

2010 AP[®] ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

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 CH₄ 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.

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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 CH₄ 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 CH₄ 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 CH₄/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 CH₄ 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 CH₄/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
<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.

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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 ₂ O, greenhouse gases, are released into the atmosphere.
Lack of shade.	Warmer surface temperatures.
Reduction in evapotranspiration.	<ul style="list-style-type: none">• Loss of cooling effect (atmospheric cooling) from water evaporating.• Drier climate can result in forest fires in other areas, releasing more CO₂ and N₂O, 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.