

Tropic Topic:

What Is Known About the Limestone Zone?

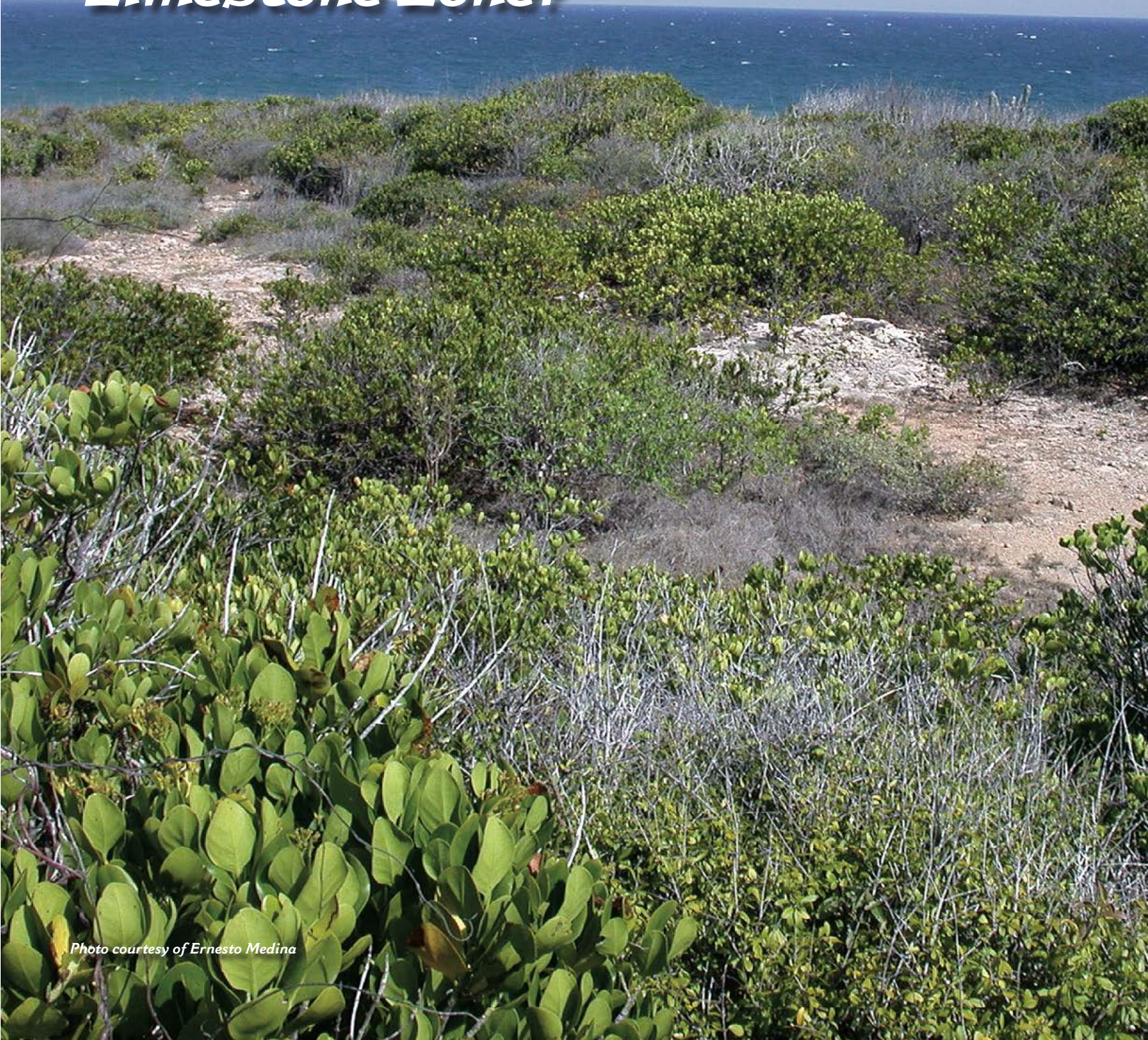


Photo courtesy of Ernesto Medina

Meet the Scientists

► **Ernesto Medina**, Plant Ecophysiolgist: My favorite science experience is being outside in the field, observing how plants respond **physiologically** to their environment. I like designing experiments to answer the questions that arise from observations, and then working with the data and writing the manuscript that explains it all. Photo courtesy of Ernesto Medina, University of Puerto Rico.



► **Ariel Lugo**, Tropical Ecologist: My favorite science experience was conducting science camps for high school students in the karst zone of Puerto Rico. We had a fabulous time and conducted cool research that we published in science journals. Photo courtesy of Ariel Lugo, USDA Forest Service.



◄ **Elvira Cuevas**, Ecologist: My favorite science experience is working outside in the field. I can see how the vegetation is interacting with the environment and measure those interactions. It is fascinating to be able to put numbers on those interactions. Photo courtesy of Elvira Cuevas, University of Puerto Rico.

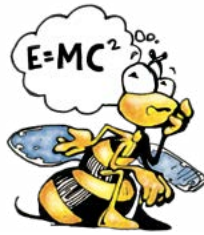


Glossary words are **bold** and are defined on page 30.

Thinking About Science

Plants receive nutrients from air, water, and soil. Chemicals move throughout the air, water, and soil, and then into plants. Plants absorb 14 nutrients from the soil. Plants have a disadvantage when faced with unfavorable conditions, such as poor soil conditions. They cannot move quickly to a new environment when conditions are unfavorable. When soil or rainfall conditions are not **optimum** for plant growth, plants must adapt to thrive. When conditions are not favorable for plants, one way they may adapt is to increase the percentage of their root structure compared with the rest of the plant's aboveground structure. They may grow their roots deeper and spread them out farther away from the main root stem.

The scientists in this study were interested in how trees growing in similar soil types, but living in different rainfall conditions, adapt so they can thrive. To understand such tree adaptation, the scientists compared the soil's chemical content with the tree leaves' chemical content. Studying the chemical content of soil and leaves helps scientists understand how plants adapt to their environment.



Thinking About the Environment

Karst is a **geochemical** landform from which caves and **sinkholes** are formed (**figures 1 and 2**). Karst is made up of limestone and other **soluble** rocks. Limestone **erodes** easily, especially when groundwater or rainfall is slightly **acidic**. As limestone erodes, water seeps into the ground and further erodes the limestone underneath. This erosion forms sinkholes, caves, and underground streams and lakes.



What Kinds of Scientists Did This Research?

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

tropical ecologist: A tropical ecologist studies the relationship of living things with their environment in the tropics. The tropics make up the region between the Tropic of Cancer and the Tropic of Capricorn (see **Figure 5**).

plant ecophysiolgist (*ē kō fī zē ā lā jist*): A plant ecophysiolgist studies how the environment, both physical and biological, interacts with the physiology of an organism. It includes the effects of climate and **nutrients** on physiological processes, or normal functioning, in plants.

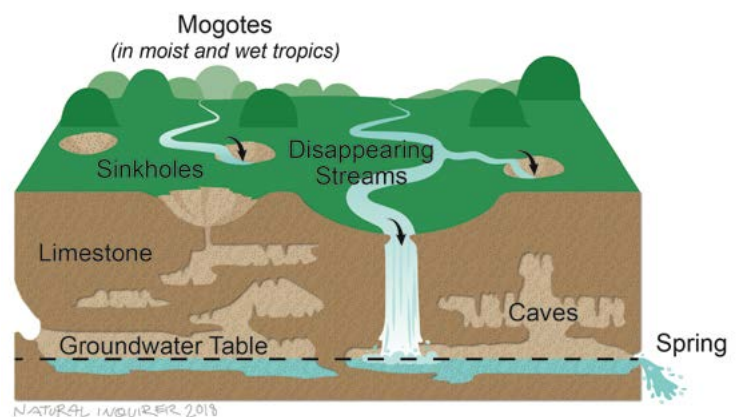


Figure 1. Karst is mainly a carbonate landform from which caves and underground waterways are formed. Illustration by Stephanie Pfeiffer.

Karst landscapes are found worldwide, covering about 20 percent of Earth's land surface. All of Florida, for example, is karst (**figure 3**). Karst landscapes are an important source of drinking water, provide wildlife habitat, and provide outdoor recreation opportunities such as caving. In this study, the scientists were interested in learning about forests growing on karst in Puerto Rico.

Introduction

Puerto Rico is an island in the Caribbean and is located in Earth's tropical region (**figures 4 and 5**). The northern region of Puerto Rico experiences a lot of rainfall. The southern region of Puerto Rico, in contrast, is **semi-arid**, an area with light rainfall (**figure 6**).

About 27 percent of Puerto Rico contains karst landscapes (see "Thinking About the Environment"). Karst is found in both Puerto



Figure 2. Mogotes are an unusual karst landform. Mogotes are found in tropical and subtropical regions, including Puerto Rico, Cuba, and parts of China. The sides of some mogotes are almost vertical. Photo courtesy of Ernesto Medina, University of Puerto Rico.

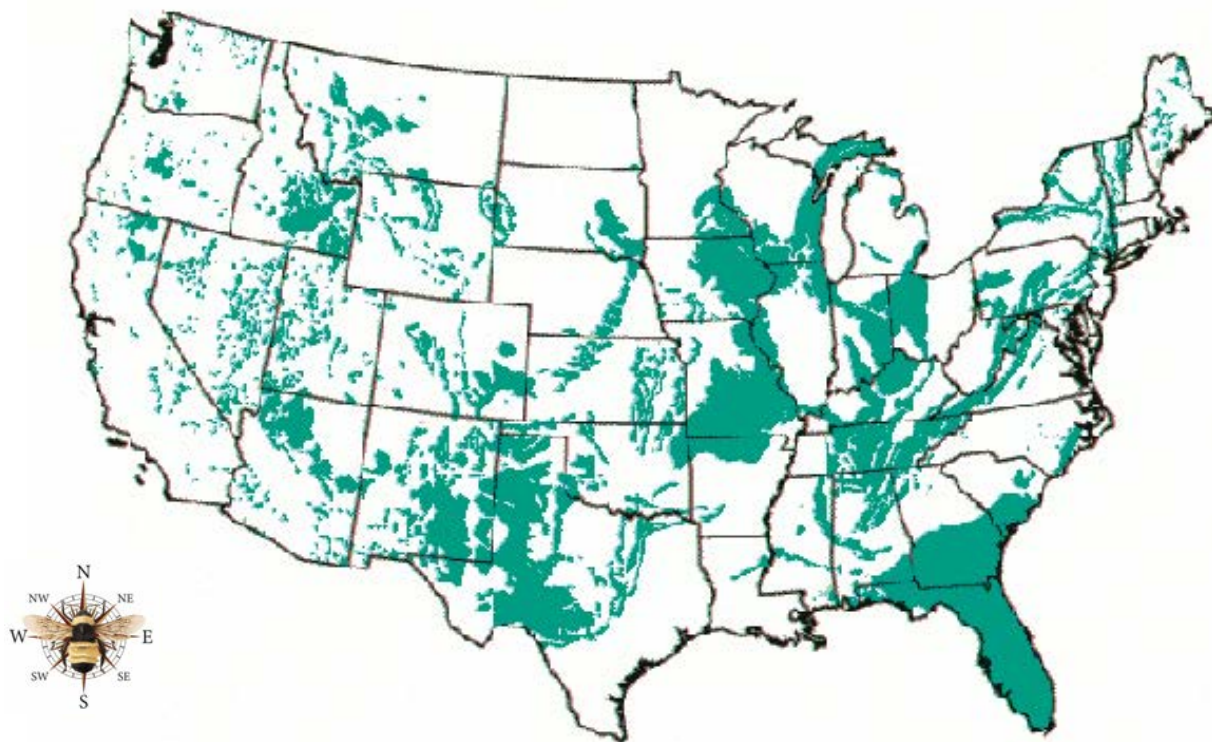


Figure 3. Karst landscapes are found across the United States. Map by Carey Burda and Stephanie Pfeiffer.

Rico's northern wet region and its southern dry region. Karst soils are shallow, and most karst soil is built from the leaves that fall from forest trees (**figure 7**). Soils in Puerto Rico's southern dry karst forests build slowly in the **crevices** between the pavement sections (**figures 8 and 9**).

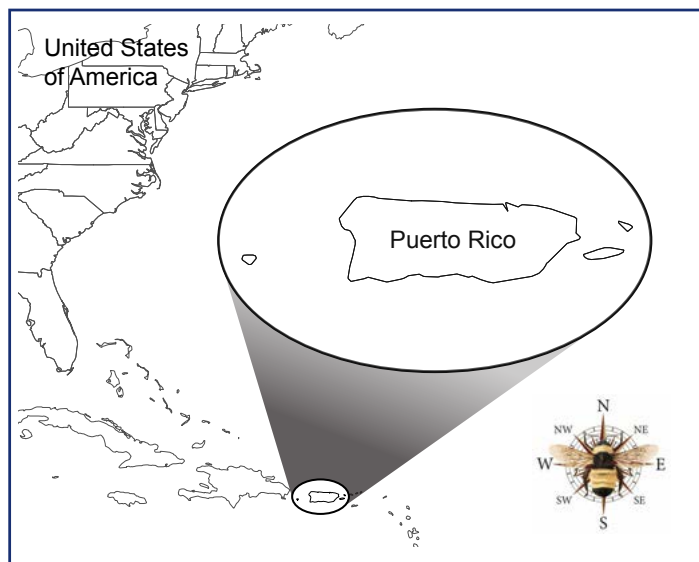


Figure 4. Puerto Rico is a United States territory. Map by Carey Burda and Stephanie Pfeiffer.

The scientists in this study wanted to compare the chemistry of soils and leaves in Puerto Rico's northern wet and southern dry karst forests. The northern wet karst forests receive an average of between 1,000 and 1,500 mm of rainfall every year. The southern dry karst forests receive an average of less than 1,000 mm of rainfall every year. The scientists wondered whether southern dry karst forests, since they grow in a semi-arid region, use water more efficiently than northern wet karst forests.

Number Crunch

- How many inches of rain do each of the karst regions receive on average every year?

Hint: Multiply the amounts in millimeters by 0.039 to find out.

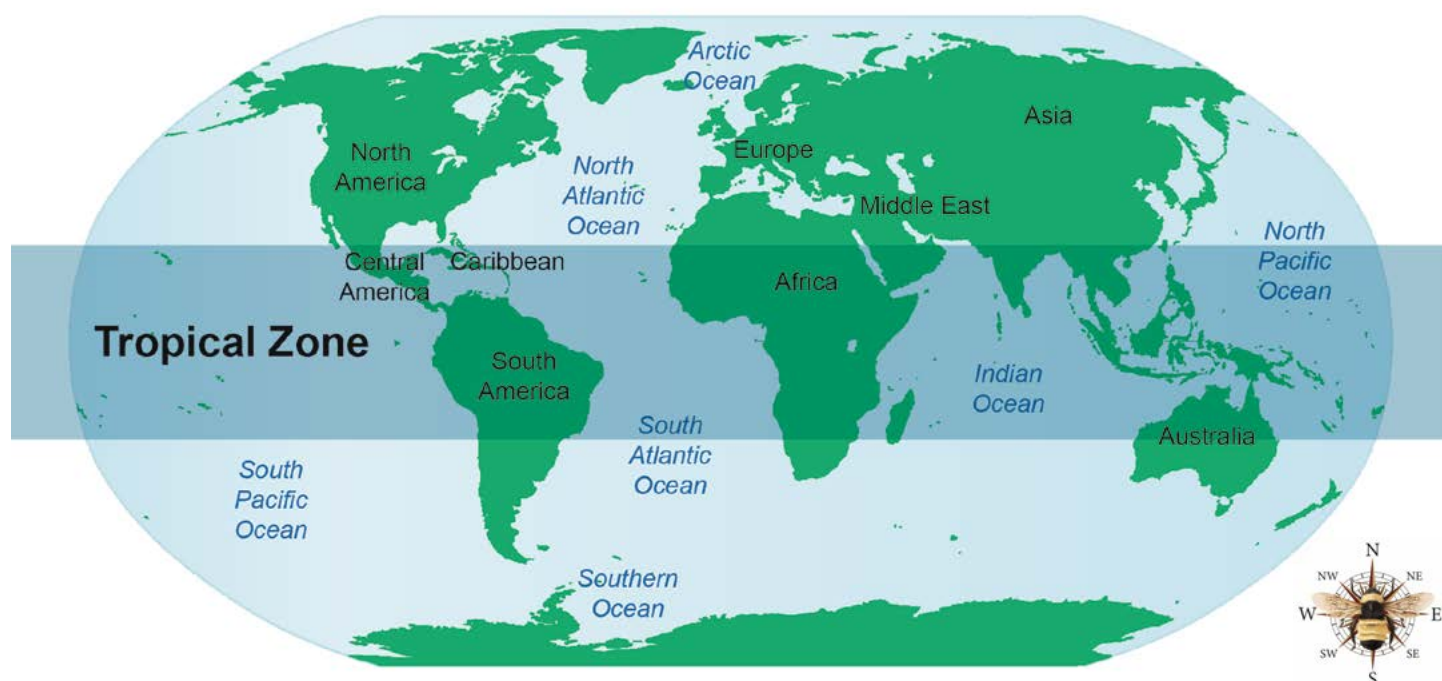


Figure 5. Puerto Rico is located in Earth's warm tropical region. Illustration by Stephanie Pfeiffer.

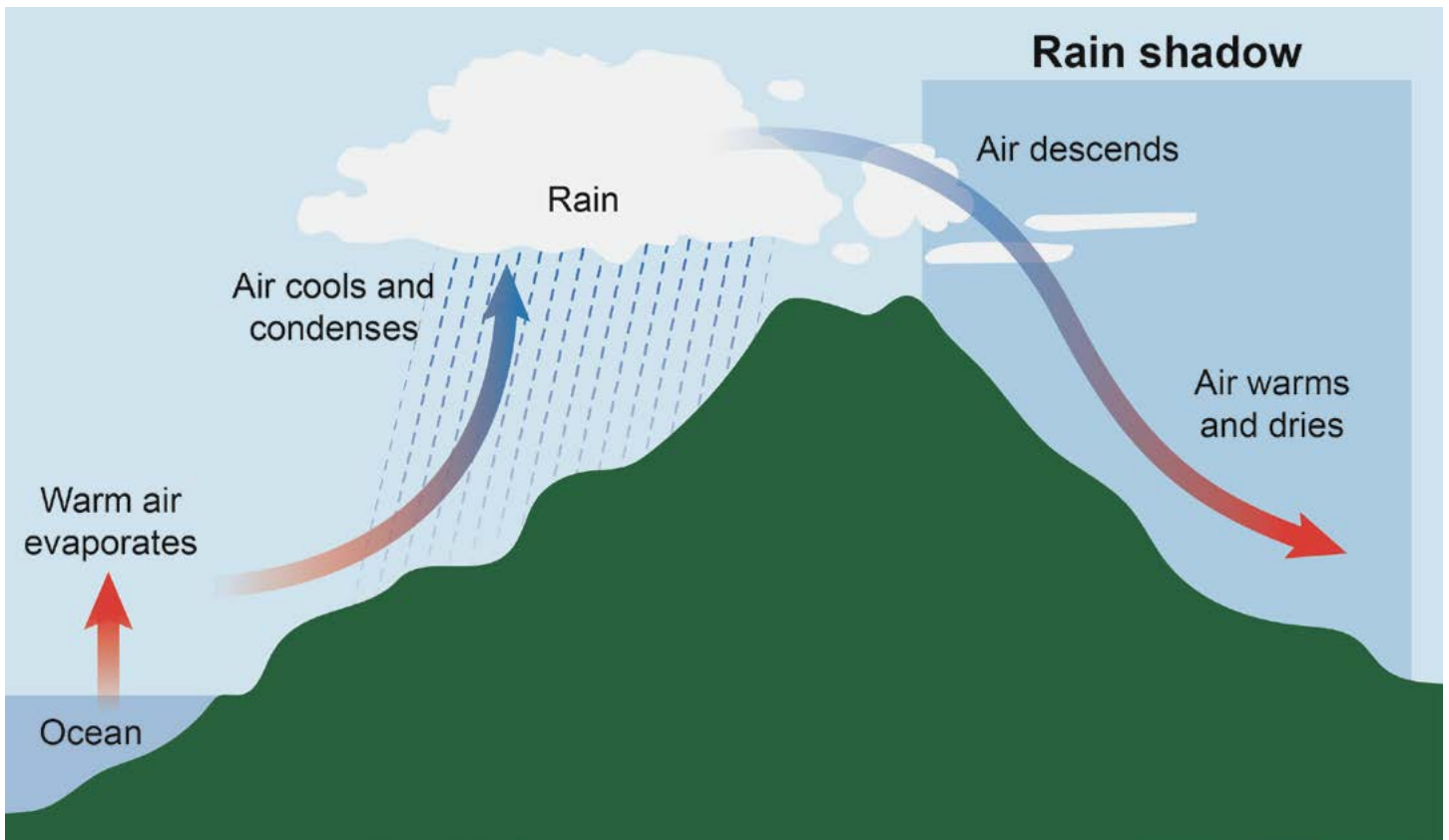


Figure 6. Puerto Rico is wet in the north and dry in the south due to the rain shadow effect. The rain shadow effect is the result of a large barrier, like a mountain range, that causes rain to fall on one side of the mountain range while the other side of the mountain remains dry. Illustration by Stephanie Pfeiffer.



Figure 7. In some karst areas with mogotes, most of the soil is found in the valleys between the steep mogote hills. Photo courtesy of Ernesto Medina, University of Puerto Rico.



Figure 8. Soil is thin in the southern dry karst forests of Puerto Rico. Photo courtesy of Clare McFadden.



Figure 9. Exposed limestone karst pavement is flat and looks similar to concrete pavement. In karst pavement areas, soil is built in the crevices between the pavement blocks. Photo courtesy of Ernesto Medina.

Reflection Section

- **Examine figures 7-9.** The northern wet karst forests contains mogote landforms, and the southern dry karst forests have ridges and pavement landforms. Do you think the soil chemistry is similar between these two karst areas? Why or why not?
- Do you think that trees in the southern dry karst forests use water more efficiently than the trees in the northern wet karst forests? Why or why not?



Methods

The scientists collected leaves from trees growing in both the northern wet and southern dry karst forests. Leaves from the northern wet karst forest were collected from trees on the mogote tops. Leaves from the southern dry karst forest were collected from trees growing on the ridges and pavement. All leaves were collected from tree **canopies**.

Recall that the scientists were also interested in the differences in how trees use water in northern wet and southern dry karst forests. After the scientists collected the leaves, they dried the leaves in an oven for 3 to 7 days and then finely ground the leaves. The scientists used specialized equipment to determine which chemicals were found in the leaves collected from the two karst regions. Measuring the chemical content of leaves enabled the scientists to compare leaf chemistry with the chemical content of the soil. This comparison helped the scientists to determine how trees growing in similar soils, but different environmental conditions, adapted to those conditions. The scientists tested leaves for the presence of:

- | | |
|--------------|-------------|
| ▶ Carbon | ▶ Calcium |
| ▶ Nitrogen | ▶ Magnesium |
| ▶ Phosphorus | ▶ Aluminum |
| ▶ Sulfur | ▶ Manganese |
| ▶ Potassium | ▶ Iron |

The scientists were also interested in stomatal **conductance**. The word stomatal

comes from the fact that leaves have small openings, called stomata, through which gases enter and exit the leaf (**figure 10**). You can see in Figure 10 that carbon enters the leaf as carbon dioxide gas.

Carbon atoms have different atomic masses. Carbon atoms are either Carbon 12, a lighter atom, or Carbon 13, a heavier atom. Carbon 12 atoms are the most plentiful on Earth, making up 98.93 percent of all carbon atoms. When plants have plenty of water, they open their stomata completely. The plant enzyme responsible for the uptake of CO₂ in most plants readily takes up the more plentiful Carbon 12 atoms entering the leaf, preferring Carbon 12 atoms to the heavier Carbon 13 atoms.

When plants have a limited supply of water, the stomata do not open completely. In this case, the plant enzyme responsible for the uptake of CO₂ will take up all available carbon atoms. Plants in water-restricted environments, therefore, may be more likely to have a greater amount of Carbon 13. The scientists measured the proportion of Carbon 13 to that of Carbon 12 in the leaf tissues. The ratio of Carbon 13 to Carbon 12, therefore, is

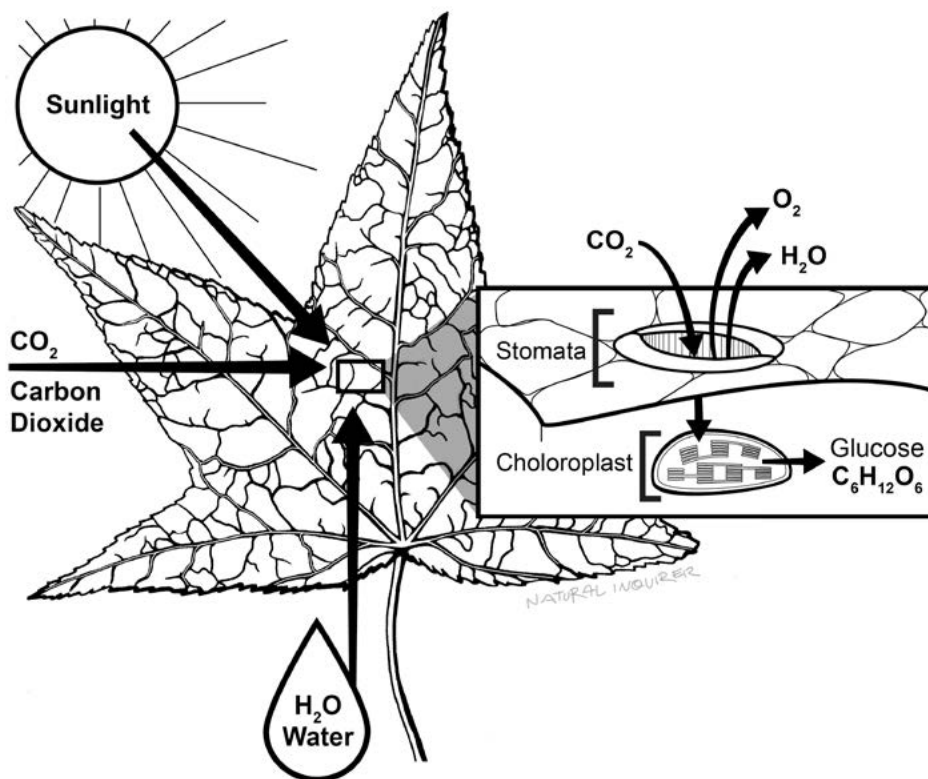


Figure 10. Small openings that open and close, called stomata, allow gases to enter and exit leaves. Illustration by Stephanie Pfeiffer.

Reflection Section

- Leaves have small openings called stomata. Gases, including water vapor, exit leaves through the stomatal openings. How do you think stomata respond in drier environmental conditions?
- Why do you think soil is built slowly in the southern dry karst forest of Puerto Rico in figure 9?



more potassium than leaves in the northern wet karst forests. The scientists believe this difference is because higher rainfall in the northern wet karst region **leaches** potassium from the soil.

The scientists found that leaves in the southern dry karst forests contained more carbon-13 than leaves in the northern wet karst forests. Leaves that use water more efficiently contain higher levels of carbon-13. Therefore, the leaves from the southern dry karst forests use water more efficiently, meaning that leaf stomata do not completely open, and less water vapor exits the leaves.

Findings

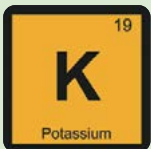
For the most part, leaves were similar in Puerto Rico's two karst regions. Leaves from the northern wet and southern dry karst forests contained similar amounts of magnesium, phosphorus, and nitrogen. Leaves in both the northern wet and southern dry karst forests contained large amounts of calcium. The scientists also found that leaves in both Puerto Rico's northern wet and southern dry karst forests are limited in phosphorus. Leaves in the southern dry karst forests, however, contain

Reflection Section

- Based on the findings, what are the two main differences between the chemical content of leaves in Puerto Rico's northern wet and southern dry karst forests?
- How are the differences you identified in the first "Findings" reflection question above **advantageous** to southern dry karst forests?



Why Do Plants Need Potassium?



Potassium is one of 17 essential plant nutrients. Plants absorb potassium from the soil through their root hairs and root tips. Among other uses, plants use potassium in photosynthesis. During photosynthesis, potassium regulates the opening and closing of stomata, and therefore regulates carbon dioxide uptake and water vapor loss.

Discussion

The soils in northern wet and southern dry karst forests were similar. Soils from both regions contained limited phosphorus. Low phosphorus levels limit the growth of karst forests in Puerto Rico. The soil in both regions contained high amounts of calcium. Calcium aids plants by holding cell walls together. The southern dry karst forest soils contained more potassium than northern wet karst forest soils. Northern wet and southern dry karst forests can primarily be distinguished by the amount of rainfall they receive.

Reflection Section

- Puerto Rico has a rainforest in its northeastern region. The Puerto Rican rainforest contains large trees and thick vegetation. Based on this research, what might be one difference between the northern wet karst region and the rainforest of Puerto Rico?
- Plants adapt to their environmental conditions. Do you think the presence of more carbon-13 in the southern dry karst region is an adaptation? If so, to what environmental condition are the trees adapting?



Glossary

acidic (a si dik): Containing acid.

advantageous (ad van tā jəs): Giving an advantage.

canopy (ka nə pē): (1) Anything that covers like a roof; (2) On a tree, the upper area of leaves that cover the ground.

conductance (kən dæk tən(t)s): The readiness with which gases pass into and out of a leaf's surface.

crevice (kre vəs): A narrow opening caused by a crack or a split.

erode (i rōd): (1) To wear away; (2) To wear away by water or wind.

geochemical (jē ō ke mi kəl): Having to do the chemical composition of and chemical changes in the solid matter of the earth or a celestial body (such as the moon).

leach (lēch): To draw out from the soil.

nutrient (nü trē ənt): (1) Any of the substances found in food that are needed for the life and growth of plants and animals.

optimum (öp tə məm): The amount or degree of something that is most favorable to some end.

physiologically (fi zē ə lä ji kə lē): Related to an organism's healthy or normal functioning.

semi-arid (se mī a rəd): An area that receives very little rainfall.

sinkhole (sɪŋk hōl): A hollow in a limestone region that is related to a cave or underground passage.

soluble (säl yə bəl): Capable of being dissolved in or as if in a liquid, especially water.

*Accented syllables are in **bold**. Marks and definitions are from <http://www.merriam-webster.com>.*

Definitions are limited to the word's meaning in the article.

Adapted from Medina, E., Cuevas, E., and Lugo, A. E. Substrate chemistry and rainfall regime regulate elemental composition of tree leaves in karst forests. *Forests*, 8, 182, <https://www.fs.usda.gov/treesearch/pubs/54455>.



Note: This FACTivity was adapted from the USDA Natural Resources Conservation Service and Project Learning Tree.



Time Needed

2 class periods (20 minutes of each class period, 24 hours apart)

Materials

(for each student or group of students)

- One small succulent (*sə kyə lənt*) house plant for each student pair (**figures 11a and 11b**)
- One small philodendron house plant for each student pair
- One quart-size “zippable” plastic bag for each plant
- Permanent marker

Leaves take in carbon dioxide and release water vapor and oxygen through small holes on their surface. In dry environments, trees have adapted to conserve the lesser amount

of water available to them. In this research, the scientists were interested in the difference between karst forests growing in the wet North and the dry South of Puerto Rico. One of the primary differences between the forests is the amount of average rainfall.

In this FACTivity, you will answer the question: What is the difference between how much water is transpired by different types of plant leaves during the day? Transpiration happens when the water that entered a tree’s roots travels up the tree’s trunk, through its branches, to its leaves, and out of the leaves through small pores called stomata.

Methods

Preparation

You or your teacher will water all of the plants using an equal amounts of water on the day before beginning the FACTivity.



Figures 11a and 11b. Two easy-to-find succulent house plants are mother-in-law’s tongue and aloe. Photos courtesy of Babs McDonald.

FACTivity Continued

Day One

Your teacher will divide your class into pairs of students and will give each pair two plastic bags that can be tightly closed. Write your name on the plastic bags. Your teacher will give you one of each type of plant.

Note that one of the plants is a succulent. Succulent plants require less water because they hold water in their leaves. Succulent plants are found in dry environments.

Place the plastic bag on a leaf of each plant and seal the bag as tight as possible. The leaf should be inside of the plastic bag. The bag must be applied as early as possible in the day (**figure 12**). Place the plants with the plastic bags in a sunny location.

Allow the plastic bag to stay on the leaf the remainder of the day. Leaves do not transpire at night, however, you may leave the plastic bags on overnight.

Day Two

Being careful not to spill any water that you might find, remove the plastic bags from

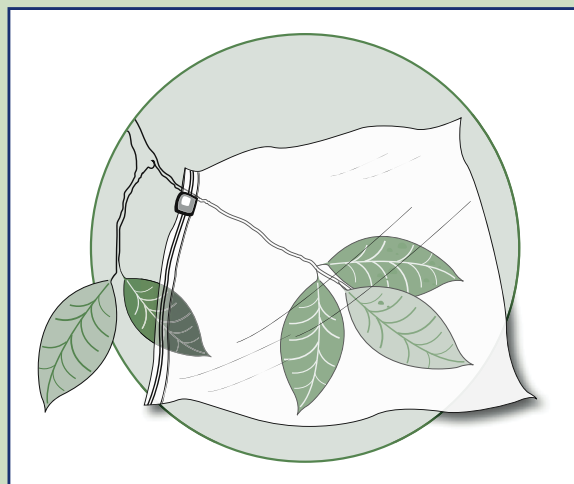
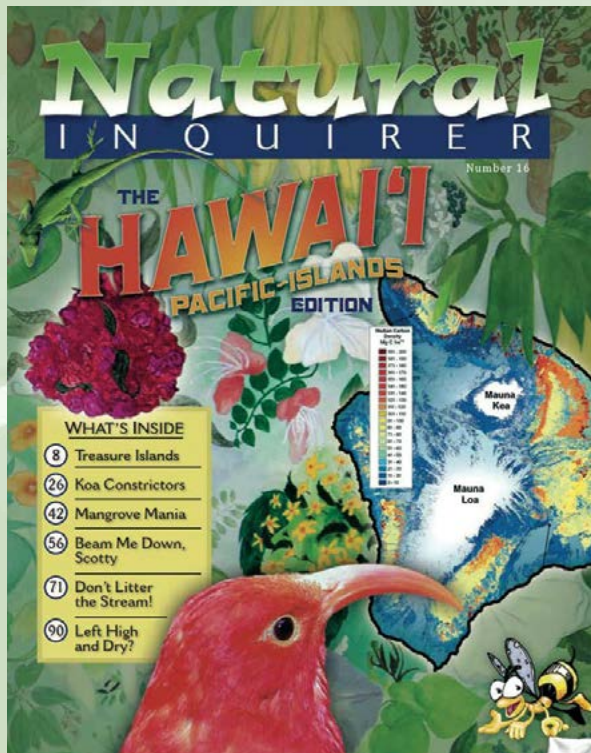


Figure 12. Place the plastic bag on a leaf. Illustration by Stephanie Pfeiffer.

the leaves. Compare the amount of water transpired from the succulent plant with that of the philodendron. Is there a difference? Why do you think you found the results you did?

As a class, discuss how this FACTivity relates to the article you just read. Which type of house plant would be most likely to be found in either the dry karst forest or the wet karst forest?

Natural Inquirer Connections



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

- For more information about tree leaf chemistry, read “Leaf Me Alone!” in the *Natural Inquirer* Tropical edition and “Don’t Litter the Stream” in the *Natural Inquirer* Hawai’i-Pacific Islands edition.

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



If you are a trained Project Learning Tree educator, you may use “Every Tree For Itself,” “Rain Reasons,” “How Plants Grow,” “Field, Forest and Stream,” and “Soil Stories” as additional resources.

Web Resources



Karst for Kids

<https://wiki.kidzsearch.com/wiki/Karst>

Public Broadcasting Service: Karst Topography and Mammoth Cave

<https://www.pbslearningmedia.org/resource/ket09.sci.ess.structure.karst/karst-topography-and-mammoth-cave/#.WsuoMljwaUk>

National Geographic Kids: Rocks and Minerals Quiz Whiz

<https://kids.nationalgeographic.com/kids/activities/funscience/rock-on/>