** a method for reducing exposure to each of the two pollutants you chose.

(2 points; 1 point for correct description of method of reduction for each indoor air pollutant chosen)

	Identification of a source	Description of a method for reducing exposure
Asbestos	• Building materials (cement, floor tiles, ceiling panels, drywall, popcorn ceiling) • Insulation • Naturally occurring in soil and rocks in a dirt-floor basement or crawlspace	• Safely remove asbestos-containing materials/abatement • Encapsulate/cover and seal materials/construct temporary enclosure • Leave undisturbed
Radon	• Soil, rocks, Earth's crust • Gas from uranium containing rocks • Gas penetrates foundation	• Seal floors, walls, and joints • Install structural exhaust venting • Install subfloor depressurizing system
Mold	• Water from flooding, natural disasters, or leaks • Poorly vented or maintained damp environments	• Replace or repair damaged surfaces/structures • Clean and/or disinfect affected areas • Dehumidify or ventilate inside air • Improve drainage (from roof or yard, sump pump the basement)

AP[®] Environmental Science

2016 Scoring Guidelines

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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
- Advanced age at first reproduction
- Long generation times in bats
- 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

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

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)

$$0.95 \times 800 \text{ billion tons of iron} = 760 \text{ billion tons iron ore used to make steel}$$

OR

$$0.95 \times 800 = 760 \text{ billion}$$

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

$$0.7 \times 80 = 56 \text{ million}$$

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 ○ severe accidents ○ death ○ 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, CO₂, 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 CC
- 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 used 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 – increases 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.
- Identify** one specific biotic component of the A horizon.
 - 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.