Tropical Forests and Global Environmental Change

Focus *questions*

What is global environmental change?

What is the role of tropical forests in the global carbon cycle?

How do humans affect tropical forests?

Did you know that we humans add about 7.1 trillion kilograms (that's 7,100,000,000,000 kilograms, or 7.1 billion metric tons!) of carbon to Earth's atmosphere every year? We add carbon to the air by burning fuels like oil, gasoline, and coal. Yet the total amount of carbon in the atmosphere increases by just 3.3 trillion kilograms each year. Where do the other 3.8 trillion kilograms of carbon go? About 2 trillion kilograms dissolve into the oceans. The fate of the remaining 1.8 trillion kilograms of carbon is a bit of a mystery. Scientists **hypothesize** that the world's forests absorb a lot of it, but they are just beginning to understand the details of this process.

What is the role of tropical forests in the global carbon cycle?

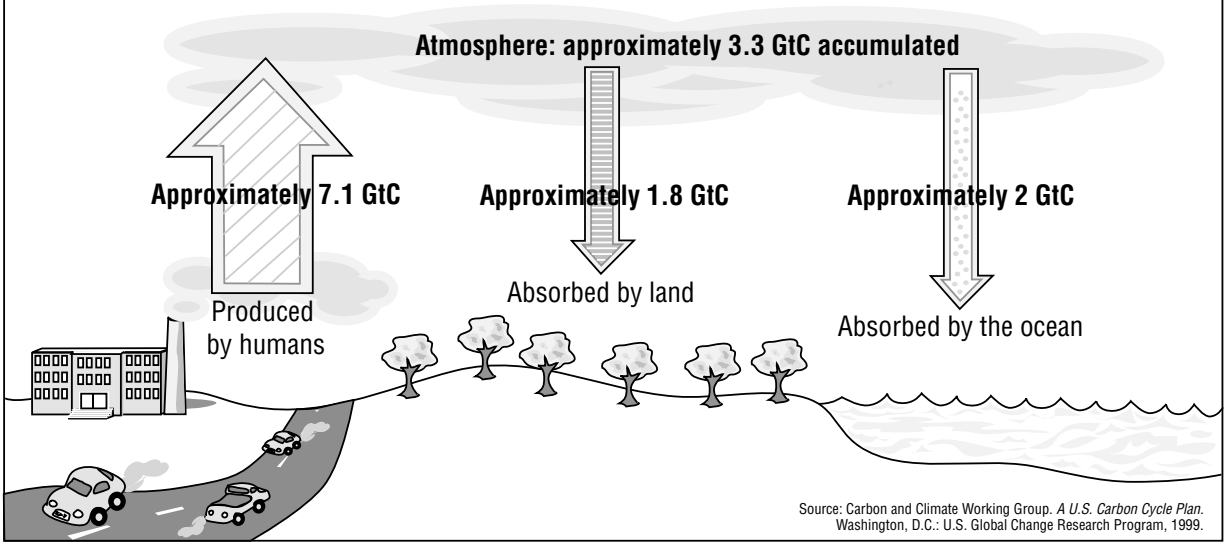
Tropical forests store about one-fifth of all the carbon contained within Earth's **terrestrial ecosystems!** Understanding how tropical forests recycle carbon is important to understanding changes in the Earth's climate. That's because carbon in the atmosphere affects the Earth's surface temperature. Though the world's climate is always changing, changes are now happening very fast—which is disturbing to scientists and non-scientists alike. Because tropical forests store large amounts of carbon, they play a very important role in the world's carbon cycle. Scientists studying the carbon cycle in Panama's tropical forests may help us better understand the role that forests around the world play in the Earth's climate.

One of these scientists is host researcher Dr. Robert Stallard. He is a **biogeochemist.** He studies the chemical interactions between Earth's living features (such as plants and animals) and its non-living features (such as atmosphere, rocks, and water). These chemical interactions are important to understanding global climate change.

Research *article*

What happens to carbon released by humans each year?

Carbon absorbed by land = Carbon produced by humans – Carbon absorbed by ocean – Carbon accumulated in atmosphere



Source: Carbon and Climate Working Group. *A U.S. Carbon Cycle Plan.* Washington, D.C.: U.S. Global Change Research Program, 1999.

The numbers represent the average amount of carbon generated by human activities emitted to (or absorbed from) the atmosphere each year between 1980 and 1990. Units are in billions of metric tons (GtC) of carbon.

Research *article*

Dr. Stallard believes that the Isthmus of Panama may be among the first of the Earth's warmer regions to show the effects of global climate change.

What is global environmental change?

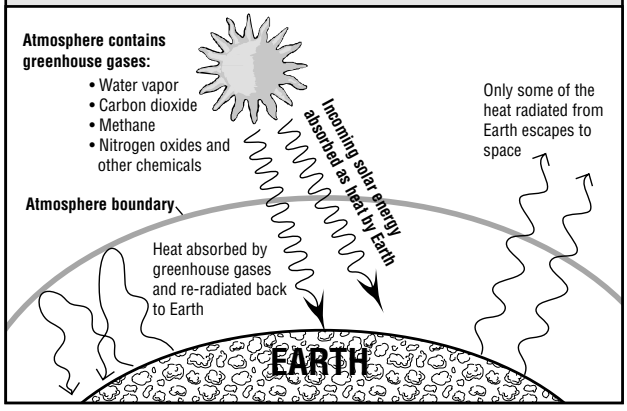
Dr. Stallard also studies **global environmental change.** Global environmental changes often involve environmental cycles, like the water cycle, the nutrient cycle, and carbon cycle. Scientists have recorded new climate patterns that are developing throughout the world. They have linked the rise in Earth's surface temperature with a rise in the level of carbon dioxide in the atmosphere. The relationships between carbon dioxide levels, increased global temperatures, and local climate conditions are important and complex. Many scientists, including Dr. Stallard, are working hard to better understand these connections.

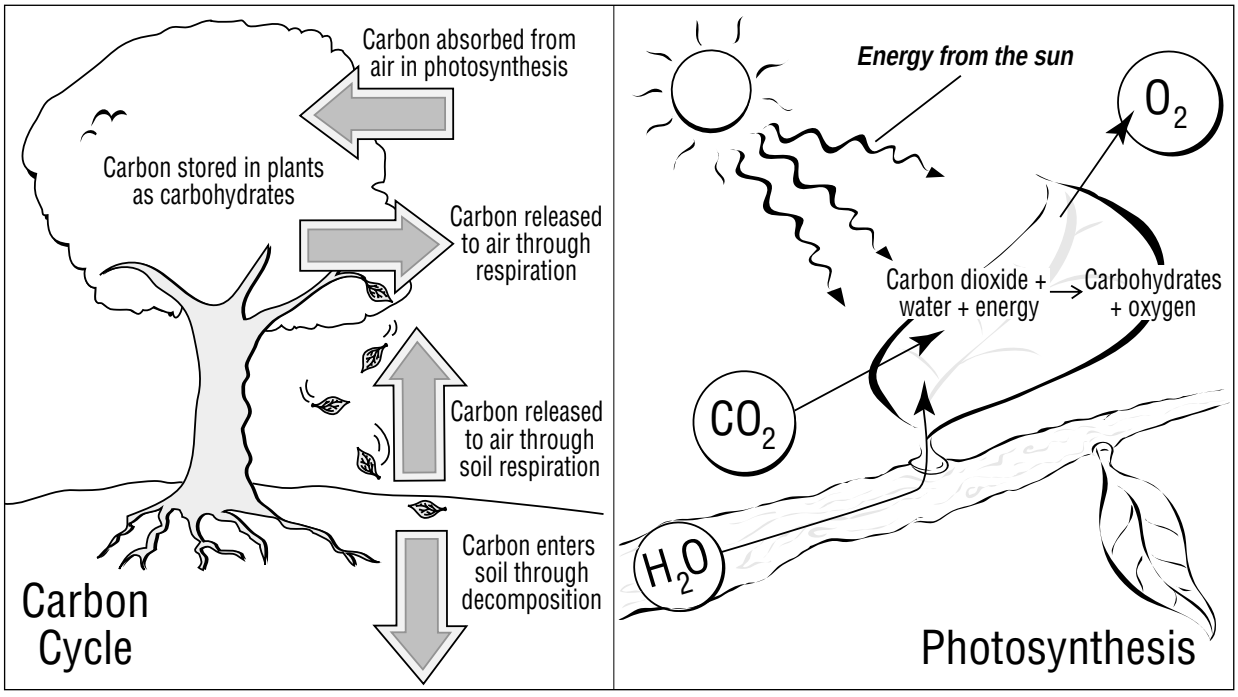
How do humans affect tropical forests?

At the end of the last ice age, around 11,000 years ago, tropical forests began to thrive in the Isthmus of Panama region. About 8,000 years ago, humans began clearing these forests to plant food crops. When the first Europeans arrived in the early 1500s, large areas of forest had been completely cut down for farming. These forested areas grew back,

Global Greenhouse

Why does the level of carbon in the atmosphere matter? Carbon dioxide in the atmosphere acts as a **greenhouse gas,** trapping energy from the sun near Earth's surface. Scientists have recorded changes in global climate patterns and an increase in Earth's temperature. These changes have been linked to the increase in the amount of carbon dioxide in the atmosphere. Scientists are concerned because modern-day humans are increasing greenhouse gases in the atmosphere faster than Earth can absorb them. These increases may actually be changing our planet's climate!





Plants (both on land and in the water) use the energy of the sun to make their food through **photosynthesis.** During this process they take in carbon dioxide and water and release oxygen. As plants die and **decompose,** carbon is released back into the soil and atmosphere (through erosion, some also ends up in streams). From there, carbon is cycled through the system again.

however, as native human populations declined in number. It was not until the 1850s that the rapid clearing of the area's forests began again.

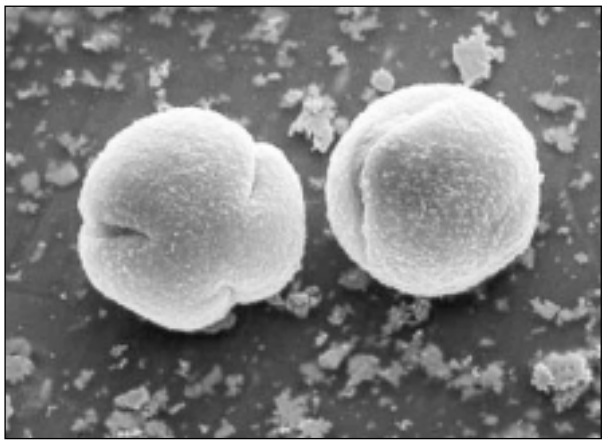
Dr. Dolores Piperno, a scientist at the Smithsonian Tropical Research Institute, is learning more about these early farmers. She is researching what kind of crops they grew and where in tropical America they originated. She does this by searching lake sediments for tiny plant **fossils,** charcoal particles, and bits of preserved pollen. Her data indicate that people were growing seed plants (maize and squashes) and root vegetables (manioc, yams, and arrowroot) in Panama as early as 7,000 years ago!

Today, Panama's tropical forests are still under increasing pressure from humans. Only about a third of Panama's original forests remain. The rest have been cut down or are threatened by nearby development. The reasons for **deforestation** in Panama are complex. As in most parts of the world, the population of Panama is increasing. Panamanians need cleared land to grow food and build homes. They also rely on the natural resources of the forests for many other purposes. For medicinal, building, or energy purposes, they harvest forest resources locally. For timber, they clear forests on a larger scale.

Without careful management, deforestation in Panama's tropical forests (and in tropical forests around the world) threatens the human, animal, and plant populations that rely on them.

Carbon Sinks

We can't understand how forests absorb carbon by simply thinking of them as collections of trees and other plants. Forests also contain living animals and decomposing organic matter. All of these release carbon dioxide to the atmosphere. In theory, a mature forest ecosystem should give off about as much carbon as it absorbs. Yet some forests—usually fast-growing, young forests—are carbon sinks. Carbon sinks absorb more carbon than they give off. They help to reduce the effects of human activities that add carbon to the atmosphere. Are tropical forests carbon sinks? Scientists are still studying this question. For a closer look at the global carbon cycle, explore Exercise 4.1, Carbon in Motion.



BIODIC

Pollen grains from an oak tree, magnified with an electron microscope.

Deforestation also threatens the important role that tropical forests play in the water and carbon cycles.

The people of Panama are working to develop long-term plans for managing the use of their forest resources in a way that is **sustainable.** Scientific research is an important part of these plans. For example, Dr. Stallard's work helps planners understand how tropical forests are valuable for preventing landslides during heavy rains. In Panama and throughout the world, it is important for scientists and managers to work together to balance the needs of local peoples with economic and forest conservation goals.

STRI's Legacy

The laboratory of the Smithsonian Tropical Research Institute, located on Barro Colorado Island (BCI), provides important data for studying global environmental changes. For over 90 years, Panama has been an important research site for Smithsonian scientists. For many years, researchers on BCI have been taking notes about weather conditions, plant and animal species, and other features of their tropical environment. Scientists today can compare data on BCI's tropical environment with data from 10, 20, or even 30 years ago. For example, Dr. Stallard has studied these long-term records to look for trends and changes in Panama's climate patterns. Careful records of past observations are very important for understanding slow changes that are hard to detect. The observations we make today might lead to an important discovery many years in the future!

Research *article*

Research *article*

The Water Cycle

An important part of Dr. Stallard's research focuses on the water cycle—or how fresh water moves from the land to the oceans, into the atmosphere, and back to the land. Storms moving in from the Atlantic and Pacific Oceans dump about 2,500 millimeters (100 inches) of rain a year on Barro Colorado Island. When water vapor in the atmosphere condenses into rain, trees soak up a large portion of the rainwater with their roots. Eventually, the trees release water vapor back into the atmosphere through their leaves. This process, called **transpiration,** is an important part of the water cycle.

Journal Question

Why are tropical forests important in the carbon cycle? View the JASON XV Expedition Field Notes Video and visit Team JASON Online to discover more to add to your journal!

Fact or *Fallacy?*

The greenhouse effect is mostly caused by carbon dioxide in the atmosphere.

Fallacy: The most important greenhouse gas is actually water vapor. It accounts for about 65 percent of the heat trapped in Earth's atmosphere. Carbon dioxide is the next most important greenhouse gas (25 percent of the heat trapped). Changes in the atmospheric concentration of either of these gases may affect global climate patterns.

Vocabulary

Biogeochemist *n.* A scientist who studies the chemical interactions between Earth's living features (such as plants and animals) and its non-living features (such as atmosphere, rocks, and water).

Deforestation *n.* A process that involves cutting down, burning, clearing, or otherwise damaging forests.

Decompose *v.* To be consumed and broken down by bacteria and other microorganisms after death.

Fossil *n.* A rock containing a trace of an ancient organism.

Global environmental change *n.* Any change in the environment that occurs throughout the world.

Greenhouse Gas *n.* Any gas present in Earth's atmosphere that is particularly effective at preventing the planet from radiating heat.

Hypothesize *v.* To suggest a scientific explanation that seems reasonable and can be tested with experiments.

Photosynthesis *n.* The process by which plants use sunlight, carbon dioxide, and water to make their own food (sugar). Oxygen is a by-product.

Sustainable use *n.* The consumption of a natural resource at a rate that does not exceed the ecosystem's ability to regenerate that resource.

Terrestrial ecosystem *n.* A group of land-based living things interacting with each other and their environment.

Transpiration *n.* The process by which a plant absorbs liquid water through its roots, pulls the water upward, and then releases water vapor through its leaves.

Tropical forest *n.* Any forest located in the tropics—a geographic region near the Earth's equator. Since Panama is entirely within the tropics, all of Panama's forests are tropical forests.

