2019

AP® CollegeBoard

AP® Environmental Science

Sample Student Responses and Scoring Commentary

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Free Response Question 4

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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 (CO_2)
- Carbon monoxide (CO)
- Nitrogen oxides (NO_X)
- Nitrous oxide (N_2O)
- Particulate Matter (PM)
- Sulfur dioxide (SO_2)
- Methane (CH_4)
- 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 (O_3)
- Sulfuric acid (H_2SO_4)
- Sulfur trioxide (SO_3)
- Nitric acid (HNO_3)
- Peroxyacyl nitrates (PANs)
- Nitrogen dioxide (NO_2)
- Aldehydes

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

(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.

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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.

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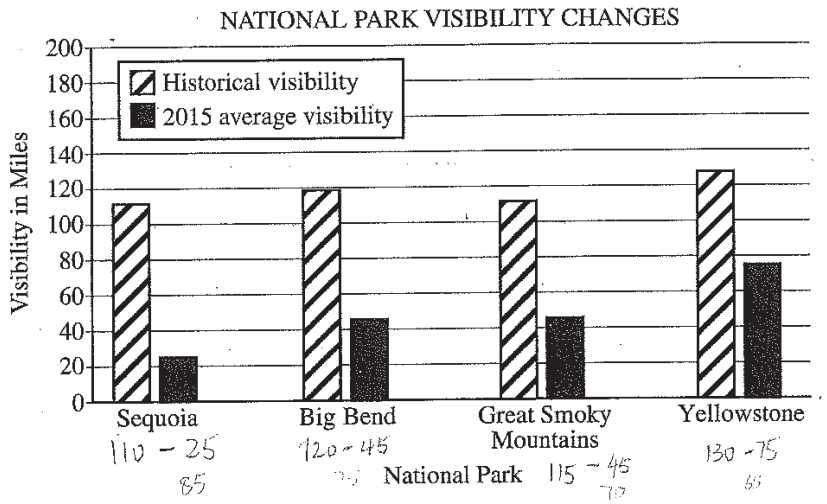
4. One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles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

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

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

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

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

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

(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 increase in visibility from 1990 to 2015.

(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.

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

a) Sequoia national park had the greatest lose of visibility as of 2015.

b) i) One primary air pollutant can be CO.

(ii) CO becomes part of the atmosphere through incomplete combustion of fossil fuels such as oil and coal. Fossil

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fuels like oil and coal include carbon, when they are burned incompletely, carbon reacts with oxygen to form carbon monoxide which is released into the air.

b(iii) One secondary air pollutant is Ozone (O_3).

b(iv) Secondary air pollutant SO_3 is formed when SO_2 ~~in the atmosphere~~ ~~react~~ reacts with O_2 in the atmosphere.

(C) (i) [(45 − 25) miles ÷ 25 miles] ~~#~~ × 100% = 80%

The percentage increase in visibility from 1990 to 2015 is 80%.

~~d~~ (C) (ii) Government could provide tax incentives for ~~near~~ ~~factory~~ factories near the national ~~park~~ park to use cleaner source of energy such as natural gas or wind or solar energy instead of burning ~~to~~ coal. By ecouraging the use of cleaner energy, less air particulates would be produced and visibility would improve. The incentive would encourage factories to ~~take~~ adopt cleaner source of energy because they could save money through the tax incentives. ~~Feder~~ Government could offer reduction of the price of public transportation near the national park such as ~~buses or~~ buses or metro. Instead of driving their own car, people may take ~~it~~ public transportation to save money, thus, less air pollutants are produced and the visibility of the national park would improves.

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(d) Natural park can be degraded by habitat fragmentation caused by ~~the~~ tourisms. The natural habitat is fragmentated by the building of roads or trails for the visitors and ~~ecotor~~ ecotones are destroyed and organisms living in that area are displaced. The waste produced by tourists can also degrade the natural park ecosystem. The waste produced by tourists are mainly municipal wastes like paper or plastic. ~~Plastic is hard~~ It takes many years for plastic to degrade and organisms in the natural park might accidentally consume the waste like plastic bag and get sick.

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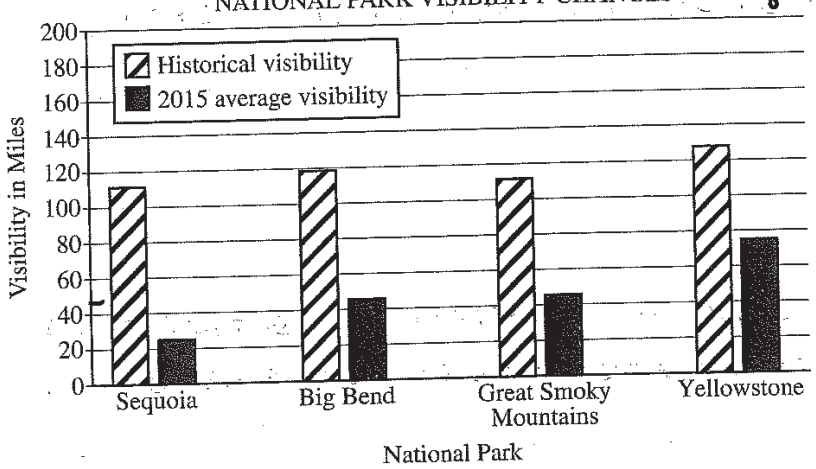
4. One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles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

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

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

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

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

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

(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 increase in visibility from 1990 to 2015.

(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.

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

a) Sequoia had the greatest loss of visibility.

b) (i) Carbon monoxide is a primary air pollutant.

(ii) Most primary air pollutants enter the atmosphere

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through combustion. Carbon monoxide, for example, is a result of motor vehicle combustion.

(iii) Ozone is a secondary air pollutant.

(iV) A secondary air pollutant forms from the interactions between primary pollutants or between primary pollutants and natural elements already in the air.

c) (i) $\frac{\text{Visibility in 2015} - \text{Visibility in 1990}}{\text{Visibility in 1990}} \times 100$

$\frac{45\text{ mi} - 25\text{ mi}}{25\text{ mi}} \times 100$

$\frac{20}{25} \times 100 = \frac{4}{5} \times 100 = \frac{400}{5} = \boxed{80\% \text{ increase}}$

(ii) The federal government could set limits on the amount of people entering the park at a time, as driving through the Smoky Mountains releases air pollutants. Also, the federal government could ban VOCs from entering the park (or products containing VOCs) because

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VOCs reacting with nitrogen oxides, heat, and sunlight can create photochemical smog, which decreases visibility.

d) Despite urging by the park rangers and signs, some visitors decide to leave their trash in areas where it can be eaten directly by an animal or runoff into a stream. Some trash contains toxic chemicals, and plastic is a prime example. Plastic can choke animals, many of which are crucial to the overall health of the ecosystems. Plastic can also disrupt endocrine systems. Also, some visitors decide to wear shoes or clothing from a different environment without washing them first, which can spread invasive species into the Smoky Mountain ecosystems. Invasive species decrease native biodiversity and competitively exclude many species.

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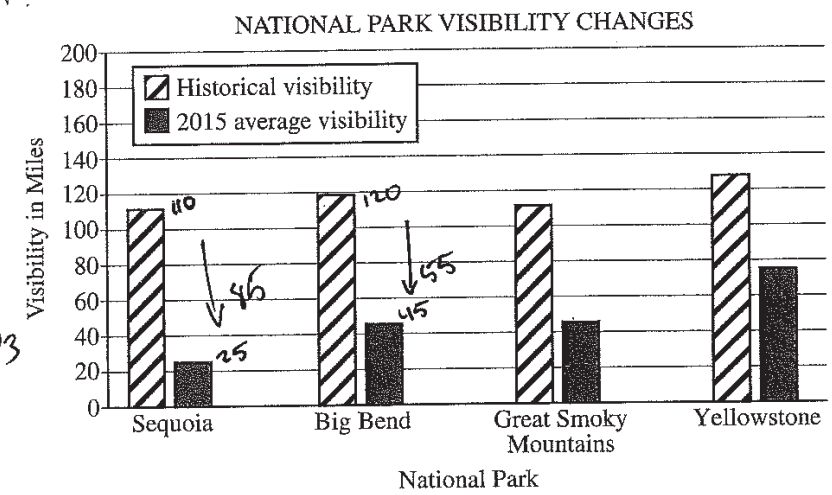
4. One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles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

CO + H2 + O2
+ CO2
C2
CH4
CH4 + O3



46
25
20

(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.

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

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

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

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

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

(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 increase in visibility from 1990 to 2015.

(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.

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

a.) Sequoia National Park

b.) i) a primary air pollutant is a pollutatant that directly affects climate change in the troposphere

ii.) primarily air pollutants become apart of the

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air through the combustion of fossil fuels such as coal and natural gas.

iii) a secondary air pollutant in the troposphere is Ozone (O_3).

iv) it is formed when CO enters the atmosphere and reacts with both hydrogen and Oxygen to form carbohydrates and the secondary air pollutant ozone.

c.) ii) could ~~provide incentives to the~~ place a tax on cutting old growth trees and provide incentives for those who own hybrid or electric vehicles such as a tax break, to encourage purchase of those cars and decrease photochemical smog emissions.

i.) $\frac{45-25}{2015-1990} \times 100 = \frac{20}{25} \times 100 =$ 80% increase

d.) visitors can not follow the park path and step on other plants and kill them. this would degrade national park ecosystems. Commuting to the park releases photochemical smog which is trapped due to thermal inversion, which decreases plant productivity due to less sunlight reaching the plants which degrades

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the national park's ecosystem.

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Question 4

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

The intent of this question was for students to evaluate a graph showing the visibility changes in four national parks, to identify and describe different types of air pollutants, and to discuss ways that national park ecosystems are being degraded by high levels of visitor use.

In the first part of the question, the stimulus provided a bar graph showing the historical visibility and the 2015 average visibility in four different national parks in the United States. Students were asked to use the data in the graph to identify the national park with the greatest loss of visibility as of 2015 when compared to the historical natural visibility.

Students were then asked to identify a primary pollutant and describe how a primary pollutant is formed, and to identify a secondary air pollutant and describe how a secondary pollutant is formed. Students were asked to use the visibility data in the graph and a provided value for 1990 to calculate the percentage increase in visibility from 1990 to 2015. Students were then asked to discuss two specific actions the state or federal government could take to further improve the visibility in Great Smoky Mountains National Park. These concepts were drawn from the following sections of the topic outline: VI. Pollution, A. Pollution Types, 1. Air Pollution and C. Economic Impacts.

Finally, students were asked to discuss two additional ways that national park ecosystems are being degraded by high levels of visitor use. These concepts were drawn from the following sections of the topic outline: III. Population, B. Human Population, 3. Impacts of Population Growth; VI. Pollution, A. Pollution Types, 2. Noise Pollution and 4. Solid Waste; and VII. Global Change, C. Loss of Biodiversity.

Sample: 4A
Score: 10

The response earned 1 point in part (a) for identifying the national park that had the greatest loss of visibility as of 2015 as "Sequoia national park" based on the data in the graph. The response earned 4 points in part (b): 1 point in (b)(i) for identifying "CO" as a primary air pollutant; 1 point in (b)(ii) for describing that "CO becomes part of the atmosphere through incomplete combustion of fossil fuels"; 1 point in (b)(iii) for identifying a secondary air pollutant as "Ozone"; and 1 point in part (b)(iv) for describing that a "[s]econdary air pollutant SO_3 is formed when SO_2 reacts with O_2 in the atmosphere." The response earned 3 points in part (c): 1 point in (c)(i) for calculating the percentage of increase in visibility in Great Smoky Mountains National Park from 1990 to 2015 as "80%" and 2 points in part (c)(ii). The response earned 1 point for discussing how the "[g]overnment could provide tax incentives for factories … to use cleaner source of energy such as natural gas or wind or solar energy instead of burning the coal. … less air particulates would be produced." A second point was earned for discussing how the "[g]overnment could offer reductions of the price of public transportation near the national park such as buses … thus, less air pollutants are produced." The response earned 2 points in part (d): 1 point for discussing that national park ecosystems are being degraded when "the natural habitat is fragmented by the building of roads or trails for the visitors" and I point for discussing how "the waste produced by tourists … takes many years … to degrade and organisms in the national park might accidentaly consume the waste … and get sick."

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Question 4 (continued)

Sample: 4B
Score: 8

The response earned 1 point in part (a) for identifying the national park that had the greatest loss of visibility as of 2015 as "Sequoia" based on the data in the graph. The response earned 4 points in part (b): 1 point in (b)(i) for identifying "Carbon monoxide" as a primary air pollutant; 1 point in (b)(ii) for describing that a primary air pollutant becomes part of the atmosphere as "a result of motor vehicle combustion"; 1 point in (b)(iii) for identifying a secondary air pollutant as "Ozone"; and 1 point in (b)(iv) for describing that "[a] secondary air pollutant forms from the interactions between primary pollutants or between primary pollutants and natural elements already in the air." The response earned 1 point in (c)(i) for calculating the percentage of increase in visibility in Great Smoky Mountains National Park as "80%." The response did not earn points in part (c)(ii) because the responses are not realistic actions that can be taken by the government to increase visibility. The response earned 2 points in part (d): 1 point for discussing that national park ecosystems are being degraded when "visitors … leave their trash … where it can be eaten directly by an animal … [and] can choke [them]" and 1 point for discussing how "visitors … wear shoes … from a different environment … which can spread invasive species … Invasive species decrease native biodiversity and competitively exclude many species."

Sample: 4C
Score: 6

The response earned 1 point in part (a) for identifying the national park that had the greatest loss of visibility as of 2015 as "Sequoia National Park" based on the data in the graph. The response earned 2 points in part (b): 1 point in (b)(ii) for describing how a primary air pollutant becomes part of the atmosphere "through the combustion of fossil fuels" and 1 point in (b)(iii) for identifying "Ozone" as a secondary air pollutant. No point was earned in part (b)(iv) because the response is inaccurate in its description of the formation of a secondary pollutant. The response earned 2 points in part (c): 1 point in (c)(i) for calculating the percentage of increase in visibility in Great Smoky Mountains National Park as "80%." The first response discussing a specific action to improve visibility in (c)(ii) is inaccurate. The second part of the response earned 1 point in part (c)(ii) for discussing how the state or federal government could "provide incentives for those who own hybrid or electric vehichles such as a tax break … and decrease photochemical smog emissions." The response earned 1 point in part (d) for discussing that national park ecosystems are being degraded when "visitors can not follow the park path and step on other plants and kill them."

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