AP® ENVIRONMENTAL SCIENCE
2010 SCORING GUIDELINES

Question 2

(a) Respond to the following using the data in the table above, which gives the rate of wood consumption by termites, in mg per day per termite, under various temperature and relative humidity conditions. Under optimal conditions, the emission rate of methane by termites is approximately 70 kilograms of CH_4 per year per 1,000 termites.

(i) According to the data, what are the optimal temperature and relative humidity for termite activity?

One point can be earned for correctly identifying the optimal temperature (30°C) AND relative humidity (90 percent).

(ii) Given a density of 4.5×10^7 termites per hectare and optimal conditions, calculate the annual amount of methane emitted, in kilograms, by the termites inhabiting a 2,000-hectare tropical rain forest.

One point can be earned for a correct setup (all units must be included), and 1 point can be earned for correctly calculating the amount of CH_4 produced per year. (Units are not required in the answer, but the student must show the calculation in order to receive the answer point.)

Points may be earned if the student writes the answer as a word problem. Solutions to the question that use alternate setups and arrive at a correct answer will also earn a point. Equivalent correct answers (e.g., 6,300,000,000 kg CH_4/year) are acceptable.

$$2{,}000 \text{ hectares} \times \frac{4.5 \times 10^7 \text{ termites}}{1 \text{ hectare}} \times \frac{70 \text{ kg } CH_4 / \text{year}}{1{,}000 \text{ termites}} = 6.3 \times 10^9 \text{ kg } CH_4 / \text{year}$$

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Question 2 (continued)

(iii) Suppose the temperature increases to 35°C and the relative humidity decreases to 50 percent. Using the data provided, determine the amount of methane, in kilograms, that would be emitted by the termites in the 2,000-hectare tropical rain forest.

One point can be earned for a correct setup, and 1 point can be earned for correctly calculating the amount of CH_4 produced per year (units are not required in the answer). Because this calculation could reasonably be done in a student's head, this answer point can be earned without a setup.

Points may be earned if the student writes the answer as a word problem. Solutions to the question that use alternate setups that produce a correct answer will also earn a point. Equivalent correct answers (e.g., 21,000,000,000 kg CH_4/year) are acceptable.

$$\frac{0.09}{0.27} \times 6.3 \times 10^9 \text{ kg } CH_4\text{/year} = 2.1 \times 10^9 \text{ kg } CH_4\text{/year}$$

(iv) Explain why the population size of the termites is also affected by temperature and humidity.

One point can be earned for a reason, and 1 point can be earned for an explanation. The reason and the explanation must be correctly linked; however, students can earn an explanation point without earning a reason point.

Reason	Explanation
• Temperature and humidity are limiting factors for the termite populations and/or their symbionts. • There is a range of tolerance for temperature and humidity values for termites and/or their symbionts.	• At temperatures of 40°C, all termite wood consumption ceases; and at 20°C, activity is at its lowest regardless of relative humidity values. • At 40°C, the symbionts living in the termite's gut may die. • At relative humidity levels less than 90 percent, termite wood consumption declines regardless of temperature.
Termites reproduce less when conditions are not optimal.	Termites swarm less, and fewer new colonies are established.
Temperature and humidity are limiting factors for plant growth and survival.	With fewer plants available, less food will be available and termite numbers will decline.

Question 2 (continued)

(b) It has been observed that soon after a tropical rain forest is cleared, termite density increases to an estimated 6.8×10^7 termites per hectare. Thereafter, the termite population size decreases dramatically.

One point can be earned in part (i) for the most likely reason, and 1 point can be earned in part (ii).

(i) What is the most likely reason that the density of the termites increases when a tropical rain forest is cleared?

- When the forest is first cleared, there is a substantial increase in dead plant material.
- The food source for the termites has dramatically increased and supports a larger population of termites.

(ii) Why do the termite populations eventually decrease dramatically?

- The termites exhaust their food supply and die off due to a lack of food.
- The termite population exceeds the carrying capacity of the forest, and the population crashes.
- With no trees, the surface temperatures increase and may exceed the upper temperature limit at which termites can survive.
- There is competition for a limited resource.

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Question 2 (continued)

(c) Describe one way, other than changes in termite activity, that tropical rain forest destruction contributes to anthropogenic climate change.

One point can be earned for stating a correct change, and 1 point can be earned for describing the response. The change and the response must be correctly linked. Students can earn a response point without earning a change point.

Change	Climate Response
Reduction in photosynthesis.	Less CO_2 is removed from the atmosphere, increasing the concentration of CO_2, a greenhouse gas, in the atmosphere.
Loss of a carbon sink.	Increased amounts of CO_2 and/or CH_4, greenhouse gases, are released into the atmosphere.
Slash/burn removal of trees.	Increased amounts of CO_2 and N_2O, greenhouse gases, are released into the atmosphere.
Lack of shade.	Warmer surface temperatures.
Reduction in evapotranspiration.	• Loss of cooling effect (atmospheric cooling) from water evaporating. • Drier climate can result in forest fires in other areas, releasing more CO_2 and N_2O, greenhouse gases, into the atmosphere.
Bulldozers, chain saws, and trucks, which are used to remove trees, consume fossil fuels.	CO_2, a greenhouse gas, is released into the atmosphere.
Increase in albedo.	More energy is reflected from the surface.

2. Termites are social insects that are essential decomposers in tropical rain forest ecosystems. Termites may account for up to 95 percent of insect biomass in tropical rain forests. Termites consume vast amounts of dead and decomposing plant material, thanks to the work of mutualistic cellulose-digesting microorganisms that inhabit their guts. In addition to their roles as important decomposers, termites digest plant materials and directly contribute to carbon dioxide and methane emissions into the atmosphere. It is likely that, like many insect species, termites and their symbionts may be sensitive to changes in their microclimate caused by global climate change, especially with regard to temperature and humidity.

		Relative Humidity		
		50%	70%	90%
Temperature	20°C	0.04	0.05	0.05
	25°C	0.05	0.07	0.10
	30°C	0.12	0.13	0.27
	35°C	0.09	0.13	0.15
	40°C	0.00	0.00	0.00

(a) Respond to the following using the data in the table above, which gives the rate of wood consumption by termites, in mg per day per termite, under various temperature and relative humidity conditions. Under optimal conditions, the emission rate of methane by termites is approximately 70 kilograms of CH_4 per year per 1,000 termites.

(i) According to the data, what are the optimal temperature and relative humidity for termite activity?

(ii) Given a density of 4.5×10^7 termites per hectare and optimal conditions, calculate the annual amount of methane emitted, in kilograms, by the termites inhabiting a 2,000-hectare tropical rain forest.

(iii) Suppose the temperature increases to 35°C and the relative humidity decreases to 50 percent. Using the data provided, determine the amount of methane, in kilograms, that would be emitted by the termites in the 2,000-hectare tropical rain forest.

(iv) Explain why the population size of termites is also affected by temperature and humidity.

(b) It has been observed that soon after a tropical rain forest is cleared, termite density increases to an estimated 6.8×10^7 termites per hectare. Thereafter, the termite population size decreases dramatically.

(i) What is the most likely reason that the density of the termites increases when a tropical rain forest is cleared?

(ii) Why do the termite populations eventually decrease dramatically?

(c) Describe one way, other than changes in termite activity, that tropical rain forest destruction contributes to anthropogenic climate change.

(a) (i) 30°C and 90% relative humidity

(ii) 4.5×10^7 termites per hectare $\div 1 \times 10^3$ termites $= 4.5 \times 10^4$ termites

4.5×10^4 termites $\times$ 70 kg $= 315 \times 10^4$ kg $= 3.15 \times 10^6$ kg per hectare

3.15×10^6 kg of CH_4 $\times$ 2000 hectare $= 6300 \times 10^6$ kg $= 6.3 \times 10^9$ kg

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(iii) .27 mg × 1000 termites = 270 mg per 1000 termite

270 mg × 365 days = 98,550

.09 mg × 1000 termites = 90 termites

90 × 365 = 32,850

98,550 ÷ 32,850 = 3

6.3 × 10^9 kg of methane ÷ 3 = 2.1 × 10^9

2.1 × 10^9 kg of methane

(iv) It is affected by temperature and humidity because termites depend on the dead and decomposing plant material to live. If conditions are bad for plant growth, such as being not humid enough or too hot, then no plants will grow and the termites will have no food and they will die.

(b) (i) It increases because there is a sudden abundance of food in the form of all of the trees that were cleared and are now dead and decomposing. This is like an all you can eat buffet for the termites and the population increases because there is enough food for that many termites.

(ii) it decreases dramatically because when all of the cleared dead trees and plants are eaten there is no more food, because all of the plants were killed, there are now no new plants to die and provide food for the termites and

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

how the over-populated termites must fight for less food then there was before the tropical rainforest was cleared.

(c) It contributes to climate change because rain forest require a large amount of CO_2 to survive. They provide an ecosystem service by taking in CO_2 and providing a carbon sink to release some of the carbon from the atmosphere. When rainforests are destroyed they can no longer remove CO_2 from the atmosphere and because CO_2 is a greenhouse gas, higher levels of CO_2 result in higher global temperatures.

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(a) i) The optimal temperature and relative humidity is 30°C and 90% humidity.

ii) $\frac{4.5 \cdot 10^7 \text{ termites}}{\text{hectare}} \cdot \frac{2{,}000 \text{ hectares}}{\text{forest}} \cdot \frac{70 \text{ kilograms of } CH_4}{1{,}000 \text{ termites}} = \frac{9 \cdot 10^{10} \text{ termites}}{\text{forest}} \cdot \frac{70 \text{ kg } CH_4}{1{,}000 \text{ termites}} = 9 \cdot 10^7 \cdot \frac{70 \text{ kg } CH_4}{1}$

$= 63 \cdot 10^8$ kilograms of CH_4 annually

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

iii) $\frac{.27}{.09} = 3$ $\frac{63 \cdot 10^8}{3} = 21 \cdot 10^8$ kilograms of CH_4 annually

iv) The population size is affected by temperature and humidity because if the conditions for termite activities are not optimal than there will be less reproducing by the termites.

B) (i) After a forest is cleared there will be large amounts of dead plant matter leftover which is what termites feed on. With this abundance of food they are able to reproduce much more rapidly

ii) The populations eventually decrease rapidly because after clearing all the left over dead plant matter there will be no more food for them because the forest which provided them with the dead plant material is gone. They will starve quickly after clearing what is left of the forest and die off.

c) Tropical rainforest destruction contributes to climate change because trees filter out Carbon dioxide and act as carbon sinks. When they are destroyed carbon is no longer filtered out of the atmosphere or stored in the trees.

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(i) What is the most likely reason that the density of the termites increases when a tropical rain forest is cleared?

(ii) Why do the termite populations eventually decrease dramatically?

(c) Describe one way, other than changes in termite activity, that tropical rain forest destruction contributes to anthropogenic climate change.

a) i. The optimal temperature and relative humidity are 30°C and 90% for termite activity.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

ii. $\frac{70\ kg/year}{1{,}000\ T} \times 4.5 \times 10^7\ T = 3.150 \times 10^6\ kg/y \times 2{,}000\ h = 6.3 \times 10^6\ kg$ / 1 hectare

Termites emit 6.3×10^6 kg of methane annually in 2,000 hectares.

iv. Termites have an absolute threshold ~~wer~~ where they would not be able to survive. Based on the chart, their threshold is 40°c, at which point consumption stops completely and the population is diminished.

b) i. When a forest is cleared the habitat of many of the termites' predators is lost and their population suffers. With less predators, termite populations grow exponentially.

ii. With the growing population comes a loss of available food supply and termite populations decrease again.

c) Tropical rain forest destruction means the loss of tree and plant cover to the forest floor. Without the shade and protection from the plants, the ground temperature increases and has more direct contact with rainfall.

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Question 2

Overview

The intent of this question was to assess whether the student could interpret and apply information supplied in a data table to determine the optimal conditions for wood consumption by termites and to determine quantitatively the amount of methane produced by termites. Students were required to apply the concepts of limiting factors or range of tolerance or both to the termite population. The question also required students to demonstrate an understanding of the impact of tropical rain forest destruction on anthropogenic climate change.

Sample: 2A
Score: 10

Six points were earned in part (a). One point was earned in part (a)(i) for correctly identifying the optimal temperature and humidity. One point was earned in part (a)(ii) for the correct answer. The student did not earn a point for the setup because units (year) are left out of the calculation. Most students who showed their work lost the setup point because they did not include all the units in the calculation. Two points were earned in part (a)(iii): 1 point for a correct setup and 1 point for a correct answer. Two points were earned in part (a)(iv): 1 point for explaining how temperature and humidity impact plant growth and 1 point for explaining the impact of no plants on the termite population.

Two points were earned in part (b). One point was earned in part (b)(i) for correctly identifying "a sudden abundance of food" as the most likely reason for the termite population increasing. One point was earned in part (b)(ii) for correctly explaining that a lack of food was the most likely reason for the termite population decreasing.

Two points were earned in part (c): 1 point for correctly describing the rain forest as a carbon sink that is lost and 1 point for explaining that "higher levels of CO_2 result in higher global temperatures."

Sample: 2B
Score: 8

Five points were earned in part (a). One point was earned in part (a)(i) for correctly identifying the optimal temperature and humidity. One point was earned in part (a)(ii) for the correct answer. The student did not earn a point for the setup because units (year) are left out of the calculation. Two points were earned in part (a)(iii): 1 point for a correct setup and 1 point for a correct answer. One point was earned in part (a)(iv) for stating that termites produce less outside of optimal conditions.

Two points were earned in part (b). One point was earned in part (b)(i) for correctly explaining the most likely reason for the termite population increasing: "After a forest is cleared there will be large amounts of dead plant matter leftover which is what termites feed on." One point was earned in part (b)(ii) for correctly explaining the most likely reason for the termite population decreasing: "after clearing all the left over dead plant matter there will be no more food … because the forest which provided them with the dead plant material is gone."

One point was earned in part (c) for identifying the loss of a carbon sink.

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Question 2 (continued)

Sample: 2C
Score: 6

Three points were earned in part (a). One point was earned in part (a)(i) for correctly identifying the optimal temperature and humidity. One point was earned in part (a)(ii) for the correct setup. Although the setup is correct, the student calculates the wrong answer. The student does not attempt part (a)(iii). One point was earned in part (a)(iv) for explaining that wood consumption stops at 40°C, a threshold for temperature.

One point was earned in part (b). No points were earned in part (b)(i). One point was earned in part (b)(ii) for correctly explaining that a lack of food was the most likely reason for the termite population decreasing.

Two points were earned in part (c): 1 point for identifying loss of shade as a result of deforestation and 1 point for describing increased surface temperatures as a result of the increased sunlight.