

Question 1: Design an Investigation**10 points**

A	Describe one reproductive strategy used by a K-selected species such as the chickadee. Examples of acceptable responses may include the following: (K-selected species) provide considerable parental care for offspring. (K-selected species) have few offspring. (The parents) expend significant energy for each offspring. (Individuals) reproduce more than once in their lifetime. (K-selected species) have a long gestation period/reach reproductive maturity later.	Point 01
B	Based on the information provided, explain how a decrease in spider populations could affect a lower trophic level. Examples of acceptable responses may include the following: - Insects/insect populations would increase because the insects are not being preyed on/eaten as much. - Plants/plant populations would decrease because the number of insects that eat plants will increase.	Point 02
C	Based on the data in Figure 1, identify the number of spiders per sample at 25% nonnative plants. Examples of acceptable responses may include the following: 2.0 2	Point 03
D	Based on the data in Figure 1, describe the trend in the number of insects per sample in relation to the percentage of nonnative plants. Examples of acceptable responses may include the following: - As nonnative plant percentage/percent increases, the number of insects decreases. - As nonnative plant percentage/percent decreases, the number of insects increases. - They have an inverse/indirect/negative relationship.	Point 04
E	Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. Describe one way that the data in Figure 2 support this hypothesis. Examples of acceptable responses may include the following: - Below this level/With fewer than 25%, the growth rate is at/above replacement level. - Below this level/With fewer than 25%, enough reproduction is occurring to replace the population. - Below this level/With fewer than 25%, the population growth rate is positive.	Point 05

F	(i) Identify a likely scientific question for the students' investigation of ant diversity. Examples of acceptable responses may include the following: - Does the number of species/species richness/biodiversity differ between an urban park and a grassland? - Does mowing affect the number of species/species richness/biodiversity?	Point 06
	(ii) Identify the dependent variable in the students' investigation. Examples of acceptable responses may include the following: - Number of ant species - Ant species richness - Presence/absence of different ant species	Point 07
G	(i) Explain why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would. Examples of acceptable responses may include the following: - With a larger number of species, the grassland is more likely to have some species/individuals with adaptations that allow them to survive. - The grassland is more diverse, so the loss of one species is less likely to cause a collapse (of the whole ecosystem).	Point 08
	(ii) Explain how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland. Examples of acceptable responses may include the following: (The playground) would have fewer species (than the grassland/urban park) because the paved area is not suitable habitat for many ant species. (The playground) would have fewer species (than the grassland/urban park) because humans could trample the ants/ant habitat.	Point 09
H	Describe one effect a paved road in a forest can have on animal species such as deer or bears. Examples of acceptable responses may include the following: - Animals can get hit by cars when trying to cross the road/hunt/migrate. - Fragmentation can lead to isolation of individuals/loss of genetic diversity. - Noise pollution can damage hearing/cause stress/mask the sounds used to communicate/hunt. - The road/noise pollution can cause changes in migratory routes/prevent movement of animals (to access resources). - Species that thrive in edge habitats might increase.	Point 10

Question 1: Design an Investigation**10 points**

A	Based on the data in the graph, identify the number of Common Tern breeding pairs in 1995. Acceptable identification point: 1400	Point 01
B	Based on the data in the graph, describe the trend in the number of Common Tern breeding pairs from 1995 to 2008. Examples of acceptable responses may include the following: - The number of breeding pairs varies but shows an overall decrease. - The number of breeding pairs decreases.	Point 02
C	A group of students hypothesized that sea level rise will lead to an increase in Common Tern populations. Describe one reason the data in the graph refute this hypothesis. Examples of acceptable responses may include the following: - The data suggest that a rise in sea level will decrease the number of breeding pairs. - As sea level rises, fewer breeding pairs will likely lead to smaller populations.	Point 03
D	Explain how climate change can lead to sea level rise. Examples of acceptable responses may include the following: - Increasing global temperatures results in melting glaciers/land-based ice sheets. - Increasing global temperatures causes ocean water expansion.	Point 04
E	(i) Identify a hypothesis that researchers are likely investigating in the wading bird study. Examples of acceptable responses may include the following: - If sea level rises, wading bird diversity/species richness will decrease. - If sea level rises, wading bird diversity/species richness will increase. - Sea level rise will/will not affect wading bird diversity/species richness. - Wading bird diversity/species richness is correlated with sea level rise. (ii) Identify the dependent variable in this study. Examples of acceptable responses may include the following: - Number of wading bird species - Species richness of wading birds	Point 05 Point 06

F	If the researchers repeated their study, explain how this environmental change could affect the results of the study. Examples of acceptable responses may include the following: - There would be a decrease in wading birds because PCBs tend to magnify/concentrate in higher trophic levels. - There would be a decrease in wading birds because PCBs can bioaccumulate (in fatty tissue). - There would be a decrease in wading birds because PCBs are toxic/kill birds/make birds sick when ingested. - There would be a decrease in wading birds because of eggshell thinning/developmental deformities/reproductive problems caused by PCBs.	Point 07
G	Describe a regulating ecosystem service that can be provided by wetlands. Examples of acceptable responses may include the following: (Wetlands) filter/purify/improve water (quality). (Wetlands) provide flood regulation/erosion control. (Wetlands) store/sequester carbon.	Point 08
H	Explain how increased sediment might lead to a change in the size of the wading bird populations. Examples of acceptable responses may include the following: (Increased sediment) can reduce the ability of wading birds to see prey/food/fish. (Increased sediment) can reduce/increase the ability of wading birds to hunt. (Increased sediment) negatively impacts organisms in lower trophic levels, reducing food/energy for the wading birds. - Reduced light infiltration can decrease the (number of) primary producers, resulting in less energy for higher trophic levels.	Point 09
I	Describe an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development. Examples of acceptable responses may include the following: - Construction projects can reduce/fragment wetland habitats. - Runoff of fertilizers/wastewater effluent can lead to eutrophication, (decreasing DO and killing fish). - Runoff of litter can kill animals when ingested/tangled. - More impervious structures/roads/buildings/sidewalks/parking lots can lead to flooding. - Runoff of heavy metals/pesticides can kill/weaken organisms when absorbed/ingested. - Noise/light pollution can disrupt hunting/migrating/behavior. - Runoff of oil can block light, preventing photosynthesis. - Increased water use can decrease the amount of groundwater/cause wetlands to dry up.	Point 10

Question 1: Design an Investigation**10 points**

- (a) Based on the information in the diagram, **identify** the zone with the lowest level of dissolved oxygen. **1 point**
- Zone C/C
- (b) Based on the information in the diagram, **describe** the relationship between biological oxygen demand and dissolved oxygen. **1 point**
- Accept one of the following:
- As biological oxygen demand increases, dissolved oxygen decreases.
 - As biological oxygen demand decreases, dissolved oxygen increases.
 - As dissolved oxygen increases, biological oxygen demand decreases.
 - As dissolved oxygen decreases, biological oxygen demand increases.
- (c) Based on the information in the diagram, **identify** the zone where there is likely point-source water pollution discharged into the stream. **1 point**
- Zone B/B
- (d) **Identify** the dependent variable in the researchers' investigation. **1 point**
- Accept one of the following:
- The number of macroinvertebrate species
 - Macroinvertebrate diversity
 - Macroinvertebrate species richness
- (e) **Identify** a testable hypothesis for the researchers' investigation. **1 point**
- Accept one of the following:
- As dissolved oxygen levels increase, the number of macroinvertebrate species increases.
 - As dissolved oxygen levels decrease, the number of macroinvertebrate species increases.
 - There is a direct/inverse relationship between dissolved oxygen levels and the number of macroinvertebrate species.
 - There is no relationship between biological oxygen demand and macroinvertebrate biodiversity.

- (f) **Describe** the reason the researchers selected zone A to serve as the control in the investigation. **1 point**
- Accept one of the following:
- Zone A/A/It is upstream from the source of pollution/organic waste/discharge/change.
 - Zone A/A/It would not be affected by the source of pollution/organic waste/discharge/change.
 - Zone A/A/It has levels of dissolved oxygen that are not impacted by the source of pollution/organic waste/discharge/change.
- (g) **Explain** how the modification to collect data in the winter months could alter the results of the investigation. **1 point**
- Accept one of the following:
- Cold water will have more dissolved oxygen, which could increase the number of species.
 - Colder water may be below the range of tolerance for some of the organisms, which could decrease the number of species.
 - Lower light levels in the winter decrease plant activity/photosynthesis, which lowers dissolved oxygen levels, which could decrease the number of species.
- (h) **Describe** the effect that the introduction of raw sewage into the stream could have on the population of bacteria in the stream. **1 point**
- Accept one of the following:
- Raw sewage contains nutrients that could increase the population of bacteria.
 - Raw sewage contains bacteria that could increase the population size.
- (i) **Identify** an abiotic factor other than dissolved oxygen and organic pollution that could also influence the population size of bacteria in the stream. **1 point**
- Accept one of the following:
- Temperature
 - pH
 - Light/Sunlight
 - Turbidity/Sediment
 - Salinity
 - Nitrate/Phosphate

- (j) **Explain** how persistent organic pollutants can affect higher trophic levels in an aquatic food web. **1 point**

Accept one of the following:

- Persistent organic pollutants/Pollutants can bioaccumulate in the tissues of organisms at higher trophic levels because they consume prey that have accumulated the pollutants.
- Persistent organic pollutants/Pollutants can accumulate/concentrate in the tissues of organisms at higher trophic levels because they consume prey that have accumulated the pollutants.
- Persistent organic pollutants/Pollutants can bioaccumulate in organisms at higher trophic levels because of higher fat content in their tissues.
- Organisms at higher trophic levels can experience neurological toxicity because persistent organic pollutants bioaccumulate.

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** a characteristic of a specialist species that would make the specialist species more likely to be negatively affected by habitat fragmentation than a generalist species. **1 point**

Accept one of the following:

- Specialists have narrow ecological niches compared to broad niches of generalist species, which are reduced even further by habitat fragmentation.
- Specialists with specialized adaptations are unable to adapt quickly, making them more vulnerable to habitat fragmentation than generalists that adapt quickly.
- Specialists tend to have small populations with less genetic variation than generalist species with larger populations and more genetic variation, making specialists more vulnerable to habitat fragmentation.

- (b) **Identify** the symbiotic relationship between the wood thrush and the cowbird. **1 point**

Accept one of the following:

- Parasitism
- Brood Parasitism
- The cowbird uses the wood thrush (as the surrogate parent) to raise their hatchling, which negatively affects the wood thrush and benefits the cowbird.

- (c) **Describe** one ecological advantage of leaving areas of undeveloped forest in the development plan as compared to clear-cutting the property. **1 point**

Accept one of the following:

- Since the habitat isn't being clear-cut, it does preserve some biodiversity by allowing some of the species to survive in the fragmented areas of the forest.
- Habitat fragmentation can benefit some generalist species or species which thrive in edge habitat, leading to population increases for those species.
- If planned with buffer zones around targeted conservation areas, edge disturbances for specialist species can be reduced.
- The remaining forest/trees will reduce soil erosion.
- The remaining forest will help with climate/cooling resulting from transpiration/shade from trees.

- (d) **Propose** a solution that will minimize the effect of development on the resident population of wood thrush while still meeting the municipality's need for a housing development. **1 point**

Accept one of the following:

- Leave areas for wildlife corridors/crossings to prevent isolating populations.
- Include conservation easements in the plan that will preserve species and also provide tax breaks for the residents.
- Create buffer zones near the development to separate it from wildlife habitat.
- Create a mitigation plan that preserves land elsewhere of similar quality.
- Cluster housing or vertical development to limit the development footprint.
- Incorporate common green spaces that promote wood thrush populations.

- (e) A male wood thrush needs a minimum of 800 m² of territory for reproduction. The municipal development committee has set a biodiversity preservation target of 275 male wood thrush territories. **Calculate** the area that must be set aside to support the goal of 275 male thrush territories. **Show** your work. **1 point**

One point for the correct setup to calculate the area:

$$275 \text{ territories} \times \frac{800 \text{ m}^2}{1 \text{ territory}}$$

One point for the correct calculation of the area:

$$220,000 \text{ m}^2$$

Total for part (e) 2 points

- (f) A real estate developer wants to build houses on the property. The plan will support 1,000 lots with a lot size of 1,100 m². The developer has proposed setting aside land equal to 10% of the size of each lot it sells. **Calculate** the maximum number of male wood thrush territories that could be created under this proposal. **Show** your work. **1 point**

One point for the correct setup to calculate the number of male wood thrush territories:

$$1,000 \text{ lots} \times \frac{1,100 \text{ m}^2}{1 \text{ lot}} \times 0.10 \div 800 \text{ m}^2 \text{ per territory}$$

One point for the correct calculation of the number of male wood thrush territories, accept one of the following: **1 point**

- 137.5 male wood thrush territories
- 137 male wood thrush territories
- 138 male wood thrush territories

Total for part (f) 2 points

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

One point for the correct setup to calculate the percentage of each lot to be set aside:

$$\frac{220,000 \text{ m}^2}{1,100,000 \text{ m}^2} \times 100$$

$$275 \text{ territories} \times \frac{110,000 \text{ m}^2}{137.5 \text{ territories}} \div 1,100,000 \text{ m}^2 \times 100$$

$$\frac{275 \text{ territories} \times 10\%}{137.5 \text{ territories}} \times 100$$

One point for the correct calculation of the percentage of each lot to be set aside: **1 point**

- 20% of each lot

Total for part (g) 2 points

Total for question 3 10 points

Question 2: Analyze an Environmental Problem and Propose a Solution**10 points****(a) (i) Identify** the latitudinal range with the greatest amphibian species richness. **1 point**

Accept one of the following:

- Between the Tropic of Cancer and the Tropic of Capricorn
- The range between 30 degrees N and 30 degrees S latitude
- The range between 10 degrees N and 15 degrees S latitude

(ii) Identify what biome this range most likely represents. **1 point**

- Tropical Rainforest

(iii) Describe one reason amphibian species richness would tend to be highest in this region. **1 point**

Accept one of the following:

- More rainfall/warm temperatures year-round are the preferred conditions for amphibians.
- Greater biodiversity/higher NPP provides more habitat/food sources/niches.

Total for part (a) 3 points**(b)** There are many environmental threats facing amphibians today, such as deforestation. **1 point****Describe** one possible anthropogenic reason for deforestation.

- Human demand for agriculture/housing/firewood/forest products (medicine/food/lumber).

(c) (i) Explain how the species richness of an ecosystem influences its response to environmental stressors. **1 point**

- An ecosystem with greater species richness/diversity is more resilient/resistant to environment stressors because some species will survive helping to restore/stabilize the ecosystem.

(ii) Explain why amphibian biodiversity is declining globally, other than from deforestation. **1 point**

Accept one of the following:

- Increasing water pollution including:
 - Pollution from pharmaceuticals that cause reproductive harm/decrease reproductive success.
 - Pesticide pollution that is absorbed via the skin and is toxic to amphibians leading to death.
 - Endocrine disruptors (such as atrazine) can alter reproductive development leading to decreased number of successful offspring.
- Pesticide use reduces food sources for amphibians (insects), leading to decreasing population size.
- Microclimatic changes from overall global climate change (e.g., warmer, drier conditions in previously cool, moist areas, loss of wetlands) decreases available habitat leading to a decline in population size.
- Illegal amphibian trafficking removes species from an area leading to a decline in population sizes.
- Introduction of invasive species that compete for niche space leading to a decline in population sizes.
- Habitat fragmentation from human activity would limit range/reduce the ability to access resources, decreasing survival.
- Fungal infections (such as Chytrid) cause their skin to dry out, and they cannot breathe.

Total for part (c) 2 points**(d) (i) Identify** one specific piece of legislation that has been designed to protect species threatened by extinction. **1 point**

Accept one of the following:

- Endangered Species Act (ESA)
- Convention on the International Trade of Endangered Species (CITES)
- Lacey Act

- (ii) **Explain** how the requirements of the legislation identified in part (d)(i) specifically protect species threatened by extinction. **1 point**

Accept one of the following:

Legislation identified in (d)(i)	Explanation of requirements that specifically protect species threatened by extinction
Endangered Species Act (ESA)	- Lists endangered/threatened plant and animal species and prevents them from being killed or harmed. - Designates/protects critical habitat to promote survival and recovery of listed species. - Creates plans to restore populations to healthy sizes. - Identifies species that are threatened before they become endangered to provide protections.
Convention on the International Trade of Endangered Species (CITES)	A global agreement that protects endangered/threatened plants and animals (including goods such as ivory, shark fins, or rhinoceros' horns) by banning/regulating the trade of these species.
Lacey Act	Prohibits the trade of wildlife, fish, and plants that have been illegally taken, possessed, transported, or sold.

Total for part (d) 2 points

- (e) (i) **Propose** a viable solution that will result in the protection of the endemic frog species while still allowing for maximum profit of the property development. **1 point**

Accept one of the following:

- Move/transplant the frog populations to an adjacent undeveloped area prior to development.
- A portion of the wetland can be designated as a park/preserve.
- Wildlife corridors (land/bridges) can be built/created on a portion of the wetlands.
- Restrict development within a minimum setback away from the wetland.
- Project developers can group buildings together/can build up, not out.

- (ii) **Justify** the solution proposed in (e)(i) by describing a potential advantage of the plan, other than frog protection. **1 point**

Accept one of the following:

Solution proposed in (e)(i)	Justification of how solutions offer potential advantages, other than frog protection
Move/transplant frogs	- Developers will only have a one-time disruption during the removal but will not have to deal with continued disruptions (such as increasing human population, increasing use of fertilizer/pesticides). - Developer will have the maximum amount of land available.
Designate as a park/preserve	- By protecting areas, animal species will have more food and space availability increasing survival rates. - Potential educational/environmental draw of living near a park/preserve may allow the developer to charge higher rents for the apartments. - There is aesthetic value of the wetland and its species for the people that live there. - The preserved wetland area will help prevent flooding.
Use of wildlife corridors	- By establishing corridors, the other species will also not be as greatly affected by multiple habitat fragments. - The animal species can continue to move back and forth for food, shelter, and reproduction by way of the habitat corridors.
Setback	- By establishing setbacks, a buffer zone will be created between the development and the wetland area, filtering runoff into the wetland. - A buffer zone will add privacy for residents between the two developments.
Project development	By developing the apartments in groups/clusters and leaving preserved wetlands, the species will not be as affected by multiple habitat fragments.

Total for part (e) 2 points

Total for question 2 10 points

AP[®] Environmental Science

Scoring Guidelines

2019 SCORING GUIDELINES

Question 1

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

(i) **Identify** the preferred nesting habitat for piping plovers.

(1 point for the correct identification of a preferred nesting habitat for piping plovers)

- Unvegetated sand
- Sandy areas/open sandy beaches
- Washovers

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

(1 point for the correct description of the change in the number of piping plover nests)

- The number of nests decreased by almost half (43%).
- The number of nests decreased from 44 to 25.
- There were 19 more nests in 1999 than in 2009.

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

(1 point for the correct description of a likely reason for the change in the number of piping plover nests)

- The preferred habitat was reduced because of a decrease in unvegetated sandy areas.
- The preferred habitat was reduced because of an increase in the amount of vegetation/revegetation.

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

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

(1 point for the correct description of a restriction that could reasonably be implemented to help prevent the destruction of plover nests by human activity)

- Post warning signs/fencing/barrier tape/boardwalks around the nesting area.
- Place wire enclosures/other barriers over active nests.
- Limit specified recreational activity on beaches with plover nests (prohibit kite flying, fireworks, etc.).
- Implement motor vehicle restrictions (limit times, size of vehicles, raking, etc.).
- Require pets to remain indoors or on leashes.

2019 SCORING GUIDELINES

Question 1 (continued)

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

(1 point for the correct explanation of one way that features of barrier islands help to preserve and protect the environment in coastal regions)

- They block/buffer the wind and/or waves, which mitigate beach erosion.
- They reduce storm surge, which protect the interior coastline from flooding.
- They block/buffer the waves and create wetland ecosystems/pools, which serve as habitat for a variety of species (fish, turtles, migratory birds, etc.).
- They trap sediments/pollutants in wetland habitats/marsh grasses, which filter the water.

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

(2 points; 1 point for the correct identification of a human action that directly threatens coastal habitats and 1 point for the correct description of the impact of human activity on species that use the habitat)

Identify one human action that directly threatens coastal habitats	Describe one impact on species that use the habitat
Tourism/Recreation	• Beachgoers accidentally step on or crush nests of species on the beach. • Unleashed pets on beaches may cause stress and/or disrupt nesting, survival, etc. of coastal species. • Vehicles on beach can disrupt nesting, survival, etc. of coastal species habitat. • Beachgoers leave food/garbage that attracts predators/harbors pathogens of coastal species. • Sunscreen washes off and can be toxic to coral or other coastal marine organisms.
Coastal Development	• Development (commercial, residential, recreational) can lead to the loss of suitable habitats of coastal species. • Development near beach may increase noise pollution or light pollution, which disrupts nesting/migration/survival of coastal species. • Development near beach may provide food/garbage that attracts predators/harbors pathogens of coastal species.
Littering/Solid Waste Disposal	• Coastal species get tangled up in trash (plastic) on the beach or in coastal water. • Coastal species ingest trash, which fills or blocks respiratory/digestive tract.
Offshore Oil Drilling	• Spilled oil coats coastal marine organisms, impacting survival. • Spilled oil can be toxic if ingested by coastal marine species.
Commercial Fishing	• Dredging or trawling can destroy coral/habitat for bottom-dwelling organisms. • Overharvesting can dramatically decrease coastal populations of fish or shellfish. • Coastal species can unintentionally get trapped in fishing gear.

2019 SCORING GUIDELINES

Question 1 (continued)

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

(1 point for the correct identification of one economic impact on coastal communities that has resulted from rising sea levels)

- Decrease of tourist revenue
- Decrease of property value
- Increase in damage to property, land, or infrastructure requiring repair or replacement
- Increase in insurance costs
- Loss of agricultural land or aquaculture operations resulting in financial loss
- Loss of fish nurseries in wetland areas leading to less revenue for commercial fisheries
- Increase in jobs in infrastructure/construction to repair damaged structures and properties
- Increase in costs associated with preventative measures (building sea walls, raising building, etc.)

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

(2 points; 1 point for each correct description and method that may be used locally to protect coastal communities from rising sea levels)

- Raise structures to reduce or prevent water damage.
- Move/build structures back from the beach (setbacks) to reduce or prevent water damage.
- Install pumps to reduce flooding.
- Build structures, such as sea walls, to protect area from wave action/storm surge/flooding/erosion.
- Plant vegetation along appropriate shoreline to decrease erosion.
- Replenish sand to address problems from erosion or to increase width of beach.
- Build jetties/groins to act as a barrier from waves.

2019 SCORING GUIDELINES

Question 2

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

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

(1 point for the correct identification of an ecological benefit provided by forests)

- Absorb carbon dioxide/produces oxygen (gas exchange)
- Maintain ecological and/or species diversity
- Provide food for organisms
- Moderate/regulate (local) climate
- Purify/filter water or air
- Reduce soil erosion
- Absorb/store/regulate water
- Help maintain stream temperature/stream flow
- Aid in nutrient cycling
- Aid in soil formation

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

(1 point for the correct identification of an economic benefit provided by forests)

- Source of forest products (timber, medicine, nuts, crops such as shade-grown coffee, etc.)
- Tourism
- Jobs in recreation/tourism/forestry
- Reduction in air pollutants, which can
 - reduce health care costs
 - improve crop yields

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

(2 points; 1 point for each correct description of an environmental consequence that results from the extraction of bitumen or the transport of synthetic oil to customers)

- Release of greenhouse gases/air pollutants such as NO_x from fossil fuel combustion that powers equipment/transportation/oil processing
- Release of air pollutants (NO_x , SO_x , or particulates) during mining operations or oil processing
- Storage and disposal of large amounts of solid/liquid mining waste, which can be toxic to organisms
- Pollution of surface water and/or groundwater from oil spills/leaks during transport
- Sediment pollution in surface water and/or groundwater from strip mining
- Disturbance from pipelines, such as habitat fragmentation, disruption of migratory routes, etc.
- Noise pollution from use of machinery during processing or transport
- Diversion/use of water from surface water and/or groundwater for processing oil

2019 SCORING GUIDELINES

Question 2 (continued)

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

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

$$7.3 \times 10^{10} \text{ barrels of bitumen} \times \frac{1 \text{ day}}{1.0 \times 10^6 \text{ barrels of bitumen}}$$

$$= 7.3 \times 10^4 \text{ days}$$

$$= 73,000 \text{ days}$$

(Note: Units are not required in the answer)

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

(2 points; 1 point for the correct setup and 1 point for the correct answer; incorrect answer from (d), used correctly, can still earn points in part (e))

$$7.3 \times 10^4 \text{ days} \times \frac{1 \text{ year}}{365 \text{ days}}$$

$$= 2 \times 10^2 \text{ years}$$

$$= 200 \text{ years}$$

(Note: Units are not required in the answer.)

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

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

$$\frac{3 \times 10^7 \text{ barrels of synthetic oil}}{1 \text{ month}} \times \frac{2 \text{ barrels of fresh water}}{1 \text{ barrel of synthetic oil}} \times \frac{12 \text{ months}}{1 \text{ year}}$$

$$= 7.2 \times 10^8 \text{ barrels of fresh water}$$

$$= 720,000,000 \text{ barrels of fresh water}$$

(Note: Units are not required in the answer)

2019 SCORING GUIDELINES

Question 3

The graph shows measurements of atmospheric levels of carbon dioxide (CO_2) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.

(a) Use the graph above to answer the following questions.

- (i) **Determine** the concentration of CO_2 (in ppm) recorded at Mauna Loa in 2005.

(1 point for identifying from the graph the correct value of concentration of CO_2 recorded at Mauna Loa in 2005)

380 ppm (+/-5 ppm)

- (ii) **Determine** the pH recorded at Station ALOHA in 2005.

(1 point for identifying from the graph the correct value of pH recorded at Station ALOHA in 2005)

8.08 (+/- 0.02)

(b) Changes in atmospheric carbon dioxide affect Earth's oceans.

- (i) **Predict** the effect of increased concentration of atmospheric CO_2 on the concentration of CO_2 in the ocean.

(1 point for correctly predicting the effect of an increase in concentration of CO_2 in the ocean)

- Oceanic CO_2 will increase.
- Dissolved oceanic CO_2 will increase.

- (ii) Based on the data, **identify** the relationship in the concentration of atmospheric CO_2 and the pH of the ocean water.

(1 point for correctly identifying the relationship between the concentration of atmospheric CO_2 and the pH of ocean water based on data)

- As atmospheric CO_2 increases, pH decreases.
- As more CO_2 dissolves in the water, it becomes more acidic/less alkaline.
- As atmospheric CO_2 increases, H_3O^+ or H^+ ions increase.

- (iii) **Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO_2) and water (H_2O).

(1 point for the correct balanced chemical equation that represents the reaction between oceanic carbon dioxide and water)

- $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ (carbon dioxide plus water produces carbonic acid)
- $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{HCO}_3^-$ (carbon dioxide plus water produces one hydrogen ion and one bicarbonate ion)
- $\text{CO}_2 + \text{H}_2\text{O} \rightarrow 2\text{H}^+ + \text{CO}_3^{2-}$ (carbon dioxide plus water produces two hydrogen ions and one carbonate ion)

2019 SCORING GUIDELINES

Question 3 (continued)

- (iv) **Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.

(1 point for correctly identifying the specific environmental problem that directly results from the decrease in pH of Earth's oceans)

Ocean Acidification

(c) Changes in pH in the world's oceans pose a risk to many marine organisms.

- (i) **Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.

(2 points; 1 point for correctly explaining the impact of a decrease in pH on shells or exoskeletons and 1 point for an impact on survival of organisms)

Chemical impact on shell/coral formation	Impact on survival of organism
A decrease in pH levels could • Cause shells/exoskeletons to dissolve • Prevent the growth of new coral/shells • Prevent renewal/maintenance of existing coral/shells	Organisms, such as mollusks and coral, would be threatened with • Reduced fitness/decreased number of offspring • Increased predation risk • Increased threat of disease

2019 SCORING GUIDELINES

Question 3 (continued)

- (ii) Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystem and **describe** how the threat damages the coral reefs and coral reef ecosystems.

(2 points; 1 point for the correct identification of an additional anthropogenic threat to the world's coral reef ecosystem and 1 point for correctly linking a description of the identified threat to the damage to coral reefs and coral reef ecosystems)

Identify one additional anthropogenic threat to the world's coral reef ecosystems	Describe how the threat damages coral reefs and coral reef ecosystems
Increased ocean temperature	• Coral bleaching (loss of the algal symbiont) • Reduction of dissolved oxygen concentration
Recreational activities, such as watercraft, scuba, snorkeling, swimming, etc.	• Physical damage to/destruction of coral reefs
Fishing practices, such as bottom trawling, dynamite fishing, overfishing, etc.	• Physical damage to/destruction of coral reefs • Removal of key species disrupts the food web/causes a trophic cascade
Nutrient pollution (from agricultural runoff, wastewater treatment plants, etc.)	• Cultural eutrophication and eventual decrease in dissolved oxygen levels • Excessive algal growth reduces light penetration
Sediment pollution (from logging operations, mining, etc.)	• Increased turbidity/reduction in light penetration • Deposited sediments cover/smother coral reefs
Chemical pollution, such as oil spills, pesticide runoff, sunscreen, etc.	• Disruption of reproduction and growth cycles • Disruption of metabolic processes • Endocrine disruption/DNA damage • Reduction in light penetration
Plastic/solid waste pollution	• Physical damage to/destruction of members of the coral reef ecosystem • Reduction of light penetration
Introduction of invasive species (lionfish/turkey fish, Philippine mantis shrimp, etc.)	• Invasive species can outcompete native species

2019 SCORING GUIDELINES

Question 4

One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles away from national parks.

- (a) Based on the data provided in the graph, **identify** the national park that had the greatest loss of visibility as of 2015 when compared with the historical natural visibility.

(1 point for the correct identification of the national park that has had the greatest loss of visibility)

Sequoia National Park

- (b) Visibility in national parks can be affected by many different air pollutants.

- (i) **Identify** a primary air pollutant.

(1 point for the correct identification of a primary air pollutant)

- Carbon dioxide (CO₂)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_x)
- Nitrous oxide (N₂O)
- Particulate Matter (PM)
- Sulfur dioxide (SO₂)
- Methane (CH₄)
- Volatile organic compounds (VOCs)

- (ii) **Describe** how a primary air pollutant becomes part of the atmosphere.

(1 point for the correct description of how a primary air pollutant becomes part of the atmosphere)

- Primary pollutants are released directly from a specific source, such as a smokestack, tailpipe, leaking pipelines, etc.
- Primary pollutants are released from the combustion of fossil fuels.
- Some pollutants (CO, PM) are a result of incomplete combustion of hydrocarbons.
- Some pollutants (methane, nitrous oxide, ammonia) are released directly from a biological source, such as cows, swamps, etc.

- (iii) **Identify** a secondary air pollutant.

(1 point for the correct identification of a secondary air pollutant)

- Ozone (O₃)
- Sulfuric acid (H₂SO₄)
- Sulfur trioxide (SO₃)
- Nitric acid (HNO₃)
- Peroxyacyl nitrates (PANs)
- Nitrogen dioxide (NO₂)
- Aldehydes

2019 SCORING GUIDELINES

Question 4 (continued)

(iv) **Describe** how a secondary air pollutant is formed within the atmosphere.

(1 point for the correct description of how a secondary air pollutant is formed within the atmosphere)

- Secondary air pollutants are formed when primary pollutants react with other compounds.
- Ozone (O_3) forms when primary pollutants such as NO_x and VOCs react with oxygen in the presence of sunlight.
- Sulfuric acid forms when SO_x reacts with water.
- Nitric acid forms when NO_x reacts with water.

(c) In 1990 Great Smoky Mountains National Park had a visibility of 25 miles. Visibility data for 2015 can be determined from the graph above.

(i) **Calculate** the percentage of increase in visibility from 1990 to 2015.

(1 point for the correct calculation of the percentage of increase in visibility from 1990 to 2015. Students are not required to show work.)

$$80\% \text{ increase in visibility } \left(\frac{45 \text{ miles} - 25 \text{ miles}}{25 \text{ miles}} \times 100 = 80\% \right)$$

(ii) **Discuss** TWO specific actions that the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park.

(2 points; 1 point for each correct and realistic discussion of a specific action the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park)

- Require or offer incentives for utilities/corporations to reduce emissions by specific methods, such as cap-and-trade, pollution-prevention control devices, alternative energy sources, environmental standards on new equipment, etc.
- Limit vehicle traffic in the park through increased parking fees, free/required shuttles, HOV priority parking, etc.
- Enact stricter standards for emissions on motor vehicles.
- Offer incentives to switch from gasoline-powered vehicles to electric vehicles or natural-gas powered vehicles.
- Offer tax credits or subsidies to homeowners to increase the use of renewable energy sources.
- Limit incineration practices/prohibit campfires to reduce air pollutants.

2019 SCORING GUIDELINES

Question 4 (continued)

(d) Excluding air pollution, **discuss** TWO additional ways national park ecosystems are being degraded by high levels of visitor use.

(2 points; 1 point for each correct discussion of an additional way national park ecosystems are being degraded by high levels of visitor use)

- Littering or inappropriate disposal of trash can negatively impact the health of wildlife.
- Littering or inappropriate disposal of trash can negatively impact water quality.
- Infrastructure construction/maintenance can result in habitat fragmentation.
- Driving or walking off road/path damages vegetation, increases erosion, or increases soil compaction.
- Noise pollution can adversely impact wildlife by disrupting mating, ranging, foraging, etc.
- Light pollution can adversely impact wildlife by disrupting mating, ranging, foraging, etc.
- Interactions with humans or pets adversely impacts wildlife by disrupting mating, ranging, foraging, etc.
- Visitors transporting nonnative species to the park results in an increase in invasive species.
- Camp fires from visitors can lead to wildfires.
- Removal of individual organisms for food, trophies, or human use can disrupt the food web.
- Water used for bathing and sanitation can lead to pollution of water resources.

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

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

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)
- | | |
|---|--|
| <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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)
- | | |
|---|--|
| <ul style="list-style-type: none"> • Ground water, surface water, or soil contamination through some transport mechanism • Reduced quality of life and property value due to landfill and supply trucks | <ul style="list-style-type: none"> • 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 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.

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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.

- (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

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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.