Welcome to McMangrove's!

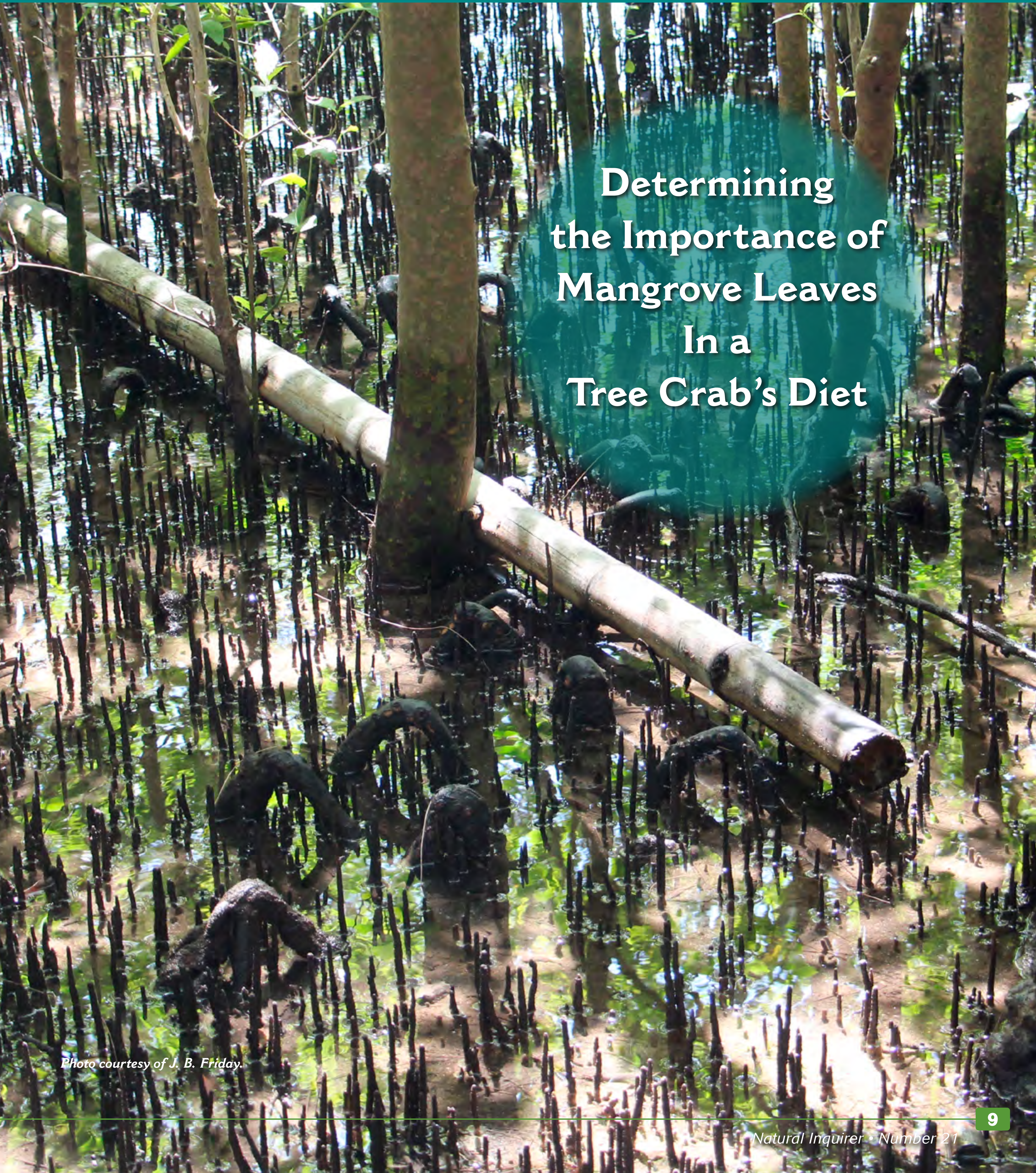
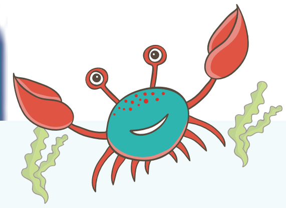


Photo courtesy of J. B. Friday.

Meet the Scientists



▶ **Richard MacKenzie,** Ecologist: I LOVE working in mangrove forests. I get to swim, climb trees, and get covered in mud almost every time I go out into the field. My mother says I was made for this job because I have been coming home covered in mud ever since she can remember.

Every time I enter a mangrove, it is like entering another world. I feel like I am entering the Dagobah Swamp in the movie "Star Wars" and almost expect to run into Yoda. Towering trees are everywhere with many kinds of aboveground roots. Prop roots, for example, grow from branches downward and create real-life jungle gyms to climb. Some roots reach up toward the sky, and giant ribbon roots meander through the soft mud (see my picture).

Tiny, beautiful colored crabs scurry all around. They are looking for food, trying to avoid being food, or madly waving their front claws at each other as they engage in mating rituals. Giant fruit bats slowly flap their modified hands and wings overhead like pterodactyls (**ter ə dak** təls) and parrots watch curiously from the trees as we work. It is like the articles I read as a kid in *National Geographic* (see additional biography information on page 30).

USDA Forest Service photo.

What Kind of Scientist Did This Research?

Ecologist: This scientist studies the relationship of living things with their living and nonliving environment.

Photo courtesy of Nicole Cormier.

▲ **Nicole Cormier,** Ecologist: My favorite science experience is any day working in the mangroves! I love the sights and sounds of the forests—the differences of the interesting species, the strange-looking **propagules** and jumbled roots, the cool squish of the mud as I walk through the forest, the slurp of the sediment and the stinky rotten egg smell of sulfur as I extract a soil core for analysis.

I love to watch the small mud crabs duck into their holes as we approach, the tree crabs scamper and hide on the other side of the trunk, and the fish dart in the tidal creeks among the mangrove prop roots. I have seen monkeys, wild boars, snakes, monitor lizards, and even baby sharks while walking through a mangrove! And most of all, I enjoy working with and learning from my fellow scientists in many different countries. I feel so lucky to work with so many awesome people in beautiful places.

▼ **Amanda Demopoulos**, Ecologist: It is hard for me to select my favorite science experience! Whenever I have the chance to go in the field, whether trudging through the mangrove forest, diving on coral reefs, or working on a ship offshore exploring the deep sea, I love it all!

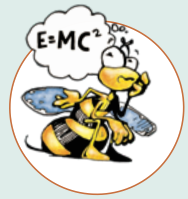
Not only do I get to work in incredibly interesting places on the planet, but I also literally dig into the mud to discover what is living there. I get to work with wonderful scientists from all over the world. This community of scientists, from students to senior researchers, help make the science happen. Through conversations and working together we learn more about our ocean planet.

I also get to use cool technology, like human-occupied underwater vehicles (small submarines) and research vessels to conduct my work. In this photo, I am scuba diving with Dr. Nicole Cormier in St. John, U.S. Virgin Islands. I am on the left in this photo. The U.S. Virgin Islands are a U.S. Territory located in the Caribbean.

Photo courtesy of Amanda Demopoulos.

Glossary words are bold and are defined on page 25.

Thinking About Science



In a scientist's world, most scientific knowledge is usually considered temporary. As scientists continue to study a topic, they learn information that either confirms or updates previous knowledge. In this research, for example, the scientists found that knowledge previously held about crab diets was not entirely correct. Are you surprised to learn that understanding crab diets is important? Studying crab diets is important because such knowledge informs how scientists understand the carbon cycle. (You will learn about the carbon cycle in "Thinking About the Environment.") Doing research to confirm or update existing knowledge is one of the critical roles of science.

In your own experience, think of something that you thought was true and was later revealed to be false. Being open to new knowledge is important. When you are open to being challenged about what you know, you are thinking like a scientist.

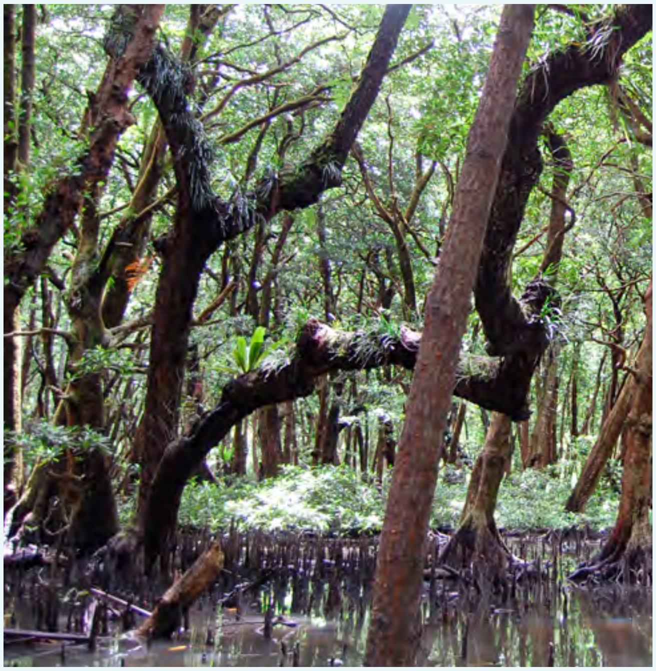
Thinking About the Environment

Carbon is an important part of our world. Carbon is an element that is found in water, soil, plants, animals, and the atmosphere. Humans contain carbon too. About 18 percent of your body is carbon!

Carbon is one of the most abundant of Earth's elements. Humans and other animals get carbon from eating plants and from eating animals that eat plants. A plant contains carbon as long as it lives and until it is eaten, completely decays, or is burned. Plants get carbon by taking in carbon dioxide (CO_2). When the plant takes in CO_2, it keeps the carbon and releases the oxygen.

In wetlands, much of this carbon is used for belowground root growth in **sediments**. Little oxygen is found in wetland sediments because all the spaces between sediment particles and roots are filled with water, not air. **Microorganisms** that would break down these roots have a hard time breathing and as a result, belowground roots decay slowly. Therefore, the carbon from these roots can be stored in wetland sediments for thousands of years. Carbon that is held in wetland sediments is known as blue carbon. Blue carbon ecosystems include salt marshes, sea grasses, and mangrove ecosystems (**figures 1a** and **1b**).

In this research, the scientists were interested in better understanding the role of decaying mangrove leaves in sesarmid (sə **sär** mid) crab diets. By increasing their understanding, the scientists gained more knowledge of how carbon moves throughout the mangrove ecosystem (**figure 2**).



Figures 1a and 1b. Mangrove forests grow in subtropical and tropical climates. USDA Forest Service photos by Rich MacKenzie.

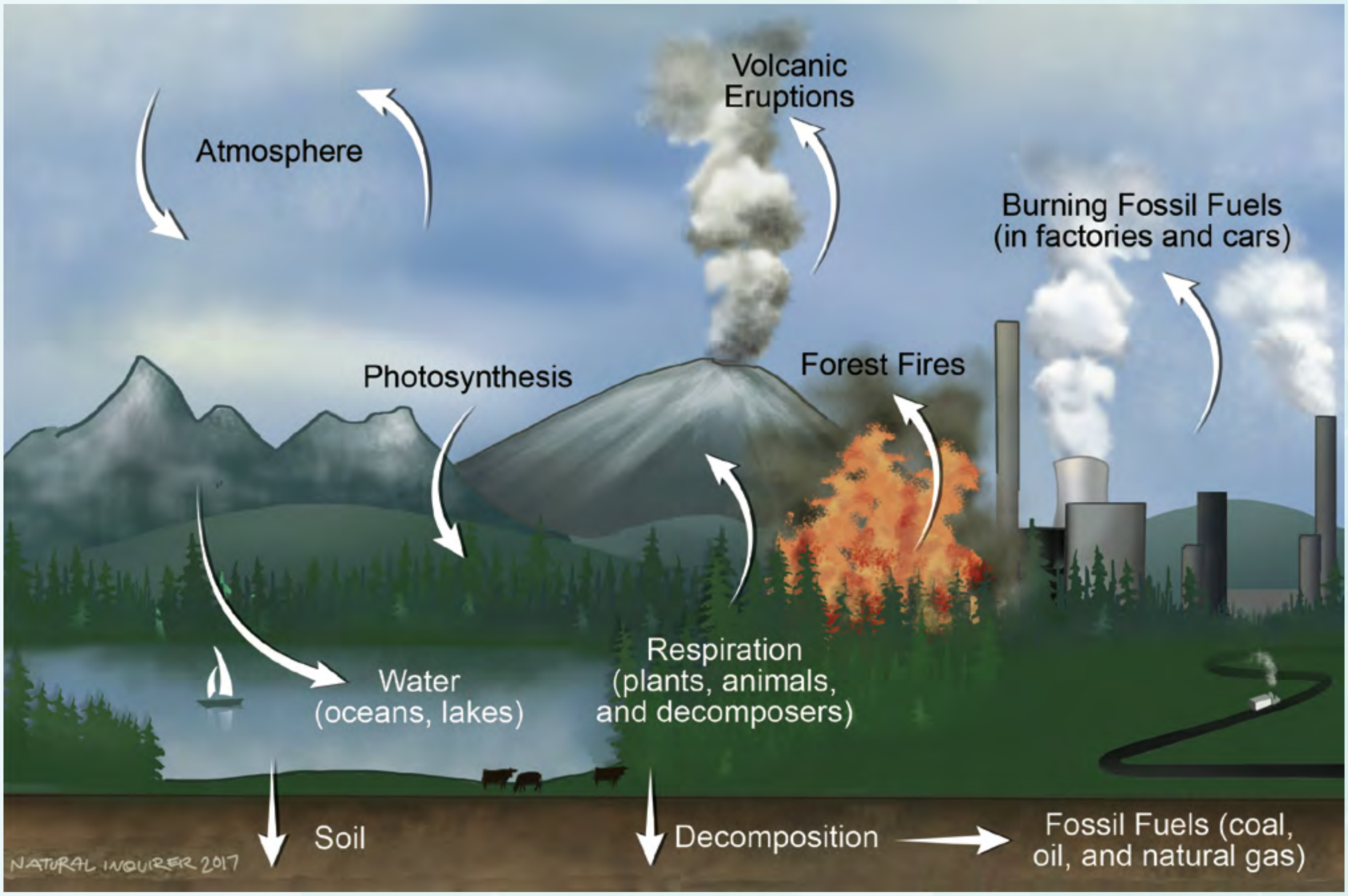


Figure 2. The carbon cycle. In a mangrove ecosystem, carbon moves from the atmosphere and into the ocean, rivers, trees, and plants. Carbon is also found in a mangrove ecosystem's animals and decomposers. FIND Outdoors illustration by Stephanie Pfeiffer Rossow.

Introduction

Sesarmid crabs are a family of crabs found in tropical coastal mangrove forests worldwide (**figure 3**). During high tide, these crabs climb onto the mangrove trees or hide in their burrows to escape from predators (**figures 4a, 4b,** and **4c**). Sesarmid crab predators include large fish that swim into the mangroves at high tide. At low tide, when the mangrove forest floor is exposed, the crabs feed on leaves and mud on the forest floor (**figures 5a, 5b,** and **6,** page 16).

Sesarmid crabs are an important part of the mangrove forest ecosystem. First, by eating decaying mangrove leaves and microorganisms that live on the sediment's surface, crabs play a role in the carbon cycle. When the crabs eat the leaves and microorganisms, the carbon is transferred to the crabs. Additionally, when other animals eat the crabs, the carbon is transferred from the crabs to the crabs' predators. When the crabs eat the leaves, other nutrients are also released that can be recycled by mangrove trees and plants.

Sesarmid crabs also contribute to the mangrove ecosystem by building complex burrows in the mangrove sediment that covers the forest floor (**figure 7**, page 17). These burrows function as pathways for the transport of decaying or digested **organic** matter. When sesarmid crabs build and then enter their burrows, they pull leaves into their burrows and store them (**figure 8**, page 17). In the burrows, bacteria and fungi begin to grow on the leaves. The bacteria and fungi make the leaves more nutritious and appealing to eat. Finally, the burrows created by sesarmid crabs may also be occupied by other small animals. These burrows provide a constant and safe environment that increases diversity in the mangrove ecosystem.

Many scientists have believed that single-celled microorganisms, such as **algae** and **cyanobacteria**, are the largest part of sesarmid crab diets. These microorganisms are found on the surface of the mangrove forest floor's sediment.

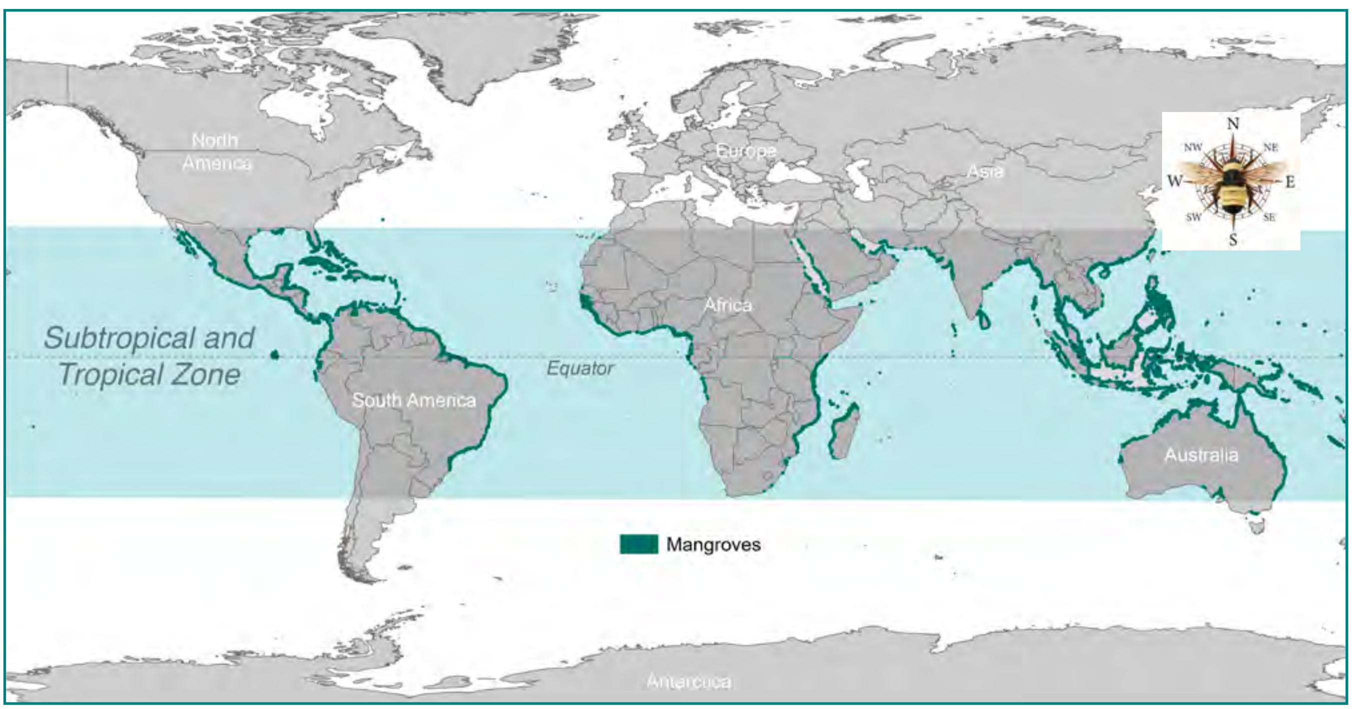
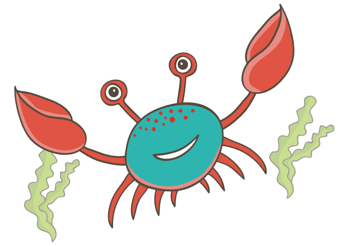
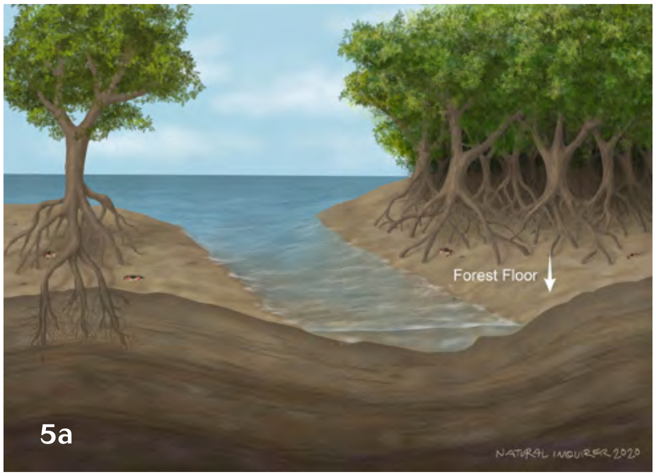


Figure 3. The subtropical and tropical zone and location of mangrove forests worldwide. FIND Outdoors map by Carey Burda.

Figures 4a, 4b, and 4c. 4a: A sesarmid crab in a mangrove tree. 4b: A line of crabs climb up a tree. 4c: A sesarmid crab hangs onto a branch. USDA Forest Service photos by Rich MacKenzie.



At the beginning of their study, the scientists began to investigate how typhoons, which may also be called hurricanes, impacted the importance of microorganisms in sesarmid crab diets. The scientists discovered, however, that instead of microorganisms, crabs appeared to be mostly eating decayed mangrove leaves. Therefore, the scientists posed an additional research question for their study. The scientists wanted to discover whether the mangrove leaves were a more important food source than scientists previously thought for this type of sesarmid crab.



Figures 5a and 5b. Mangrove forests are found in coastal areas, where they are subject to rising and falling tides. 5a: Mangrove at low tide. 5b: Mangrove at high tide. FIND Outdoors illustrations by Liz Sisk.

Figure 6. The sediment on a mangrove forest floor contains microorganisms that are one of a sesarmid crab's food sources. Photo by Babs McDonald.

Figure 7. Sesarmid crab burrow. FIND Outdoors illustration by Liz Sisk.

Figure 8. A sesarmid crab pulls a leaf into its burrow. USDA Forest Service photo by Rich MacKenzie.

Fun Fact!

What else do sesarmid crabs eat?

Decaying leaves and microorganisms are not the only things that sesarmid crabs eat. Sesarmid crabs may eat worms that are in the sediment, and they may also eat leaves off the trees.

Sesarmid crabs are coprophagous (kə **prä** fə gəs), meaning they eat feces or dung. In the case of sesarmid crabs, they eat their own feces (poop)!

Reflection Section

- When a sesarmid crab eats a decaying mangrove leaf, it transfers the carbon from the leaf into its own body. When you eat an apple, are you transferring the apple's carbon to your own body? Why do you think that is the case?
- In your own words and in the form of a question, state the additional research objective of this study.

Methods

The scientists studied sesarmid crabs living in the mangrove forests on the coasts of Yap and Babeldaob **(bä bəl daůb)** Islands (**figure 9**).

To begin the research, the scientists collected **samples** from mangroves in Yap that had been impacted by a typhoon. The scientists collected individuals of a particular species of sesarmid crab called *Parasesarma* **(pär ə sə sär mə)** (**figure 10**). This crab species was easy to find and capture.

The scientists also collected decaying leaf samples from the *Rhizophora* **(rīz ə fȯr ə)** species of mangrove tree (**figure 11**). The scientists had observed the *Parasesarma* crabs eating the leaves of this mangrove species. The decaying leaves were collected from the forest floor (**figure 12**). Sediment samples containing single-celled algae and other microorganisms were collected by scraping and removing the top 1 centimeter (cm) of sediment. Algae were also collected by gently using filtered seawater to rinse downed wood. Downed wood is wood that has fallen to the forest floor.

The scientists took tissue samples from the crabs. They used an isotope **ratio** mass spectrometer **(spek trä mə tər)** for their next step. This equipment enabled the scientists to determine the ratio of carbon-13 to carbon-12 isotopes. Isotopes are different forms of the same element. A ratio analysis was done on the crab tissues, the decaying leaves, and the microorganisms. For an additional challenge, read about carbon isotopes at the end of this "Methods" section.

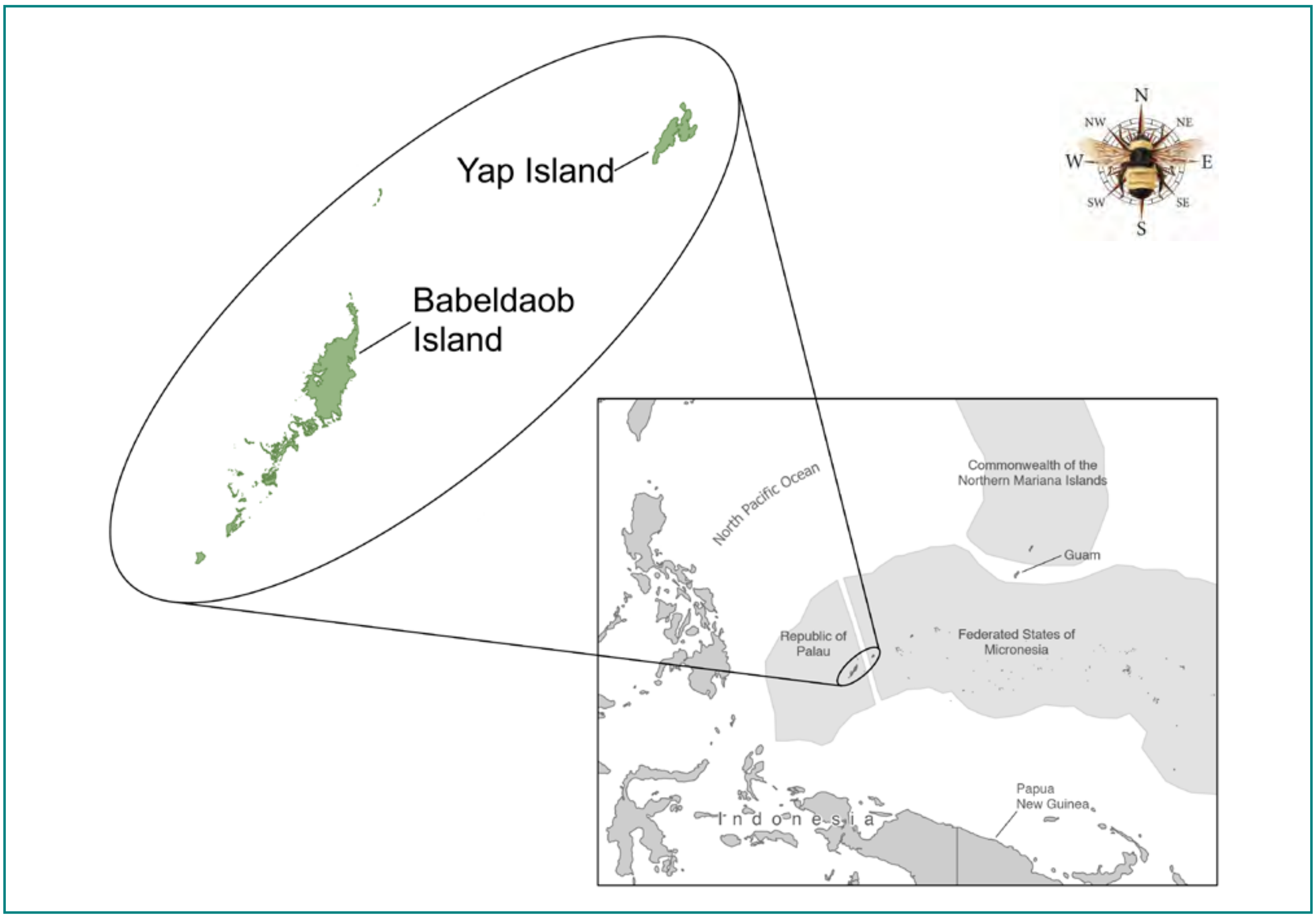


Figure 9. Yap and Babeldaob are islands in the western Pacific Ocean, north of Australia. Yap is an island in the Federated States of Micronesia, and Babeldaob is the largest island in the Republic of Palau **(pə laů)**. FIND Outdoors map by Carey Burda.

Figure 10. *Parasesarma* crab from Yap. USDA Forest Service photo by Rich MacKenzie.

Figure 11. *Rhizophora* mangrove leaf partially eaten by a crab. This leaf was painted by the scientists as a part of another study. The crabs will sometimes hold the leaf in their claws and eat it like it is an ear of corn. USDA Forest Service photo by Rich MacKenzie.

Figure 12. The scientists collected decaying leaves from the mangrove forest. Photo by Babs McDonald.

After evaluating the samples from Yap, the scientists collected samples on Babeldaob. They captured *Parasesarma* crabs and collected decaying mangrove leaves from the forest floor. Unfortunately, the scientists were unable to collect enough microorganisms from the sediment on Babeldaob.

The crabs and leaves were taken to a laboratory in Palau. The crabs were placed in plastic containers and allowed to sit for 2 days so that their stomachs were empty. Then, a decaying mangrove leaf was added to each container and replaced every 3–4 days (**figures 13a** and **13b**). The crabs were kept in the containers for 44 days. On days 0, 1, 7, 17, 21, and 44, crab tissues were collected from the crabs.

Every living and once-living animal and plant contains carbon. The scientists used special equipment to measure and compare the amount of carbon in the crabs and the mangrove leaves. When scientists compare the amount of carbon-13 (^{13}C) with the amount of carbon-12 (^{12}C) in tissues, they are calculating a value called delta carbon-13, or $\Delta^{13}C$. The "Δ" symbol is the Greek letter for delta. In science, this symbol implies that something has changed. For more information about $\Delta^{13}C$, see the "Bee Challenged" section at the end of this "Methods" section.

When an animal eats a plant or another animal, they can gain a little bit more ^{13}C than was present in the plant or animal that they ate. Scientists call this **enrichment**. Understanding the amount of enrichment that occurs when an animal eats something helps scientists to determine the importance of the food in the animal's diet.

In **food chain** studies, scientists have considered the amount of enrichment that occurs between an animal and its food source to be the same for a variety of species and ecosystems. In past studies of sesarmid crabs, scientists used enrichment values determined by other studies. The scientists in this study wanted to determine the enrichment value for sesarmid crabs in the Yap and Babeldaob ecosystems instead of using values from other studies. The scientists thought that using a value from other studies might produce incorrect information about crab diets in these mangrove ecosystems. By calculating a $\Delta^{13}C$ value for sesarmid crabs in Yap and Babeldaob, the scientists were able to accurately calculate the enrichment value for sesarmid crab diets.

The scientists entered different enrichment values into a computer program. This program estimated what percentage of the sesarmid crabs' diet was decaying mangrove leaves. The scientists ran the computer program using enrichment values from other studies and their current study. Running the program with different enrichment values enabled the scientists to compare their results with results from other studies.

Figures 13a and 13b. Crabs were placed into plastic buckets and fed decaying mangrove leaves. USDA Forest Service photos by Rich MacKenzie.

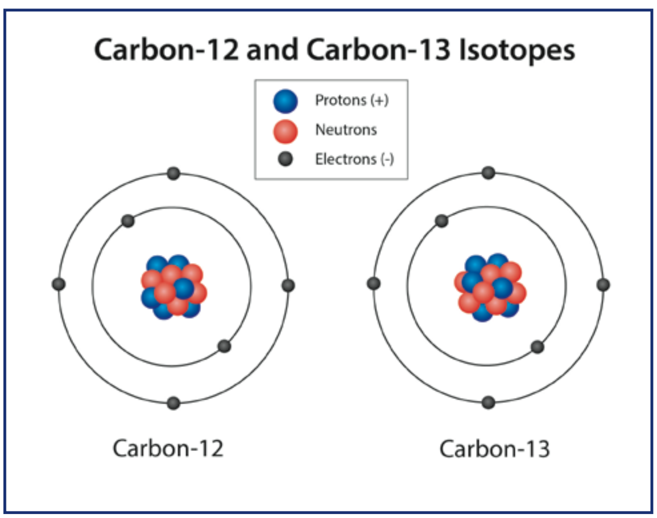
Bee Challenged!

What Are Isotopes?

You probably know that atoms are life's building blocks. An atom's nucleus (center) contains protons and neutrons. An element, such as carbon, is defined by the number of protons it contains. A carbon atom always contains 6 protons. If an atom has 7 protons, it is nitrogen. If it has 8, it is oxygen. If you look at the periodic table of elements, you will see the number of protons in each element's atomic nucleus.

Atoms of the same element can have different numbers of neutrons in their nucleus. For example, carbon can have 6, 7, or 8 neutrons. Atoms of the same element with different numbers of neutrons are called isotopes of that element. An atom's atomic number is the sum of the number of protons and neutrons. The atomic number is the isotope's total weight, or mass. Carbon isotopes, therefore, can have atomic numbers (or weights) of 12, 13, or 14. These isotopes are known as carbon-12, carbon-13, or carbon-14. The isotopes are often written as ^{12}C, ^{13}C, or ^{14}C.

All substances are made up of elements, and they may contain different isotopes of the same element. Your body, for example, contains ^{13}C and ^{12}C. Because isotopes of the same element have different weights, they can be separated and counted using specialized equipment. This equipment is called an isotope ratio mass spectrometer.



Carbon-12 and carbon-13 isotopes. How many neutrons does each isotope have? FIND Outdoors illustration by Liz Sisk.

A Thermo Scientific Delta V isotope ratio mass spectrometer. This equipment enables scientists to determine the difference between two different isotopes' masses within a tissue or substance. Grizzly Analytical photo.

Reflection Section

- Why do you think the scientists wanted to make sure that the crabs' stomachs were empty before they provided leaves to the crabs?
- Let's say the enrichment values for crabs eating mangrove leaves on Yap and Babeldaob were found to be greater than the values used in other studies. What might you conclude about the relative importance of mangrove leaves in the sesarmid crabs' diet on Yap and Babeldaob?
- Let's say the enrichment values for crabs eating mangrove leaves on Yap and Babeldaob were found to be greater than the values used in other studies. What more general conclusion might you draw about the best enrichment values to use when conducting a food chain study?

Bee Challenged Even More!

What is $\Delta^{13}C$?

An isotope ratio mass spectrometer can determine the ratio of an element's isotope to another isotope. For example, scientists often want to know the ratio of ^{13}C to ^{12}C in a tissue or substance. This ratio can vary from organism to organism. A comparison of the ratio in different tissues or substances, therefore, enables scientists to compare the tissues or substances. The ratio of ^{13}C to ^{12}C atoms is referred to as $\Delta^{13}C$. The symbol Δ is pronounced "delta." The notation $\Delta^{13}C$ refers to the ratio of ^{13}C to ^{12}C isotopes.

The scientists used an isotope ratio mass spectrometer to better understand the crab tissue and the mangrove leaf content. This analysis calculated how much ^{13}C and ^{12}C were in the crab tissue and the decaying mangrove leaves. These findings enabled the scientists to calculate $\Delta^{13}C$. The scientists wanted to compare the $\Delta^{13}C$ of the crabs with the $\Delta^{13}C$ of the leaves.

Findings

The scientists discovered that the ^{13}C enrichment values for crabs eating mangrove leaves in the laboratory were higher than the values used in the earliest studies (**table 1**).

Recall that the scientists used a computer program to determine the relative importance of mangrove leaves in the crabs' diet. The scientists used enrichment values from their study first. Then, the scientists ran the program using enrichment values from other studies that were not for sesarmid crabs, but that also have been used in previous sesarmid crab food chain studies (**table 2**).

Table 1. Enrichment values for sesarmid crabs, other water-based animals, and land animals in studies conducted between 1987 and 2019.

	Carbon 13 Enrichment Values
Parasesarma crabs enrichment value relative to mangrove leaves*	3.3
Previous sesarmid crab study (2017)	1.5–6.0
Previous sesarmid crab studies (2013 and 2014)	4.1–5.5
Previous water-based animal studies (2001 and 2003)	0.3–1.8
Initial land-based study (1987)	0.2

* Current study

Table 2. Percent contribution of mangrove leaves in sesarmid crab diets calculated using enrichment values from other studies not using sesarmid crabs and from more recent studies that included sesarmid crabs, including the present study.

Year of previous animal diet study	Percent contribution of mangrove leaves in diet using general enrichment values between other animals and their food source	Average contribution of mangrove leaves in diet based on current and more recent enrichment values specific to sesarmid crabs
1984	31.2	64.8
2002	50.0	64.9
2004	27.3	48.1
2004	0.0	66.7
2008	13.9	22.4
2010	49.0	73.2
2010	0.0	60.6
2010	51.6	65.7
2017	50.4	66.7
2019	47.8	60.6

Reflection Section

- Look at table 1. What might be one reason for the difference in reported enrichment values?
- Examine table 2. Why do you think the average contribution of mangrove leaves in sesarmid crab diets was larger in the second column?

Discussion

The scientists discovered that previously published ^{13}C enrichment values might underestimate the value of decaying mangrove leaves in sesarmid crab diets. This finding is important for two main reasons.

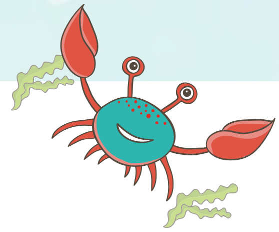
First, this finding suggests that scientists should determine ^{13}C enrichment values for unique species and ecosystems when conducting food chain studies. At the least, available enrichment values from the same type of animal (or related animal) should be used. Scientists should not simply use the ^{13}C enrichment values determined in other studies regardless of the animal being studied. Using previously determined enrichment values from studies of different animal species may result in an incorrect assessment of the importance of food sources in an ecosystem's food chain.

Second, this research suggests that decaying mangrove leaves are more important in sesarmid crab diets than previously thought. This finding helps ecologists to better understand how carbon is transferred in a mangrove ecosystem. This finding also helps to clarify the role of mangrove trees within the mangrove ecosystem.

Reflection Section

- Recall or reread "Thinking About Science" on page 12. Explain in your own words what knowledge was updated through this research.
- Reread the last paragraph of the "Introduction" on page 16. What is the answer to the scientists' second research question?

Adapted from MacKenzie, R.A.; Cormier, N.; Demopoulos, A.W. 2020. Estimating the value of mangrove leaf litter in sesarmid crab diets: the importance of fractionation factors. Bulletin of Marine Science. https://doi.org/10.5343/bms.2019.0026.



Glossary

algae (**al** jē): Simple plants that have no true root, stem, or leaf and that usually grow in water or on damp surfaces.

cyanobacteria (**sī** ə nō bak **tir** ē ə): A major group of photosynthetic bacteria that are single-celled but often form colonies in the form of filaments, sheets, or spheres and are found in diverse environments (such as salt and fresh water, soils, and on rocks).

enrichment (ən **rich** mənt): The addition or increase of some desirable quality, attribute, or ingredient.

food chain (**füd** chān): A sequence of organisms in which each depends on the next, and usually lower, member as a source of food.

microorganism (**mī** krō **ȯr** gə ni zəm): An organism or life form of microscopic size.

organic (ȯr **ga** nik): Related to or coming from living organisms.

predator (**pre** də tər): An animal that preys on other animals for food.

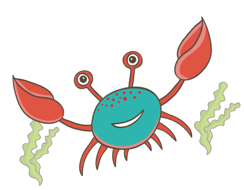
propagule (**prä** pə gyül): A structure (such as a cutting, a seed, or a spore) that reproduces a plant.

ratio (**rā** shē ō): The relationship in quantity, amount, or size between two or more things.

sample (**sam** pəl): A small subset group, representative of the entire group.

sediment (**se** də mənt): Material deposited by water, wind, or glaciers.

*Accented syllables are in **bold**. Marks and definitions are from http://www.merriam-webster.com. Definitions are limited to the word's use in the article.*



FACTivity

Time Needed

1 class period

Materials

(for each individual or group)

- Large sheet of blank paper
- Pencil and eraser
- Colored felt-tip markers, crayons, colored pencils, or paint

The question you will answer in this FACTivity is: Which organisms on a mythical planet are producers, consumers, and decomposers?

Background

The scientists in this study investigated a food chain within a mangrove ecosystem. This food chain included producers, consumers, and decomposers.

Producers make their own food from sunlight through photosynthesis. In this study's ecosystem, mangrove trees, algae, and cyanobacteria are producers.

Consumers eat producers (or other consumers). In this study, sesarmid crabs are consumers because they eat leaves, algae, and other microorganisms. During high tides, large fish are also consumers because they eat the crabs.

Decomposers break down dead plants and animals. They also break down the feces (**fē** sēs) (poop) of other organisms. This process provides nutrients for plants in the ecosystem. In this study, bacteria and fungi are the decomposers.

In his scientist statement on page 10, Dr. MacKenzie said that mangrove forests reminded him of the planet Dagobah from the movie "Star Wars." Dagobah was a swamp planet, and it was a special place to Yoda.

Dagobah was home to a few plant and animal species. The Gnarltrees looked a lot like mangrove trees. Dagobah had two seasons per year—a dry season and a wet season. Many mangrove ecosystems also have a dry season and wet season. They also have a low tide, which is drier, and a high tide, which is wetter, twice per day. In this FACTivity, you will create a scene from your own swampy planet, making sure that the planet has producers, consumers, and decomposers.

Methods

Remember that your swampy planet must have producers, consumers, and decomposers. You can do this FACTivity using a few options.

First, your teacher will decide whether you will do this FACTivity independently or as a small group activity. You will follow the same process whether individually or in a small group.

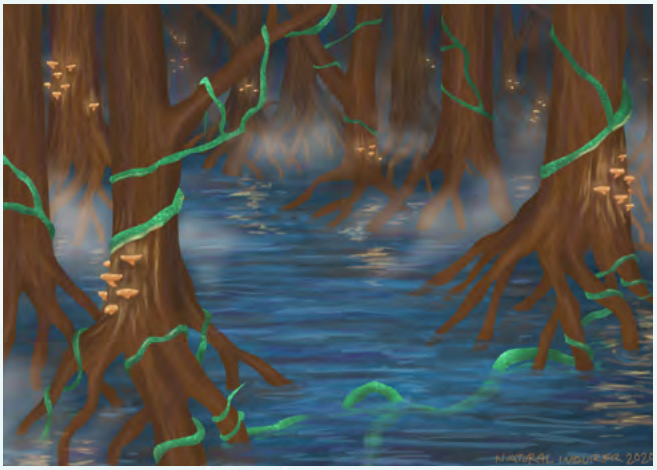


Figure 14. This drawing looks a little like the mythical planet Dagobah and a little like a mangrove ecosystem. You may use this drawing to inspire your drawing of your own mythical planet. FIND Outdoors illustration by Liz Sisk.

Using a blank sheet of paper and colored felt tip markers, crayons, colored pencils, or paint, create a color picture of your mythical planet. Use any of the photos in this article or **figure 14** for inspiration.

Be sure to name your planet and your species of producers, consumers, and decomposers. What kinds of animals are your consumers? For example, are they birds, crabs, insects, or mammals? Identify all species by creating labels on your drawing or write a caption for your drawing on a separate piece of paper. Be sure to write your planet's name on your drawing.

After you have completed your drawing, share it with the class. Describe the food chain that you have created. How does your food chain compare with the food chain in this article's mangrove ecosystem?

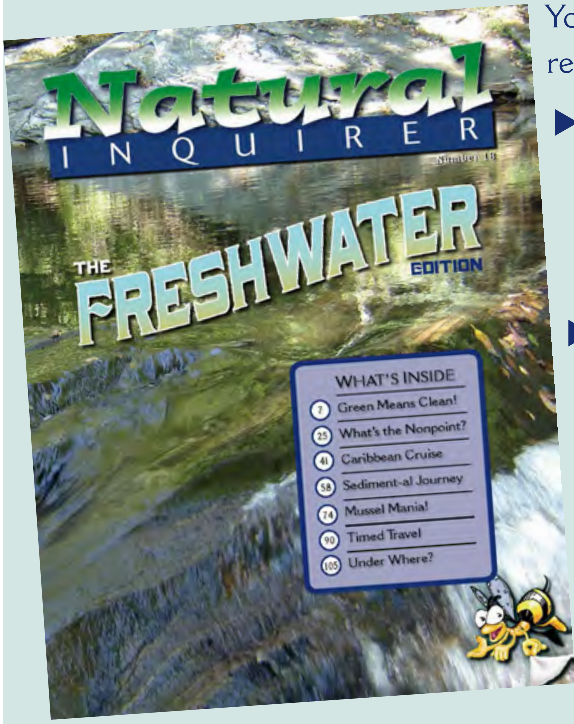
Photo Challenge

Figure 15. How many sesarmid crabs do you see in these mangrove trees?

If you need a hint, look at the photographs in the article.

USDA Forest Service photo by Babs McDonald. (Answer is at the bottom of page 28.)

Natural Inquirer Connections



You may want to reference these *Natural Inquirer* resources for additional information and FACTivities:

- Hawai'i-Pacific Islands edition—"Don't Litter the Stream: An Invasive Tree Species and a Hawaiian Stream Food Web" and "Mangrove Mania: How Elevation Change and Sea Level Rise Affect Mangrove Forests"
- Carbon Series monograph—"Logjams and Beaver Dams: How Different Landforms Affect the Amount of Carbon in an Ecosystem"
- Freshwater edition—"Caribbean Cruise: Examining the Movement and Quality of Organic Matter Over Time from Two Caribbean Watersheds"
- *Natural IQ* edition—"Everything but the Carbon Sink: Carbon Storage in the Southern United States"

These resources, along with others, can be found at https://www.naturalinquirer.org/all-issues.html.

Web Resources

Smithsonian: Mangroves
https://ocean.si.edu/ocean-life/plants-algae/mangroves

Conservation International: Mangroves
https://www.conservation.org/stories/11-facts-you-need-to-know-about-mangroves

National Park Service: Lake Mead food web
https://www.nps.gov/lake/learn/food-webs.htm

Wild Singapore: Sesarmid crabs
http://www.wildsingapore.com/wildfacts/crustacea/crab/sesarmidae/sesarmidae.htm

Science Daily: Trophic level
https://www.sciencedaily.com/terms/trophic_level.htm

Project Learning Tree®

If you are a Project Learning Tree educator, you may use "Web of Life," "Nature's Recyclers," and "The Fallen Log" as additional resources.

Sesarmid photo find answer: There are 16 sesarmid crabs in this mangrove forest photo.