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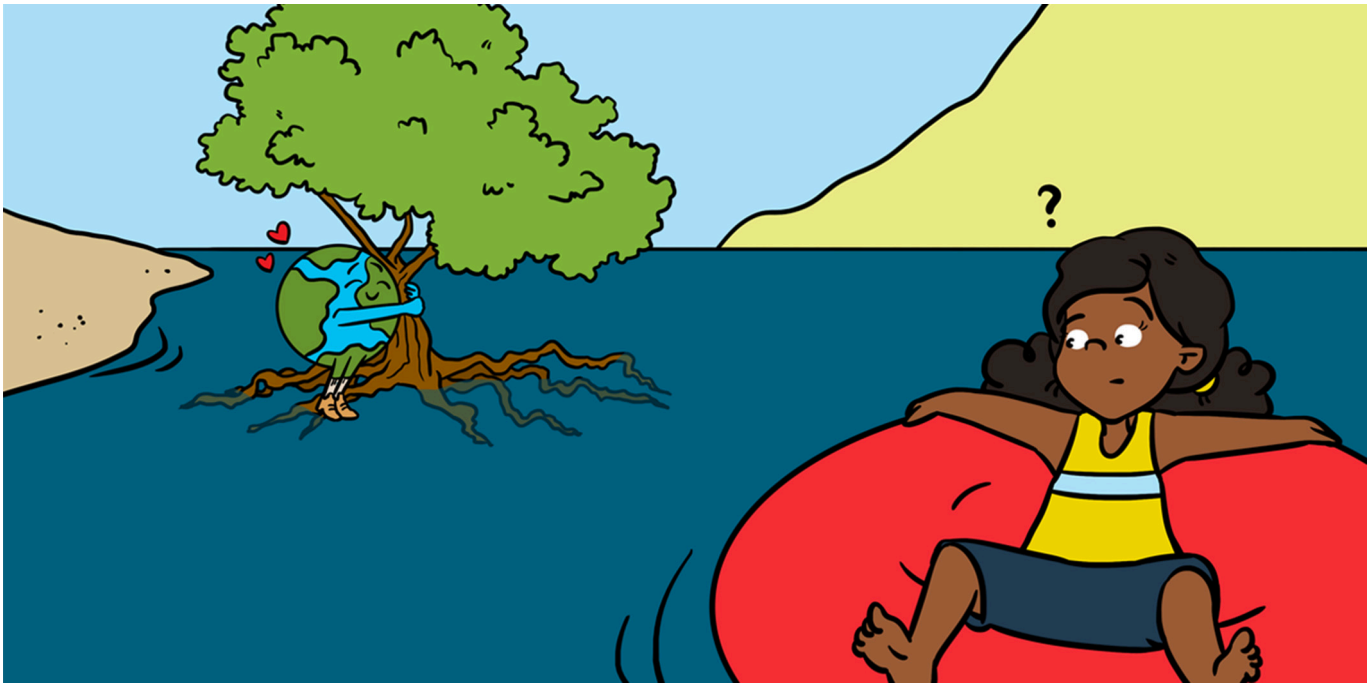

MANGROVE MADNESS: WHAT ARE MANGROVES AND WHY DO WE CARE ABOUT THEM?

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YOUNG REVIEWERS:

EMMA
AGE: 14

HEADWATERS ACADEMY 8TH GRADERS
AGES: 13–14

Mangrove communities are found in tropical regions of the world. They live along coastlines in the intertidal zone, where the land meets the sea. Mangroves provide many ecological services—a fancy term for benefits. They capture valuable sediments flowing into the ocean from streams, lower impacts from harmful substances, support many creatures, and prevent coastline erosion. At the heart of mangrove communities is the mighty mangrove tree. Mangrove trees have a unique system of roots and other structures to help them survive in a salty world. They tolerate regular flooding but can drown if they are under water too long. To adjust to rising sea levels, mangroves can bio-generate or capture materials to create soil. National Park Service scientists are studying this process. By building soil, mangroves capture and store carbon dioxide, which helps fight climate change. Mangroves are important to us all!

WHAT ARE MANGROVE COMMUNITIES?

In tropical environments all over the world, mangrove communities consist of about 70 different species of trees, palms, shrubs, and ferns that live along the Earth's coastlines in the **intertidal zone**, which is where the ocean meets the land [1]. Often, they are found in **estuaries**—places where freshwater rivers flow into the ocean. Freshwater that arrives in estuaries often carries soil sediments, nutrients, and pesticides. Mangrove communities, also called mangrove forests, slow down the flow of this water and filter it, helping to capture sediments and decrease impacts from harmful substances like pollutants. Mangrove communities also shelter and support many creatures, including humans. In addition, they help prevent **erosion** by slowing down waves as they crash into the shoreline. At the foundation of mangrove communities are the mighty mangrove trees. Over thousands of years, mangrove trees have evolved unique traits that allow them to survive in a salty world.

INTERTIDAL ZONE

The area of the marine coastline that is either flooded by water at high tide or exposed to air at low tide.

ESTUARY

The place where freshwater flows into the ocean.

EROSION

The process of wearing away of the soil or rock by water, wind, or other natural agents over time.

HOW DO MANGROVE TREES LIVE IN SALTWATER?

It is not normal for trees to grow in water, much less saltwater—but mangrove trees do it. So how *do* they do this? First, mangrove trees must deal with living in a lot of water, and then they need to figure out what to do with all the salt. Over time, mangroves have developed unique root systems that allow them to live in flooded habitats. Their roots are different from those of ordinary plants and have names like pneumatophores (pronounced new-mat-uh-fours), knees, aerial roots, and prop roots (Figures 1A,B). These special roots stick out of the water, which helps the trees breathe through special pores, called **lenticles**, that let in oxygen (Figure 1A). Other structures move the oxygen to the parts of the trees that are underwater. This unique root system prevents the trees from drowning.

LENTICLE

Special pores in woody plant stems or roots that allow gas exchange.

"Water, water, everywhere, Nor any drop to drink." Just like the sailor observed in "The Rime of the Ancient Mariner" poem by Coleridge (1798), ocean water is salty and unsafe for both humans and plants. Mangrove trees can handle salt in three ways: by blocking the salt from entering the roots, by letting the salt in and then sending it to older leaves that eventually die and fall off, or by letting the salt in and pushing it out through special salt glands on the surface of leaves, where it is washed away by rain [2]. Salt that the mangrove roots block out slowly builds up in the surrounding soil over time, making it saltier. This makes it harder for the mangroves to keep the salt out. Luckily, rainfall and ocean tides help move the extra salt back into the ocean. If this flushing process did not happen, mangrove communities would get so salty that even the mighty mangrove tree could not survive.

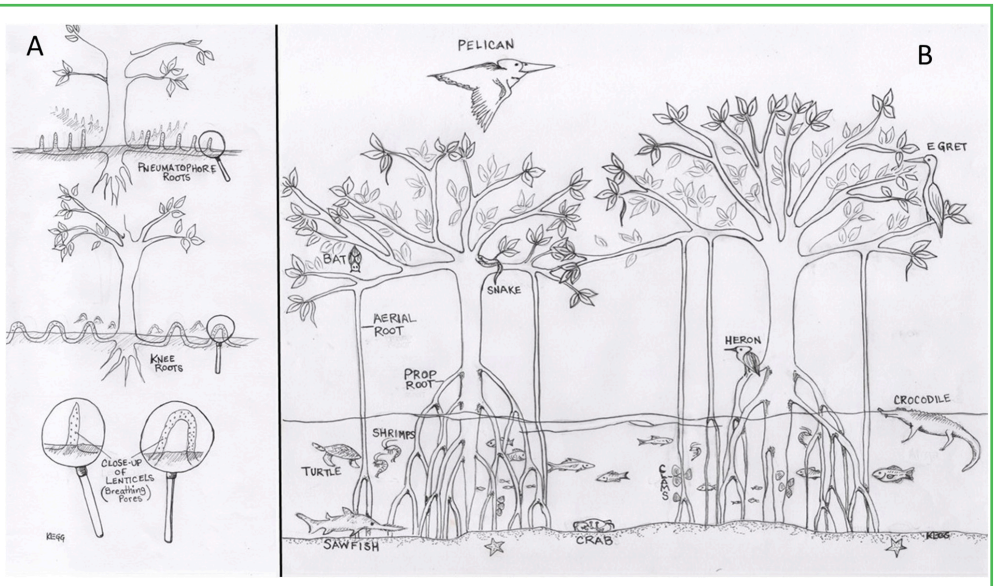

Figure 1

Figure 1

(A) Mangrove pneumatophores and knee roots, and a close-up of the lenticels (breathing pores) found on mangrove roots. **(B)** Mangrove trees with prop and aerial roots along with the animals found in the mangrove community when the area is flooded with water (Image credits: Kristin Legg).

IT IS A GIVE-AND-TAKE MANGROVE WORLD

Healthy mangrove forests are not always flooded—water flows in and out (Figure 2). The amount of water and the length of time that water is present are constantly changing. Water levels can change one or two times a day, due to the tide cycle, and sometimes over several weeks to months due, to seasonal rain events (monsoons), water pushed by the wind, or floods. As water comes into the mangrove communities, it brings in beneficial nutrients (like phosphorous) from the ocean. When the water flows out, it gets rid of materials that can be bad for the trees, like the extra salt. Water movement also brings oxygen to the tree roots and soil. In addition, leaves, nutrients, sediments, and other things that can be useful to the nearby ocean are carried away.

Shifting water levels also help mangrove communities to support many ocean creatures (Figure 2C). When the mangrove forest is flooded, the roots provide places for animals to eat and hide. Fish, crabs, shrimps, and other marine species come into the mangrove forests to find food. Even larger animals like the smalltooth sawfish, rays, crocodiles, and manatees use mangrove forests when they are flooded (Figures 1, 3). Once the water moves out, a whole different group of creatures arrives, searching for food on newly uncovered surfaces. It is common to see wading birds, raccoons, snails, lizards, and crabs like the mangrove tree crab and the fiddler crab, feeding in the mangrove forest mud (Figure 3). There is even a fish called the mangrove rivulus that can live in mangrove forests when there is no water at all. The rivulus fish has been found living inside dead mangrove logs for up to 60 days with no water [3]!

Figure 2

Figure 2

(A) Large black mangrove tree with numerous pneumatophores and adventurous roots coming out of the trunk, Biscayne National Park (Photograph credit: Kevin Whelan). **(B)** Large riverine mangroves in Tanjung Puting National Park, Kalimantan, Indonesia (Photograph credit: Craig Allen). **(C)** Corals, flat tree oysters, and sponges attached to red mangrove prop roots in Hurricane Hole, Saint John, US Virgin Islands (Photograph credit: Caroline Rogers). **(D)** Author standing on large prop root of a mangrove tree, Indonesia (Photograph credit: NPS).

MANGROVE FORESTS ARE A FISH'S (AND OTHER SPECIES) BEST FRIEND

Without a doubt, mangrove forests support abundant wildlife. Many animals spend part of their lives, or their entire lifetimes, in mangrove communities. This is especially true for fish. In South Florida, U.S.A., the home of Biscayne National Park and other nearby national parks, an estimated 90% of commercially caught fish (fish that are caught and sold for a profit) and 75% of game fish (fish caught for fun) need mangroves for some part of their lifespan. In Malaysia, scientists have found over 119 different fish species in one single mangrove creek!

Figure 3

(A) Double-crested cormorants nesting in a mangrove tree, Biscayne National Park (Photograph credit: Robert Muxo). **(B)** American crocodile in a Florida mangrove forest (Photograph credit: Kevin Whelan). **(C)** Indonesian fisherman pulling in nets on Kumai Bay, Indonesia (Photograph credit: Kevin Whelan). **(D)** Bocourt Swimming Crab in the mangroves of Saint Croix, US Virgin Islands (Photograph credit: Kevin Whelan).

Clearly, mangrove forests ARE a fish's best friend, but other life forms benefit from mangrove forests as well. Mangrove roots provide a solid structure that organisms like sponges, sea fans, anemones, clams, oysters, and corals can attach to and live on (Figures 1, 2). At US Virgin Islands National Park, scientists recorded the same number of coral species in mangrove forests as they did on nearby coral reefs. That is amazing! In addition, the scientists found over 60 species of sponges attached to mangrove tree roots.

MANGROVE SUPERHEROES: RISING SEA LEVELS AND CAPTURING CARBON DIOXIDE

Even the mighty mangrove will eventually drown if water levels do not vary enough. If the water is too deep for too long, mangrove seedlings drown. Without mangrove seedlings, there are no young trees to replace those that die. To adapt to rising sea levels within mangrove forests, mangrove trees can **bio-generate** materials to make **peat** (a soil made of partially decomposed leaves and roots) and/or capture natural materials to build up soil levels. During bio-generation, mangroves help capture and trap carbon dioxide (CO_2), making these trees important players in the fight against climate change.

Through photosynthesis, mangroves collect CO_2 from the atmosphere and lock it up for long-term storage in their peat soil. Mangrove forests are one of the most carbon-dense forests in the world, containing on

BIO-GENERATE

The building blocks of a substance or process come from biologically made components.

PEAT

Soil formed from partially decomposed plant materials (leaves, roots, etc.) in wet, low-oxygen conditions.

average 1,023 metric tons of carbon per hectare [4]. What does this mean? Well, if an average passenger car uses a 75-L tank of gas, then it produces about 178 kg of carbon. So, each hectare of a mangrove forest stores about 5,750 tanks of gas in carbon. Now that is a lot to honk about!

WHAT ELSE CAN PEAT TELL US?

Not only can peat sequester CO_2, but it can also help scientists understand how mangrove communities have survived over time. Mangrove communities have existed at the boundary between the ocean and the land, in places like Belize, for thousands of years! How do we know this? Well, scientists can gather a lot of useful information from studying the peat beneath the mangrove roots. Scientists took 12-meter-long **soil cores** out of the ground from a Belize mangrove forest. Back in the laboratory, they used microscopes and other machines and techniques to identify the types of material in the soil and how long they had been there. They found that the mangroves in Belize today are in the same spot as mangroves 8,000 years ago [5]! Who would have thought that dirt—oh sorry, peat—could tell us so much?

SOIL CORE

A vertical soil collection that samples down the soil column (profile). It is typically collected in a tube or cylinder.

To understand how mangrove forests are managing sea-level changes today, National Park Service scientists use information collected from soil-monitoring stations in mangrove forests in numerous national parks. These stations are sampled twice a year to see if the mangroves are generating peat or capturing enough soil to keep pace with the rising sea levels. And so far, mangrove forests seem to be doing their part!

PROTECTING THE EARTH'S COASTLINES

By now, you have learned about the numerous **ecological services** mangrove forests provide. But did you know that mangrove communities are also extremely important in protecting Earth's coastlines? Their presence in the intertidal zone helps buffer shores from all sizes of waves—from small, rippling waves that can result in minor erosion, to massive waves from storm surges that can wipe out entire coastal ecosystems and human developments. As our Earth experiences more frequent and extreme storm events with climate change, mangrove communities are increasingly vital to preserving these fragile areas where the land meets the sea.

ECOLOGICAL SERVICES

Benefits that an ecosystem provides for humankind, such as oxygen, habitat for animals, place for recreation.

CONCLUSION

Next time you visit a beach or go fishing, remember the valuable role of mangrove forests in keeping our coasts healthy. From

sheltering and supporting ocean and land animals to keeping the Earth's shorelines intact, this important job is accomplished by the mighty mangrove!

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

EMMA, AGE: 14

Hi, my name is Emma. I live in Bozeman, MT. Some of my interests are earth sciences, biology, rocks and minerals. I also have multiple artistic hobbies including sculpting, painting, and sketching. This fall I will be heading into 9th grade.

HEADWATERS ACADEMY 8TH GRADERS, AGES: 13–14

We are Headwaters Academy 8th grade students located in Bozeman Montana USA. Headwaters is a non-profit middle school with only 90 students, and only 27 students in the 8th grade. Headwaters mission is to educate young leaders for a changing world. We love being outdoors and base a lot of what we are learning about off of the nature around us. Our 8th graders are very lucky to be learning all about Mangroves, as well as editing the mangroves article.

AUTHORS

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Kevin R. T. Whelan is a scientist who monitors mangroves and other communities in the national parks in South Florida and the US Virgin Islands. The best part of his job is working in the field and observing nature. It is hot, buggy, and muddy in these parks, but they are also quite a beautiful place to experience. The hardest part of the job is getting folks to understand how the natural system works so they can make good decisions on how to help protect them into the future. *kevin_r_whelan@nps.gov

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Michelle Prats monitors natural resources in the national parks of South Florida and the US Virgin Islands. One of her projects is measuring the change in soil elevation in mangrove communities. She also helps monitor fresh-water algae, nesting birds, and long-term forest health. One fun part of her job is traveling in boats, ATVs, and helicopters to areas that visitors do not normally see. One challenge is sharing data results quickly enough, so that it is useful to park managers. It is important that decisions are made based on good science. Michelle_Prats@nps.gov