

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

A	Identify the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1. Acceptable identification point: (Ocean water) cooler than average	Point 01
B	Based on the information in Figure 1, identify the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean. Acceptable identification point: La Niña	Point 02
C	Based on the information in Figure 2, describe a difference in climate patterns between the regions A and B. Examples of acceptable responses may include the following: - Region A has an increased chance of precipitation, while Region B has a decreased chance of precipitation. - Region A will be wetter, while Region B will be drier.	Point 03
D	Describe one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation. Examples of acceptable responses may include the following: - Impervious/paved surfaces increase runoff/reduce infiltration/reduce absorption. - Parking lots/roads/buildings/sidewalks increase runoff/reduce infiltration/reduce absorption. - There is less vegetation and, therefore, less infiltration/absorption.	Point 04
E	Propose a realistic solution a city could implement to decrease the risk of flooding in urban areas. Examples of acceptable responses may include the following: - Use permeable pavement - Plant vegetation/establish parks/create rain gardens/build green roofs - Install retention ponds/stormwater basins	Point 05

- F** **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding. **Point 06**

Examples of acceptable responses may include the following:

Solution from part E	Justification of solution with additional advantages
Use permeable pavement	- Increased recharge of nearby aquifers/groundwater - Decreased pollution in runoff
Plant vegetation/establish parks/create rain gardens/build green roofs	- Vegetation absorbs pollutants - Vegetation stores carbon dioxide/produces oxygen - Decreased erosion - Increased/restored habitat for wildlife - Increased biodiversity - Helps reduce urban heat island effect - Aesthetic enjoyment/improved quality of life - Creates jobs (in landscaping/park maintenance)
Install retention ponds/stormwater basins	- Decreased pollution in runoff - Increased habitat/biodiversity

- G** **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna. **Point 07**

Examples of acceptable responses may include the following:

- Temperate seasonal forests have a cooler climate than a savanna.
- Temperate seasonal forests have a stronger/colder winter than a savanna.
- Temperate seasonal forests have four distinct seasons while savannas do not.
- Temperate seasonal forests receive more annual precipitation than savannas.
- Temperate forests receive precipitation throughout the year while savannas have a rainy season/dry season.

- H** **Identify** the ecological process that occurs following a forest fire that leaves the soil intact. **Point 08**
- Acceptable identification point:
- Secondary succession

I	Describe one way burning forests contribute to atmospheric pollution.	Point 09
	Acceptable description point:	
	Burning of trees releases CO₂/CO/NO_x/particulate matter/VOCs.	
J	Describe one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.	Point 10
	Examples of acceptable responses may include the following:	
	- Prescribed burns can remove excess fuel/dead leaves/underbrush. - Brush removal can remove excess fuel/dead leaves/underbrush. - Selective cutting can create a fire break. - In agroforestry, ground crops that might otherwise be fuel can be harvested/removed.	

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.	Point 01
	Acceptable identification point:	
	1400	
B	Based on the data in the graph, describe the trend in the number of Common Tern breeding pairs from 1995 to 2008.	Point 02
	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.	
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.	Point 03
	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.	
D	Explain how climate change can lead to sea level rise.	Point 04
	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.	
E	(i) Identify a hypothesis that researchers are likely investigating in the wading bird study.	Point 05
	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.	Point 06
	Examples of acceptable responses may include the following:	
	- Number of wading bird species - Species richness of wading birds	

F	If the researchers repeated their study, explain how this environmental change could affect the results of the study.	Point 07
	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.	
G	Describe a regulating ecosystem service that can be provided by wetlands.	Point 08
	Examples of acceptable responses may include the following:	
	(Wetlands) filter/purify/improve water (quality). (Wetlands) provide flood regulation/erosion control. (Wetlands) store/sequester carbon.	
H	Explain how increased sediment might lead to a change in the size of the wading bird populations.	Point 09
	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.	
I	Describe an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development.	Point 10
	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.	

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

A	Based on the information in Figure 1, identify the type of plate boundary that runs beneath Serengeti National Park.	Point 01
	Acceptable identification point:	
	Divergent (boundary)	
B	Based on the information provided, identify the dominant biome within the Serengeti.	Point 02
	Examples of acceptable responses may include the following:	
	- Savanna - Tropical grassland	
C	Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, identify the location in the Serengeti where wildebeest are most likely to give birth.	Point 03
	Examples of acceptable responses may include the following:	
	- Grumeti Game Reserve - The west/northwestern side/edge (of Serengeti National Park)	
D	Explain why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.	Point 04
	Examples of acceptable responses may include the following:	
	(Resource partitioning) reduces the (negative) impact of competition for (limited) resources. (Resource partitioning) allows species to use (limited) resources in different ways/places/at different times.	
E	Describe one way the proposed highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.	Point 05
	Examples of acceptable responses may include the following:	
	- Building the highway would fragment/destroy habitat/food/resources. - The highway could prevent/reduce/disturb migration. - Wildebeest could be hit/killed by vehicles. - Noise pollution could cause stress/change migratory routes.	

F **Propose** a solution to the negative effect created by the planned highway described in part E. **Point 06**

Examples of acceptable responses may include the following:

Problem in part E	Realistic Potential Solution
Building the highway would fragment/destroy habitat/food/resources.	- Construct a habitat corridor over/under the highway - Construct the highway over/above the habitat - Relocate the highway north/outside of the migratory path - Expand the national park/create additional protected habitat
The highway could prevent/reduce/disturb migration.	- Relocate the highway north/outside of the migratory path - Construct a habitat corridor over/under the highway
Wildebeest could be hit/killed by vehicles.	
Noise pollution could cause stress/change migratory routes.	- Install a sound barrier to mitigate noise pollution - Relocate the highway north/outside of the migratory path

G **Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species. **Point 07**

Examples of acceptable responses may include the following:

- They have many offspring/reproduce quickly/mature early/invest minimal energy in each offspring (tend to be r-selected).
- They can feed on/use many different types of resources.
- They can survive in conditions outside their normal habitat/have a wide range of tolerance (tend to be generalists).

H **Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations. **Point 08**

Examples of acceptable responses may include the following:

- Improved soil fertility/soil structure/soil quality
- Increased nutrient cycling/reduction in fertilizer use
- Reduced soil erosion
- Increased food security/crop yield
- Increased biological activity (in the soil)

I **Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide. **Point 09**

Examples of acceptable responses may include the following:

- Pesticides can harm/kill nontarget species.
- Pests can develop resistance to the pesticide.

J **Propose** a solution to controlling pests, other than pesticides or crop rotation. **Point 10**

Examples of acceptable responses may include the following:

- Use biocontrol/intercropping/natural predators
- Trap insects/use mechanical controls to eliminate the pests
- Use genetically modified crops that are pest resistant

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

(a) **Describe** how urbanization leads to the formation of urban heat islands. **1 point**

Accept one of the following:

- Urban buildings can block wind currents, increasing local temperatures.
- Urban building materials/structures such as roads, sidewalks, and/or buildings hold in heat, causing the temperatures to increase.
- Urban areas have fewer trees, resulting in less shade/less transpiration, causing temperatures to increase.
- Urban areas have large numbers of vehicles/air conditioners/machinery that produce waste heat, causing temperatures to increase.

Total for part (a) 1 point

(b) (i) **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands. **1 point**

Accept one of the following:

- Plant green roofs on buildings/plant vegetation around buildings/increase green space.
- Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces.
- Increase efficiency of a system that produces waste heat (vehicles, air conditioners).
- Decrease use of a system that produces waste heat (vehicles, air conditioners).

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands. **1 point**

Accept one of the following:

Solution proposed in (b)(i)	Justification solution with additional benefit
Plant green roofs on buildings/plant vegetation around buildings/increase green space	• Provides food crops • Creates habitat for biodiversity • Slows/captures runoff • Insulates buildings, which reduces heating/cooling costs • Provides aesthetic/cultural/recreational benefits • Reduces air pollution (particulates, O₃, SO₂, NO₂, CO) • Filters the air • Removes carbon from the atmosphere

Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces	- Reflects solar energy, which reduces cooling costs - Reduces energy consumption, which reduces cooling costs
Increase efficiency of a system that produces waste heat (vehicles, air conditioners)	- Decreased production of CO₂, which reduces climate change - Reduces energy consumption, which reduces costs
Decrease use of a system that produces waste heat (vehicles, air conditioners)	- Decreased production of CO₂, which reduces climate change - Decreased use of vehicles, which reduces air pollution - Reduces energy consumption, which reduces costs

Total for part (b) 2 points

- (c) (i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work.

One point for the correct setup (must include multiplication by 100) to calculate the percent change:

- $\frac{44.5\% - 15.9\%}{15.9\%} \times 100$
- $\left(\frac{44.5\%}{15.9\%} - 1\right) \times 100$

One point for the correct calculation of the percent change: **1 point**

Accept one of the following:

- 179.9%
- 180%

- (ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from \$0.11 per kWh to \$0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the change of electricity cost for one year:

- $12,900 \text{ kWh} \times \left(\frac{\$0.13 - \$0.11}{\text{kWh}} \right)$
- $12,900 \text{ kWh} \times \frac{\$0.13}{\text{kWh}} = \$1677$ **AND** $12,900 \text{ kWh} \times \frac{\$0.11}{\text{kWh}} = \$1419$; $\$1677 - \1419

One point for the correct calculation of the change of electricity cost for one year: **1 point**

- \$258

- (iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of kWh that can be produced at maximum output:

- $30 \text{ panels} \times \frac{300 \text{ watts}}{\text{panel}} \times \frac{1 \text{ kW}}{1,000 \text{ watts}} \times \frac{4 \text{ hours}}{\text{day}} \times \frac{365 \text{ days}}{1 \text{ year}}$

One point for the correct calculation of the amount of kWh that can be produced at maximum output: **1 point**

- 13,140 kWh per year

Total for part (c) 6 points

- (d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August. **1 point**

- During June through August, the Northern Hemisphere is tilted toward the Sun and receives more direct solar energy (per unit area) than the Southern Hemisphere.
- During June through August, the Northern Hemisphere is tilted toward the Sun and has more hours of sunlight.

Total for part (d) 1 point**Total for question 3 10 points**

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

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

- Urban

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

Accept one of the following:

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

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

Accept one of the following:

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

Total for part (a) 3 points

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

Accept one of the following:

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

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

Accept one of the following:

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

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

Accept one of the following:

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

Total for part (b) 3 points

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

Accept one of the following:

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

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

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

- (iii) **Identify** one water quality test, other than measuring nitrates or phosphates, that the researchers could use to evaluate how riparian vegetation buffers affect water quality. **1 point**

Accept one of the following:

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

- (iv) During the investigation, researchers discovered that some of the land next to one of the streams with a riparian vegetation buffer is going to be converted from cornfields into a large-scale concentrated animal feeding operation. **Explain** one way that this change in land use could alter the results of the study. **1 point**

Accept one of the following:

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

Total for part (c) 4 points

Total for question 1 10 points

Question 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.