

Standing on the Shoulders of Giants

How Well Do Big-Leaf Mahogany Trees Grow in Different Conditions?

Photo by Jerry Bauer,
USDA Forest Service.

MEET THE SCIENTISTS!

◀ Elvira Cuevas, Ecologist

My favorite science experience is working 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.

I use equipment to measure rainfall, air and soil temperature, and how much water is in the soil. I **sample** water from the soil, leaves, fine roots, and young stems in the forest. In the lab, I measure how many nutrients are in these items. I

use **stable isotopes** to determine how the plants are responding to the environment. With these analyses, I can explain what is happening and what can happen if environmental conditions change.

These explanations are important right now with the extreme drought conditions currently occurring in the Caribbean. However, one thing is most important to me, no matter if I'm working in a plantation, a wetland with mangroves, or a dry forest: It is the feeling of being an **integral** part of nature. It is an important responsibility for me to share this feeling with my students, family, and friends.

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.

Glossary words are in **bold** and are defined on page 24.



From left to right are Patricia Montañez, Juan J. Jimenez-Osnorio, Ernesto Medina, and Pedro Macario. Photo courtesy of Ernesto Medina, USDA Forest Service.

◀ Ernesto Medina, Plant Ecophysiologist

My favorite science experience is observing in the field how the **physiology** of plants is responding 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.

What Kind 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 (figure 1).
- **plant ecophysiologist:** A plant ecophysiologist 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 in plants.

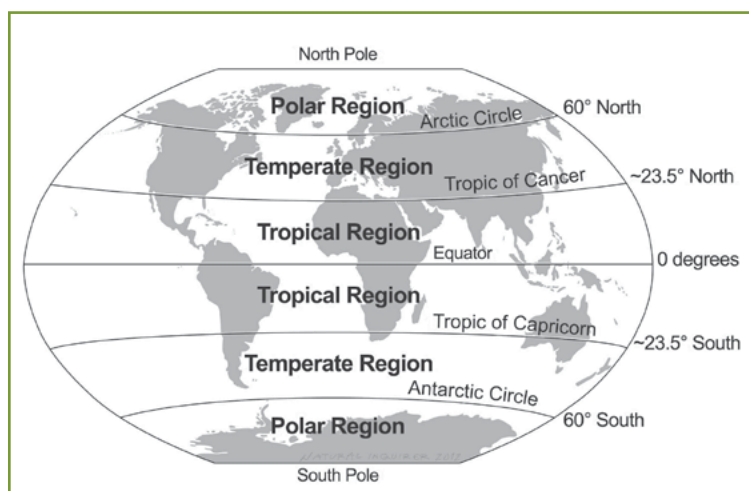


Figure 1. Tropical regions are areas located between the Tropic of Cancer and the Tropic of Capricorn. The tropics are known for warm to hot temperatures year-round with a lot of moisture and often lush landscapes. Additionally, in the tropics, there is never any frost in the lowlands.

Illustration by Stephanie Pfeiffer.

Thinking About Science



Scientists from different organizations and in different parts of the world often work together to analyze, study, and understand a problem. Organizations working together to understand common problems may include government agencies, nonprofit organizations, and universities. In this research, the organizations that worked together were the USDA Forest Service's International Institute of Tropical Forestry (figure 2), the University of Puerto Rico's Biology Department, Mexico's Department of Natural Resource Management (Yucatan), and the Center for Investigations in Quintana Roo, Mexico. Scientists from all of these different organizations worked together, or collaborated (kə la bə rā təd).

Collaboration is an important part of the scientific process. Collaboration involves at least two people with different backgrounds or viewpoints discussing a problem and working toward a solution. The process of discussing ideas and debating points may bring **clarity** to a problem and may provide meaningful solutions. Collaboration can occur during face-to-face meetings, by phone, through email, through virtual meetings, and through other online collaboration methods. In this research, scientists collaborated on research involving a specific tree called big-leaf mahogany. You will learn more about this collaboration and big-leaf mahogany as you read the article. Think of a time you collaborated with someone at school or at home. Why was the collaboration useful to you?

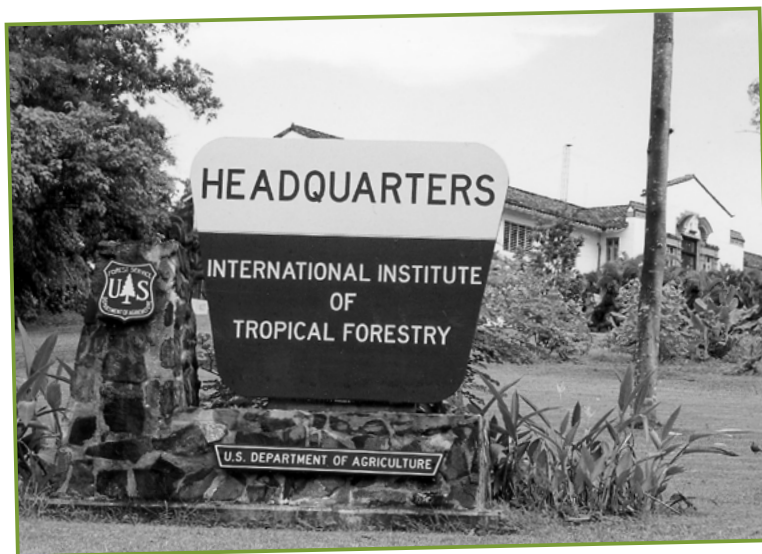


Figure 2. The USDA Forest Service's International Institute of Tropical Forestry is located in Río Piedras, Puerto Rico. The Institute was established in 1939.

USDA Forest Service photo.

Thinking About the Environment



Balancing the needs and wants of humans with the health of the environment can be a tricky balancing act. As humans move into new areas and build new things, certain resources are used more. Animal and plant habitat is changed, and it is often no longer suitable for the animal or plant to live there.

Humans create changes in the environment that may influence the well-being of plants and animals in the surrounding areas. For example, a new house or building may be built on an area that used to be an animal's habitat. Once a house or building has been built, the area is no longer suitable for the animal's habitat (figure 3). Therefore, some animals, plants, and resources may become stressed due to the habitat changes.

The **Endangered** Species Act (ESA) was passed in 1973 to help protect animals and plants from **extinction**. The ESA provides for the conservation of species that are endangered or threatened throughout their habitat range.

International organizations and programs like CITES also help animals and plants. CITES stands for the Convention on International Trade in Endangered Species of Wild **Fauna** and **Flora**. CITES is an agreement among 181 countries. The agreement's goal is to ensure that the trade of wild animals and plants does not endanger the survival of these animals and plants. Trade in wild animals and plants involves trading any animal or plant part for money or other items. Examples of illegal trade of wild animals and plants are harvesting, or cutting down, of endangered tree species and trading or selling ivory from elephants.



Figure 3. This photo shows an area after it was developed.

Photo by Babs McDonald, used with permission.

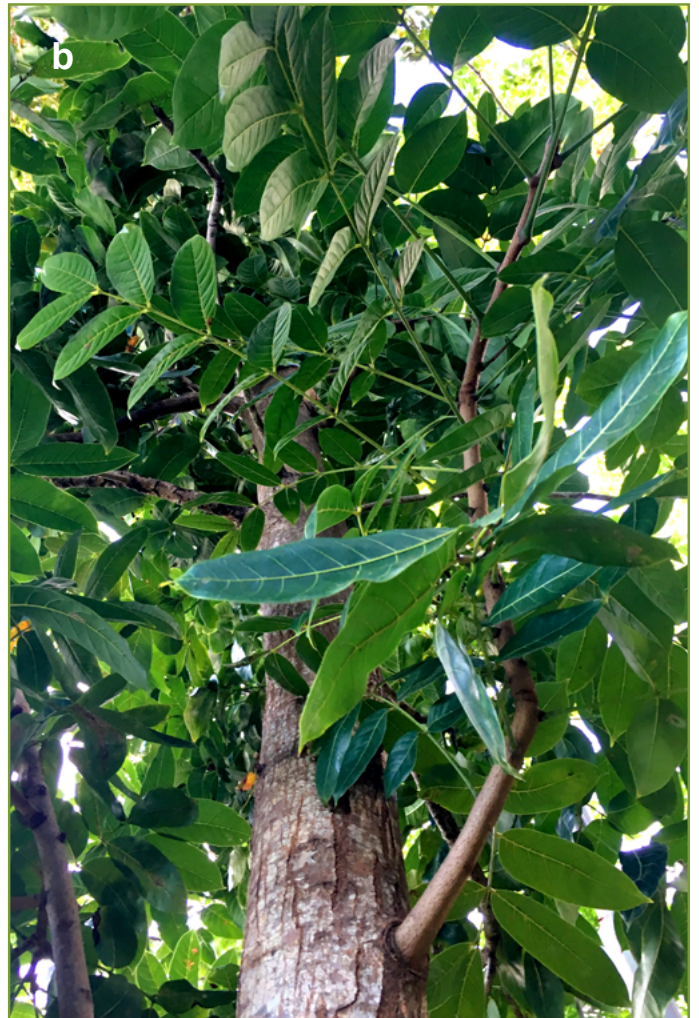
Introduction

Big-leaf mahogany is a tree species known for its beautiful wood (figure 4a and 4b). Over time, humans have cut down many big-leaf mahogany trees for use in furniture and other products (figure 5). Because of this regular human use, big-leaf mahogany is considered **vulnerable**. It has been listed in the **appendixes** to CITES.

Species are listed in one of three appendixes depending on the level of protection they need. Big-leaf mahogany is listed in

Appendix II of the CITES agreement. This listing means that the species is not yet in danger of becoming extinct. However, this listing means the species is at the point where certain precautions need to be taken to ensure its survival.

The listing in CITES is intended to make sure that trade involving big-leaf mahogany is **sustainable**. Sustainable trade means that big-leaf mahogany could be used and traded without endangering its survival.



Figures 4a and 4b. Big-leaf mahogany trees are long-lived and slow-growing trees. The trees in these photos are growing in Puerto Rico.

Photos by Grizelle Gonzalez, USDA Forest Service.



Figure 5. Big-leaf mahogany is known for its beautiful red-colored wood. People like to use mahogany to make furniture.

Photo by tacstef, via <http://www.iStockphoto.com>.

This listing also helps to address illegal harvesting of big-leaf mahogany and **unregulated** trade of big-leaf mahogany.

To ensure that big-leaf mahogany harvesting is sustainable, scientists and land managers must know the conditions in which mahogany grows. The scientists in this study knew that the amount of sunlight

big-leaf mahogany received was important for its growth. The scientists did not know, however, how the availability of **nutrients** in the soil and the amount of water received through rainfall affected big-leaf mahogany growth. Therefore, the scientists in this study wanted to examine how big-leaf mahogany responds to different amounts of rainfall and availability of nutrients in the soil.



Several laws and organizations were discussed in the Introduction section. Name an advantage and disadvantage of having these organizations and laws.

In your own words and in the form of a question, state what the scientists wanted to learn.

Methods

The scientists studied big-leaf mahogany in Central and South America. Specifically, scientists studied trees in the State of Quintana Roo, Yucatan, Mexico; and in the State of Para, Brazil (figure 6). Within each country's site, leaf samples were taken from several areas.

At each of the sites and areas within the sites, the scientists collected mature, healthy big-leaf mahogany leaves (figure 7). These leaves were selected **randomly** from three to five trees at each area. When the leaves were taken off the tree, the scientists traced the leaf on paper to measure the area of the leaf.

The scientists then dried the leaves in an oven (figure 8). The scientists dried the leaves to remove water so that they could grind up the leaf samples and analyze them for different nutrients such as nitrogen, potassium, and calcium. The scientists also measured the weight of the leaves and gathered information about the amount of rainfall in each area.

At each of the sites and areas within the sites, the scientists collected three samples of the upper soil layer. The upper soil layer is 0 to 20 centimeters (cm) deep. The scientists used a soil corer to collect each soil sample (figure 9). The scientists collected these soil samples 50 cm away from the trunk of each tree.



Figure 6. The State of Quintana Roo, Yucatan, Mexico, is in Central America, and the State of Para, Brazil, is in South America.

Map by Carey Burda.



Figure 7. Mature, healthy leaves of big-leaf mahogany can reach up to 20 inches in length. Look at the size of the leaves that Dr. Cuevas is holding in this photo.

Photo courtesy of Elvira Cuevas, University of Puerto Rico, used with permission.

Figure 8. An oven was used to dry the leaves to remove water from the leaves.

Photo courtesy of Elvira Cuevas, University of Puerto Rico, used with permission.



Figure 9. Soil corers help scientists take measurements of soil samples.

Photo by Jessica Nickelsen, Cradle of Forestry in America Interpretive Association, used with permission.



Number Crunch

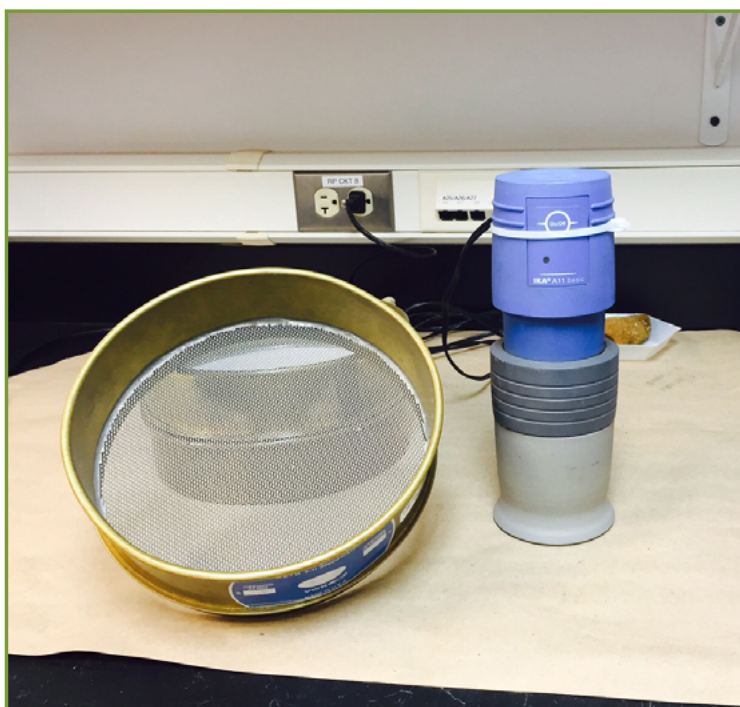
The upper soil layer is 0 to 20 cm deep.
How many inches is that?
(Hint: 1 cm = .393 inches)

The soil samples were air dried, ground up, and passed through a 2-millimeter (mm) mesh sieve (figure 10). The scientists need particles to be 2 mm or smaller to be tested for nutrients. To do this nutrient testing, the scientists used a LECO® elemental analyzer and a **spectrometer** (figure 11).

The scientists measured the amount of nitrogen, potassium, and calcium in the leaves. The scientists then used computers to help them compare the amount of nutrients in the leaves with the amount of nutrients in the soil at the different sites and areas within the sites.

Figure 10. Soil was passed through a 2-mm mesh sieve before the soil was analyzed for nutrients.

Photo courtesy of Elvira Cuevas, University of Puerto Rico, used with permission.



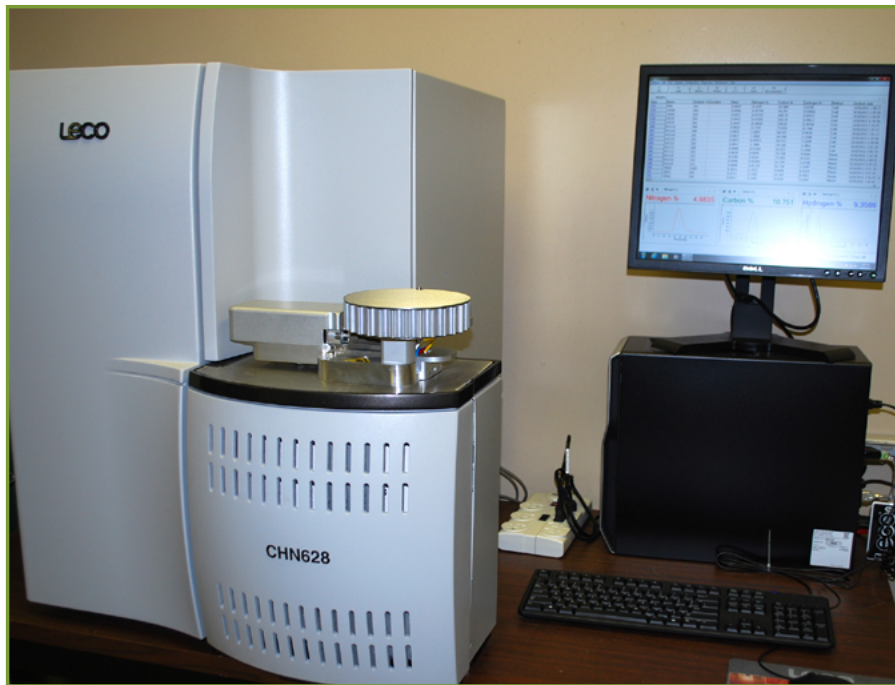


Figure 11. A LECO® elemental analyzer and a spectrometer are machines that help scientists determine the amount and type of nutrients in a sample. The analyzer in this picture helps determine carbon, nitrogen, and hydrogen concentrations.

The University of Kentucky Center for Applied Energy Research (<http://www.caer.uky.edu>) photo.

Reflection Section

The scientists took soil sample measurements 50 cm away from the trunk of the tree. What are some reasons that the scientists might have for taking the sample 50 cm away from the trunk instead of just taking the sample from somewhere near the tree?

The scientists used several types of technology in their study. How do you think this technology helped them? Do you think they would have been able to get the same information without the use of technology? Why or why not?

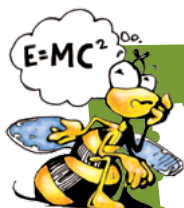
Findings

The scientists found an average rainfall of 2,301 mm a year and an average temperature of 26 degrees Celsius in the Para, Brazil, location. In Quintana Roo, Mexico, the average rainfall was 1,290 mm a year and the average temperature was 26 degrees Celsius.

The scientists found that the leaves from the two sites were similar. However, Quintana Roo had one area with smaller leaf sizes. Additionally, the amount of **organic** matter in the Quintana Roo,

Mexico, soils was 12 times higher than the amount of organic material in Para, Brazil's soils.

The Quintana Roo soils had a higher average concentration of nitrogen, potassium, and calcium than Brazil soils. From previous scientific studies, the scientists knew that calcium played an important role in seedling growth and survival. Overall, the leaves ended up being very similar between the two areas.



Number Crunches

Convert the following measurements:

26 degrees Celsius = _____ degrees Fahrenheit

2,301 mm = _____ inches

1,290 mm = _____ inches

Hint: 1 mm = 0.0393 inches and 0 degrees Celsius = 32 degrees Fahrenheit. To calculate the temperature in Fahrenheit, use the following equation: $^{\circ}\text{F} = ^{\circ}\text{C} \times 9/5 + 32$

Reflection Section



What do you notice about the average rainfall and temperature for the two locations? How do you think that these values affected big-leaf mahogany growth?



The Introduction section of this article described how the listing of big-leaf mahogany in CITES is intended to ensure that trade and harvesting of big-leaf mahogany is sustainable. With the information the scientists discovered about big-leaf mahogany's ability to live in different conditions, do you think sustainable harvesting is possible?
Why or why not?

Discussion

The scientists found that despite differences in the nutrients available in the soil and a differing amount of rainfall, the big-leaf mahogany leaves were similar regardless of location. This finding tells scientists that big-leaf mahogany may possibly be grown in a variety of locations with success.

The scientists also noted the importance of calcium to seedling growth and survival. Therefore, soils with higher amounts of calcium would be beneficial to growing big-leaf mahogany. If big-leaf mahogany can be grown successfully in many locations, managers can feel more confident that the tree species can be sustainably harvested.

Reflection Section



Adapted from Medina, E.; Cuevas, E.; Lugo, A.E.; Terezo, E.; Jiménez-Osornio, J.; Macario-Mendoza, P. A.; Montañez, Patricia. 2014. Conservative nutrient use by big-leaf mahogany (*Swietenia macrophylla* King) planted under contrasting environmental conditions. *Revista Árvore*. 38(3): 479-488.

Glossary

accumulate (ə kyü m(y)ə lāt): The act of collecting or gathering.

analysis (ə na lə səs): Separating something into its parts to examine it.

appendixes (ə pen diks səz): Additional material attached at the end of a piece of writing.

clarity (klar ət ē): The quality or state of being clear.

endangered (in dān jər ed): Threatened with extinction.

extinction (ik stɪŋk shən): (1) The state of being extinct; (2) No longer existing.

fauna (fōn ə): Animals or animal life especially of a region, period, or environment.

flora (flōr ə): Plants or plant life especially of a region, period, or environment.

hypothetical (hī pə the ti kəl): Imagined as an example for further thought.

integral (in te grəl): (1) Necessary to make a whole complete; (2) Essential.

karst (kärst): An irregular limestone region with sinkholes, underground streams, and caverns.

longitudinal (län jə tüd nəl): Involving the repeated observation over time with respect to one or more study variables.

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

organic (ör ga nik): Of, relating to, or coming from living organisms.

physiology (fiz ē āl ə jē): A branch of biology dealing with the processes and activities by which life is carried on and which are special features of the functioning of living things, tissues, and cells.

prescribed fire (pri skrib(d) fir): The controlled use of fire to forested areas under certain weather conditions as a forest management tool.

randomly (ran dəm lē): A way of selecting a smaller number from a group in such a way that all members of the group have the same chance of being selected.

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

spectrometer (spek trā mə tər): An instrument used for measuring wavelengths of light spectra.

stable isotopes (stā bəl ī sə tōp): An isotope that shows no tendency to undergo radioactive decomposition.

sustainable (sə stā nə bəl): Of, relating to, or being a method of using a resource so that the resource is not depleted or permanently damaged.

unregulated (ən reg yə lāt ed): Not controlled.

vulnerable (vəl n(ə-) rə bəl): Open to attack or damage.

Marks and definitions are from <https://www.merriam-webster.com>.
Accented syllables are in **bold**.
Definitions are limited to the terms used in the article.