Tropical Forest Ecosystems

Focus *questions*

What is a tropical rainforest?

What roles do arthropods play in the rainforest ecosystem?

What are green and brown food webs and how are they connected?

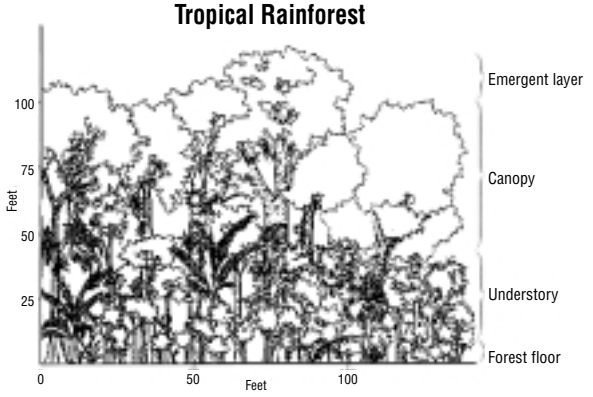
Step into the tropical rainforest on Barro Colorado Island (BCI). High above you, there is a thick roof of leaves. Insects are eating the leaves in the rainforest **canopy,** dropping nutrients down to the forest floor in their waste products. Under your feet are rotting leaves and fruit, as well as thousands of tiny creatures feeding on these treats. Huge tree trunks, plants with exotic leaves and flowers, and thousands of plant and animal **species** surround you. These species range from the tiniest insects to singing birds, brightly colored frogs, and swinging monkeys.

Don't get lost in the maze of the rainforest! JASON host researchers Dr. Meg Lowman, Dr. Mike Kaspari, and Mr. Randy Morgan are here to show you the ropes. If you're looking for Dr. Lowman, you might find her up in a construction crane, tagging leaves with tape or checking for signs of **herbivory.** Mr. Morgan might be investigating an underground leaf-cutter ant colony, while Dr. Kaspari could be searching the soil for interesting **arthropods.** Let's join them in their quest to learn more about the amazing tropical forest ecosystem!

What is a tropical rainforest?

Tropical rainforests are warm—24 to 31 °C (75 to 88 °F) year-round—because they are near the equator. And they live up to their name: they receive at least 2,000 millimeters (80 inches) of rain every year. The forest on BCI receives about 2,500 millimeters (98 inches) of rain annually. It has a distinct dry season, though, from the end of December until early April. During that period, it receives only about 300 millimeters (12 inches) of rain.

Rainforests cover less than 7 percent of the Earth's surface, but they are estimated to contain about half of the plant and animal species on the planet. Since the rainforest is home to so many plant and animal species, the level of **biodiversity** may be higher in rainforests than in any other place on Earth. For example, an average of 20 to 86 tree species exist per acre in a tropical rainforest. (In a temperate zone forest, there are about four tree species per acre.) Panama is particularly diverse. Chagres National Park, a protected area of forest in the Panama Canal area, has 1,185 species of plants, 130 of which are **endemic.** (Endemic plants are unique to the region in which they grow.) There are also 650 species of birds and 93 amphibian species in the Panama Canal region.



Emergent layer. This layer gets a lot of sun and wind. It is significantly warmer than the forest floor.

Canopy. Canopy plants produce 90 percent of all forest leaves, fruit, and seeds. Most forest insects, birds, bats, frogs, and snakes live here.

Understory. The understory gets 60 percent less light and 50 percent less wind than the canopy, but is more humid.

Forest floor. The forest floor is the coolest, darkest, and most humid part of the forest. It gets less than 3 percent of the available sunlight.

Meg Lowman and Bart Bouricius

How is the rainforest structured?

There are four main layers of a rainforest: the ground layer, the understory layer, the canopy layer, and the emergent layer (see the diagram above). The ground layer, or forest floor, is dark. It receives less than 3 percent of the sunlight that hits the forest and is quite humid. Ferns, seedlings, and palm plants grow here. The tops of young trees form the understory, the next layer above the forest floor. The canopy, located above the understory, is full of life. This layer contains most of the leaves in

Research *article*

Research *article*

the forest, so it attracts beetles, caterpillars, and many other **herbivores.** The trees are often covered with plants called **epiphytes,** which grow right on their trunks, leaves, and branches. Lianas, woody vines with roots in the ground, climb up the trees to reach the sunlight in the canopy. The emergent layer is the top of the rainforest, where a few of the tallest trees poke out above the canopy. These trees are more exposed to sunlight, high temperatures, low humidity, and strong winds.

How do scientists get up into the canopy, and what do they do when they get there?

For many years, scientists used the "reach-and-grab" technique to study herbivory in the rainforest. They only examined the branches that they could reach from the ground. Without access to the canopy, scientists could only guess how many insects were up in the trees, eating the leaves. But recently, scientists have found some interesting new ways to get up into the canopy and study the leaves and insects that live there.

Dr. Lowman uses many of those techniques: single-rope climbing techniques, cherry pickers, construction cranes, canopy walkways, and canopy rafts. Once she is up in the canopy, she examines selected leaves and estimates what percentage of each leaf has been eaten by herbivores. Dr. Lowman tags the leaves so that she can observe them repeatedly, over a long period of time. This is called long-term sampling.

Early scientists (before techniques to reach the canopy were developed) estimated that herbivores consumed 3 to 10 percent of available leaves. Now that long-term sampling data from the forest canopy are available, scientists know that the overall herbivory rates are higher—as much as 15 to 20 percent. This means that herbivores eat up to one in five leaves produced by a forest! Herbivory rates can vary from place to place. For example, in Australia, herbivory rates can be as high as 300 percent: herbivores eat three entire sets of new leaves per year.

Meg Lowman

Don't look down!
Dr. Meg Lowman climbs into the canopy to study herbivory.

What roles do arthropods play in the rainforest ecosystem?

Spiders and insects are classified as arthropods because they have jointed legs and **exoskeletons.** Arthropods fill many roles in the tropical rainforest ecosystem. They eat leaves and are eaten by other animals. They also break down leafy debris and recycle other animals' wastes. Arthropods are everywhere—they outnumber every other living thing on Earth and have been around for at least 350 million years! There could be as many as 10 million arthropod species living in tropical rainforests around the world. Scientists often find species of arthropods that have not been identified before.

How do scientists collect arthropods?

Because arthropods do so many things, they can be found throughout the layers of a tropical rainforest. Some arthropods live in the canopy and use leaves for food. Others can be found in the soil and decaying leaf litter of the forest floor. Several methods are used to study arthropods. These methods depend on where the arthropods are collected. Scientists can catch arthropods by picking them off leaves or sweeping nets back and forth along the canopy. They sometimes beat branches with sticks and collect the arthropods that fall into a tray below. To capture

flying insects, scientists set up traps. They are careful to tag the trees from which they collect samples so they can easily collect samples again from the same tree. For each tag number, they record data about the arthropods found there.

Dr. Kaspari is an ecologist and an **entomologist.** He uses some interesting techniques to catch insects that live in the soil and leaf litter of the forest floor. After scooping up a sample of litter, he sifts and pours it into a mesh bag, which he lays on a screen over a funnel. A light bulb overhead gently heats the litter, driving the arthropods downward. Eventually, they fall through the screen, down the funnel, and into a vial of alcohol. The alcohol kills and preserves the arthropods so scientists can study them.

Mike Kaspari

Dr. Mike Kaspari in the field, collecting a sample of leaf litter.

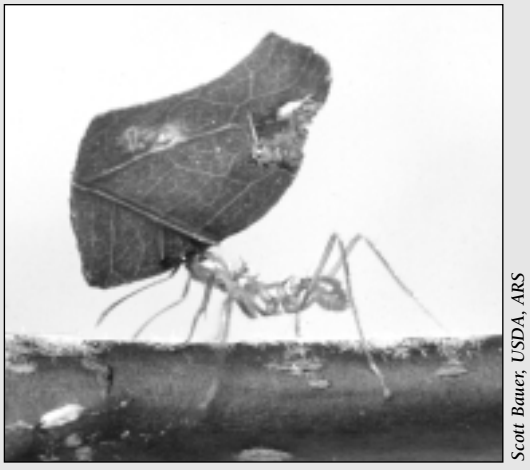
How do scientists identify the arthropods that they find?

When the scientists get back to the laboratory, they organize and review what they have collected. They attempt to identify the arthropods that they have found by comparing them to other arthropods in collections and book illustrations. Once an arthropod is identified, the scientist puts it in a collection with similar arthropods. If it is unfamiliar, it is sent to an expert **taxonomist.** If the expert cannot identify the arthropod, it is classified as a new species and the scientist gives it a name. While this type of critter may have always been in the forest, it is the first time that a scientist has found, described, and named it!

Leaf-Cutter Ants: Tropical Rainforest Farmers

JASON host researcher Randy Morgan is an ant expert. The tropical rainforests on Barro Colorado Island are home to a species of arthropod that Randy finds extremely interesting: leaf-cutter ants.

The worker leaf-cutter ants climb the trees of the rainforest and cut pieces of leaves from the canopy. They carry these leaf bits on their backs to their underground colony. A bit of leaf may weigh 30 times more than the ant carrying it! (Some ants carry an even heavier load: a small "hitchhiker" ant that rides on top of the leaf. The hitchhiker ant provides protection against attacks from flies.) An ant's journey home can take more than an hour. Back at the colony, different ants chew the leaves but they don't eat them. They place them in a pile called a fungus garden. The ants eat the fungus that grows on the chewed leaves.



Scott Bauer, USDA, ARS

A leaf-cutter ant begins the long journey back to the colony.

This is a **mutualistic relationship:** the ants and the fungus depend on each other for survival. The ants depend on the fungus for food, and the fungus depends on the ants to provide leaves to grow on. Leaf-cutter ants are important to the rainforest ecosystem because they prune the trees and stimulate forest growth. But in agricultural settings, such as farms, leaf-cutter ants can be pests that cause serious crop damage.

Research *article*

Randy Morgan

Randy Morgan makes friends with a male elephant beetle—one of the largest beetle species in the world! This beetle hatched from one of 11 eggs laid by a female elephant beetle that Randy collected during a trip to the Amazon rainforest for *JASON X—Rainforests: A Wet and Wild Adventure.*

What are green and brown food webs and how are they connected?

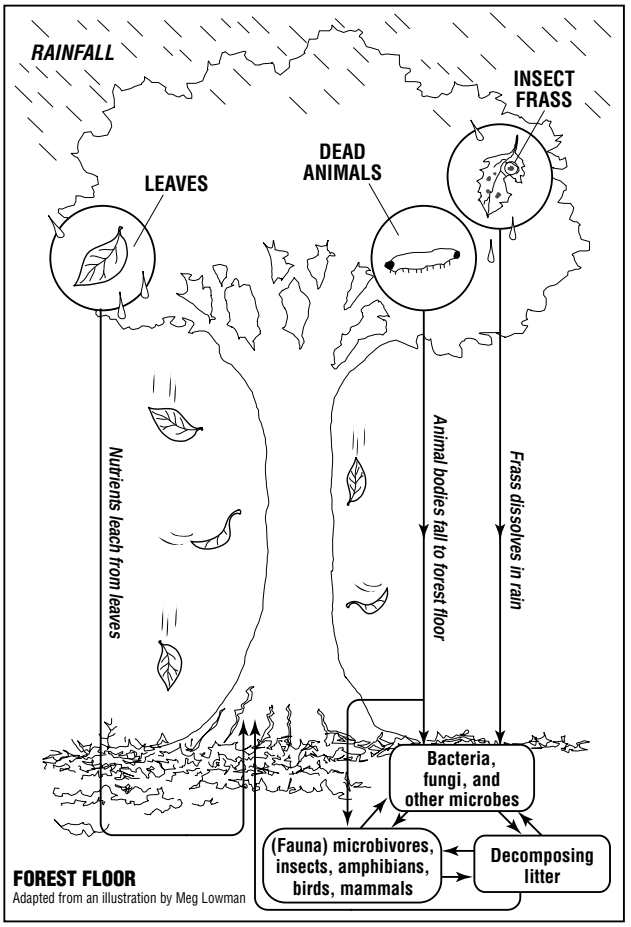
All animals and fungi, as well as many bacteria, are **consumers.** They get their energy and nutrients from food that already exists. Plants are **producers.** They manufacture their own food from nutrients (including carbon dioxide and water) and the sun's energy. This process is called **photosynthesis.**

If you make a chart with lines between each consumer and the species that it eats, you are drawing a food web. **Green food webs** include all species that feed on living plants or prey upon species that feed on living plants. Other species feed only on dead matter: the leaves that fall from trees, **frass,** and carcasses. **Decomposers** (microscopic bacteria and fungi) feed directly on this dead matter. These tiny life forms are in turn eaten by **microbivores,** which in turn are consumed by other animals. Food webs that start with decomposers are called **brown food webs.**

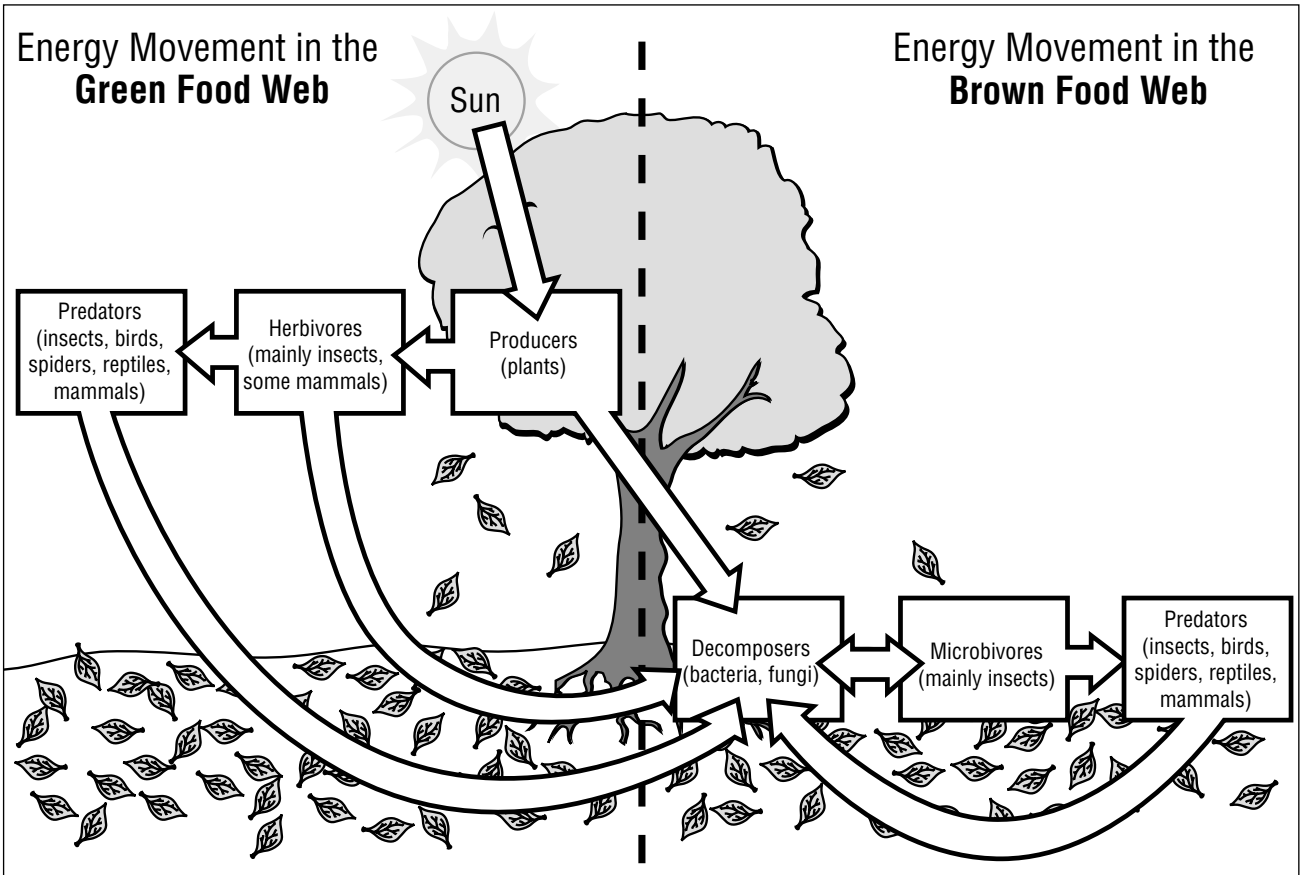
What is the nutrient cycle?

In nature, there is a constant process of building up and breaking down. Plants use water, carbon dioxide, and nutrients from the soil to grow. Consumers, such as herbivores and decomposers, process the nutrients in food and reassemble them to make their own tissues. Decomposers eventually break down everything that has been built up: dead animals, dead plants, and animal waste. This process recycles nutrients (including carbon [C], nitrogen [N], magnesium [Mg], calcium [Ca], iron [Fe], and phosphorous [P]) right back into the soil or air. Once returned to the environment, these nutrients are available to build new plants.

The process of plants taking nutrients from the soil and then returning those nutrients to the soil is part of the "nutrient cycle." Although most of the nutrients recycled in a rainforest come from dead vegetation, some are contributed by the frass produced by insects feeding on plants. In the rainforest, dead matter and waste products are broken down by decomposers and absorbed by plants so quickly that almost no nutrients can be found in the soil. This means that one of the lushest places on the planet also has some of the poorest soil. While fertile soil in a temperate forest can be 3 meters deep, the depth of nutrient-rich soil in a tropical rainforest is only 2 to 4 centimeters!



The forest nutrient cycle.



Decomposing leaf litter connects the green and brown food webs. Notice that predators appear in both the green and brown food webs.

Roger J. Harris, www.junglephotos.com

A tropical rainforest leaf—nearly consumed by herbivores.

Journal Question

How do arthropods connect the green and brown food webs in a tropical forest? View the JASON XV Expedition Field Notes Video and add your thoughts to your online journal!

Fact or *Fallacy?*

Arthropods existed even before dinosaurs roamed the Earth.

Fact: Arthropods were alive about 120 million years before dinosaurs came into existence.

Want to learn more about Dr. Lowman's adventures in the rainforest canopy? Check out *The Most Beautiful Roof in the World,* by Kathryn Lasky. It's full of beautiful photos from the rainforest and exciting accounts of Dr. Lowman's work.

Research *article*

Chocolate and Fungi: a Semi-sweet Combination?

Cocoa trees, the source of chocolate, belong to the genus *Theobroma,* meaning "food of the Gods" in Greek. These trees, farmed in Panama, sometimes suffer from diseases caused by fungi—diseases with descriptive names like frosty-pod rot, black pod, and witches' broom. The American Cocoa Research Institute and STRI are working together to help protect cocoa trees from these diseases, which can destroy cocoa crops.

Many fungus species live on the roots, stems, flowers, and fruits of cocoa trees, and not all of them cause harm. Panamanian and U.S. researchers are studying the relationship between harmful species and other fungi that have proven to help their host trees. They've found that certain fungi compete with the disease-causing fungi and actually help trees resist infection. By examining cocoa farming methods in Panama, scientists hope to find ways to use helpful fungi to protect cocoa crops. In some areas, farmers are already applying beneficial fungus to their trees. So far, these methods have shown some success in fighting cocoa diseases like witches' broom.

Vocabulary

Arthropod *n.* An animal with a hard outer skeleton (exoskeleton) and jointed legs.

Biodiversity *n.* A measure of the number and variety of species within a region.

Brown food web *n.* A food web that starts with bacteria and fungi breaking down dead leaves, animal carcasses, and waste products. This kind of food web also includes microbivores that eat the bacteria and fungi, as well as the animals that prey upon the microbivores.

Canopy *n.* The layer of a forest made up of the tops of tall, leafy trees. Rainforest canopies usually reach heights of 18 to 30 meters (approximately 60 to 100 feet).

Consumer *n.* An organism that eats other organisms to get its food.

Decomposer *n.* A bacterium or fungus that feeds on and breaks down dead plant or animal matter, making nutrients available to the ecosystem.

Endemic *adj.* Living only in a certain region.

Entomologist *n.* A scientist who studies insects and other arthropods.

Epiphyte *n.* A plant that gets its moisture and nutrients from the air and rain and usually grows on another plant.

Exoskeleton *n.* The hard outer covering of an arthropod.

Frass *n.* Solid insect waste products.

Green food web *n.* A food web made up of species that feed on plants or prey upon species that feed on plants.

Herbivore *n.* An animal that feeds on plants.

Herbivory *n.* Consumption of plants by animals, including insects.

Microbivore *n.* An animal that feeds on decomposers (bacteria and fungi) at the base of the brown food web.

Mutualistic relationship *n.* A relationship between different species in which each organism benefits from its association with the other.

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

Producer *n.* An organism that makes its own food.

Species *n.* A group of individuals that share many physical characteristics and can interbreed.

Taxonomist *n.* A scientist who specializes in classification. Taxonomists classify different organisms into ordered groups related through evolution.