Caribbean Cruise:

Examining the Amount and Quality of Organic Matter Over Time From Two Caribbean Watersheds

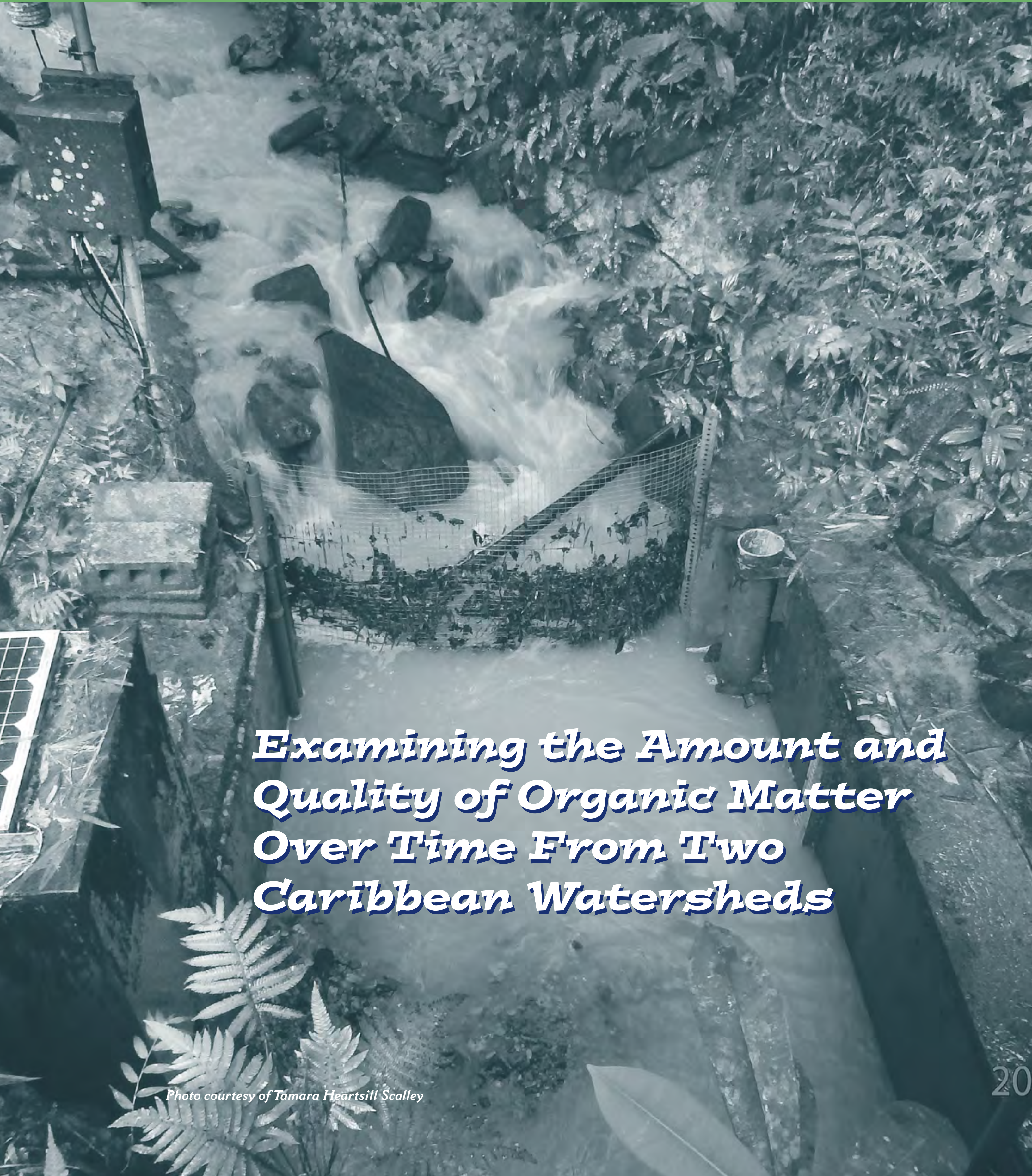
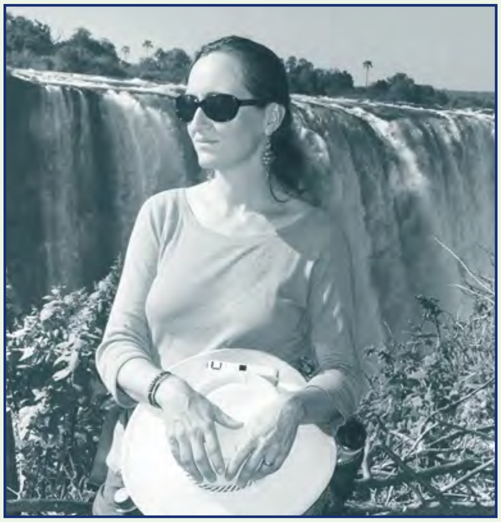


Photo courtesy of Tamara Heartsill Scalley

Meet the Scientists



◀ **Dr. Tamara Heartsill Scalley**, Ecologist: One of my favorite experiences was sampling for aquatic **fauna** in the headwater streams at the highest elevations of the Luquillo (lü **kē** ō) Experimental Forest. The Elfin Cloud Forests have many small streams. Every surface is dripping wet, covered in all kinds of **bryophytes**, and the air is cool and humid. These tiny streams have small pools where the modified minnow traps that we used for sampling barely fit. The streams were full of life—with very high densities of filter feeder shrimp such as *Atya lanipes*.

These streams were the headwaters where streams first emerge from the ground at the highest elevation possible in the forest (**figure 1**). It was a pleasant surprise, because we did not expect many shrimp to be in those pools at the top of the mountain where the river system begins. These shrimp are diadromous (dī **a** drə məs). Diadromous means that they came up the mountain by swimming upstream from the coast, where they were in the ocean saltwater. The shrimp swim and crawl to the highest elevation possible in this mountain stream system.

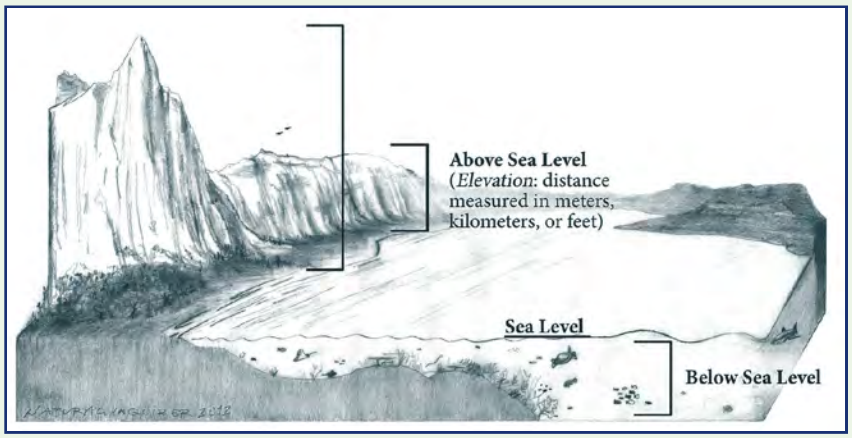


Figure 1. Observe the change in elevation. Illustration by Stephanie Pfeiffer.

◀ **Mr. Samuel Moya**, Biologist: My favorite science experience is installing new scientific equipment and sensors on experimental sites. New sensors allow me to see more accurate results using graphics and **statistical** methods.

Meet the Scientists

▶ **Dr. Ariel Lugo**, Tropical Ecologist: My favorite science experience is interacting with other scientists and debating about science.

In this photo, Dr. Lugo is on Mount Britton Tower. Mount Britton Tower is an observation tower located at high elevation in the middle of the El Yunque (**yün** kā) National Forest. Cloud cover usually **obscures** the view from the tower. The tower is named after Nathaniel Lord Britton (botanist) and his wife, Elizabeth G. Knight Britton (bryologist). The Brittons spent time doing research in Puerto Rico in the early 1900s. A botanist studies plants.

A bryologist is a type of botanist who studies plants like moss, liverworts, and hornworts (**figure 2**). Through the New York Botanical Gardens and the New York Academy of Sciences, the Brittons published the *Scientific Survey of Puerto Rico* in the 1920s.

Figure 2. Moss is growing in the forest. Photo courtesy of Jessica Nickelsen.

Glossary words are **bold** and are defined on page 54.

What Kinds of Scientists Did This Research?

biologist: This scientist studies living organisms and living systems.

ecologist: This scientist studies the relationships of living things with each other and the nonliving environment.

tropical ecologist: This scientist studies the relationships of living things with each other and the nonliving environment in tropical regions. Tropical regions are areas located between the Tropic of Cancer and the Tropic of Capricorn (**figure 3**).

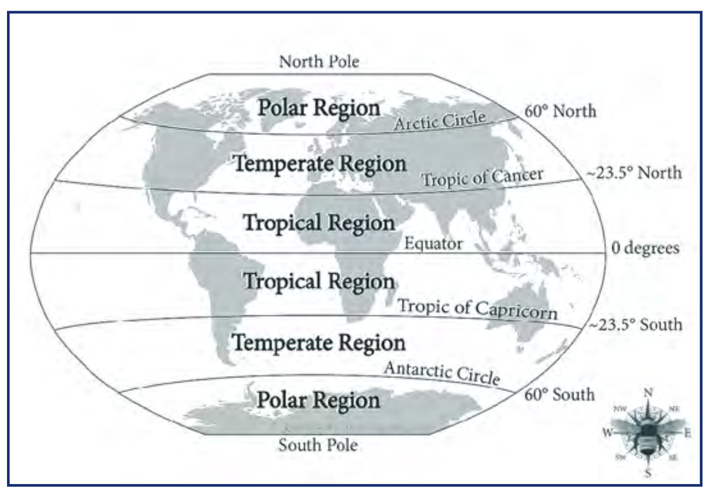
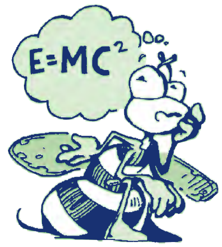


Figure 3. Tropical regions are areas located between the Tropic of Cancer and the Tropic of Capricorn. Illustration by Stephanie Pfeiffer.

Thinking About Science



Sometimes it is useful for scientists to study something over a long period of time. The Forest Service created 81 experimental forests and ranges with this idea in mind (**figure 4**). The Forest Service started setting up these experimental areas in 1908. Most of the experimental areas are at least 50 years old. These areas are useful for scientists because they provide scientists with the opportunity to observe and conduct experiments in an area over a long period of time.

When scientists are able to gather information over several years, they can gain a better idea of what is happening in the area. For example, think about a time in school when a student does not give his or her best effort with schoolwork. Then the student has several years in which he or she gives his or her best effort. If the student were given a choice to be evaluated over the short time period when they didn't give their best effort or the longer time period, the student would want to be judged on the schoolwork done over the longer period of time. The longer time period would provide better information about the student. Similarly, scientists gain a deeper understanding of what is happening when they can review several years of data. Scientists are also able to identify **trends** in the data this way. In this article, you will learn about an experimental forest located in Puerto Rico (**figure 5**).

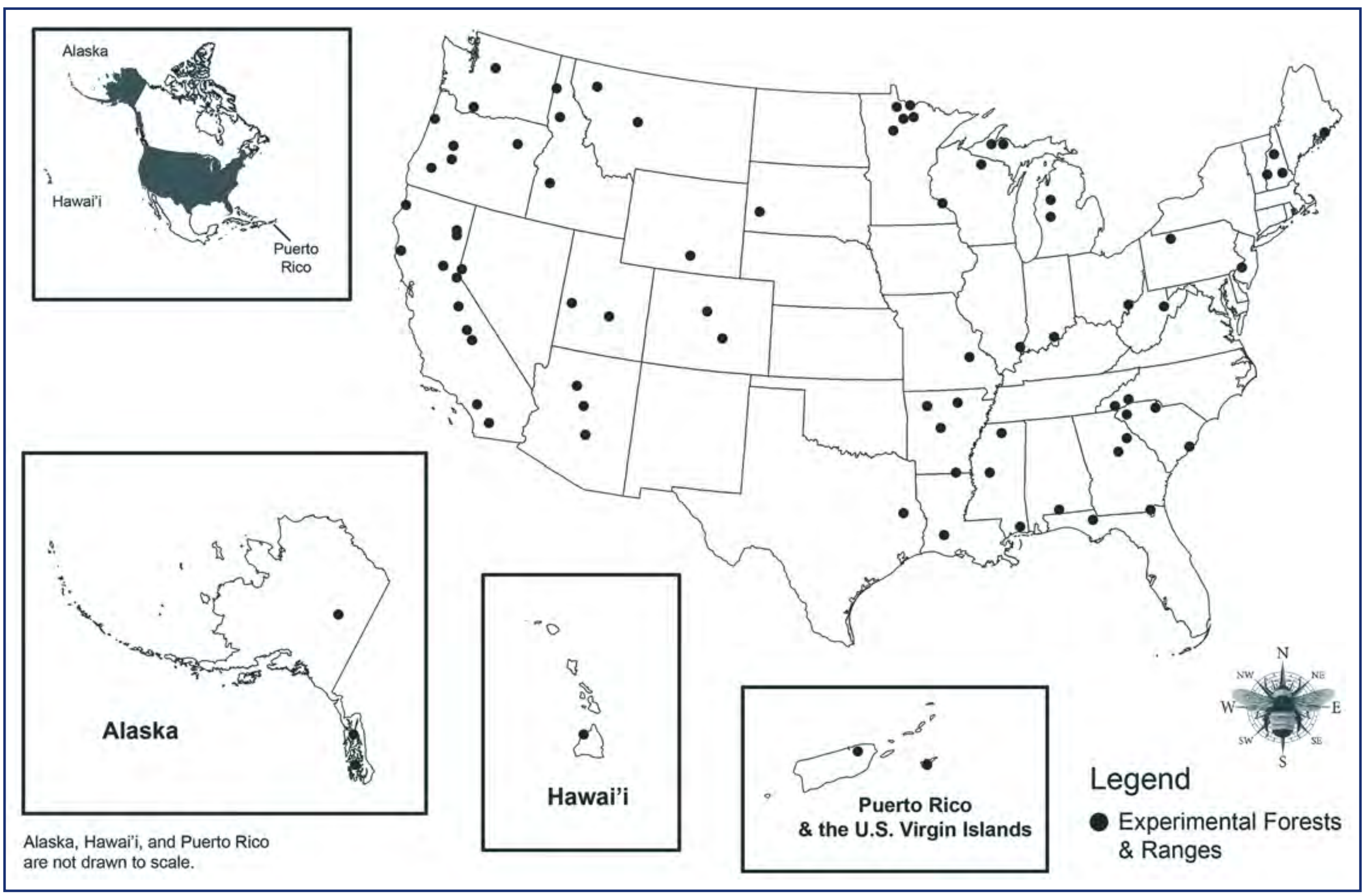


Figure 4. Experimental forests and ranges can be found throughout the United States. Find the one closest to where you live. Map by Carey Burda.

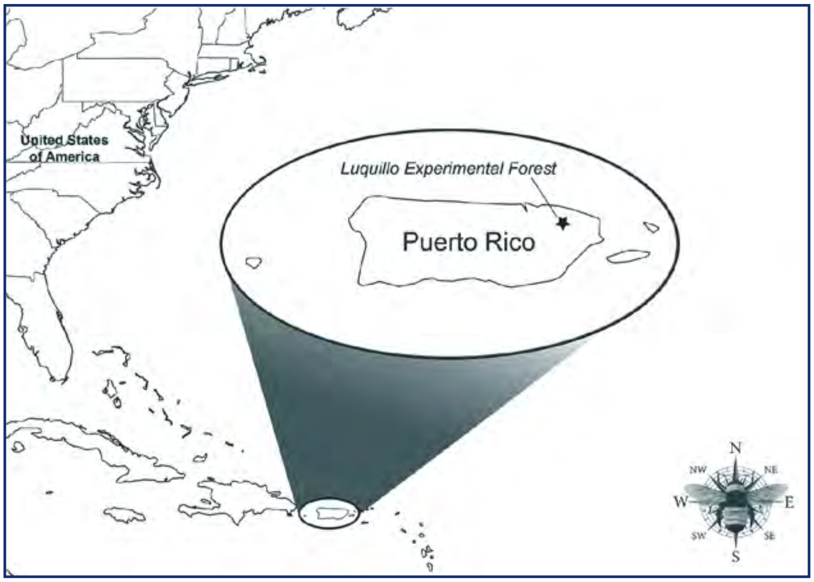


Figure 5. Puerto Rico is a territory of the United States located in the northeast Caribbean Sea. Map by Carey Burda.

Number Crunches

- The first experimental forest was Fort Valley Experimental Forest in Arizona. It was established in 1908. How many years old is the experimental forest today? How many decades old is the experimental forest?

Thinking About the Environment

A watershed is the area that drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, or even the ocean (**figure 6**). Understanding the activities that occur within watersheds and the location of the watershed is important. The activities and location can affect the watershed's water quality.

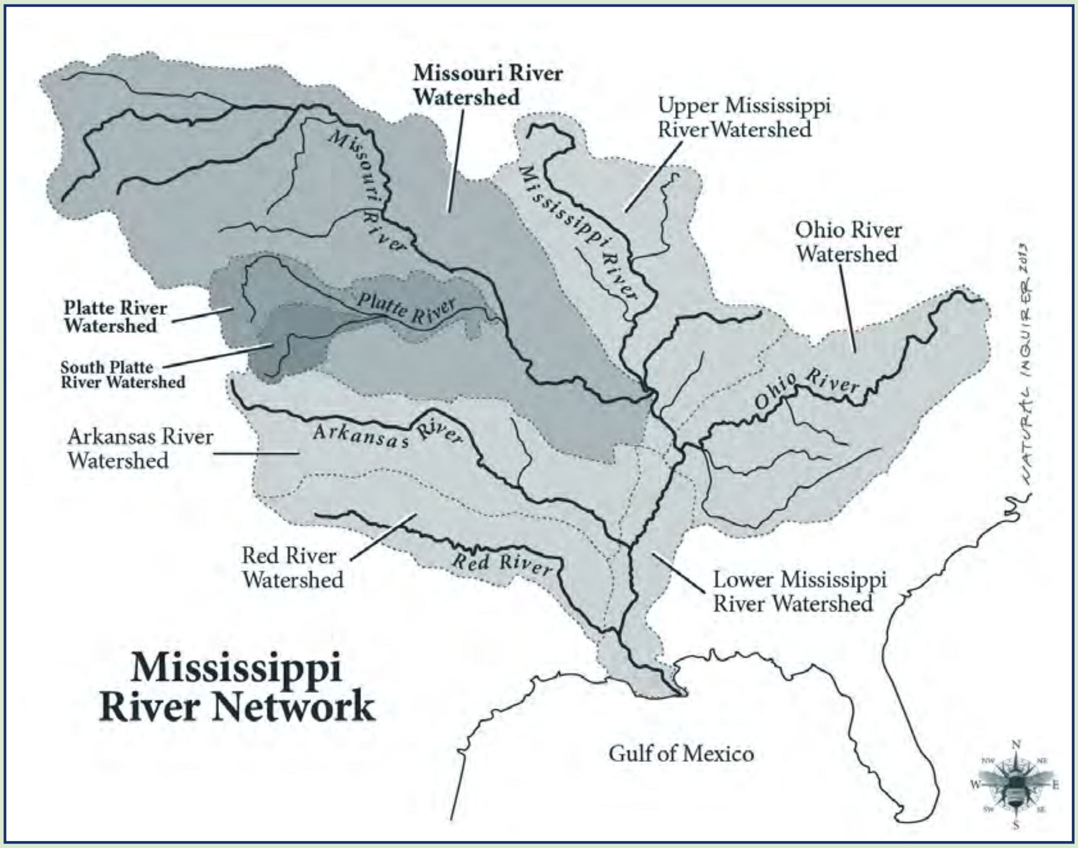


Figure 6. A watershed is the area that drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, or even the ocean. Illustration by Stephanie Pfeiffer.

In this research, scientists studied two watersheds in Puerto Rico. The watersheds are located in tropical forests. Tropical forests are unique because they are located near the Equator (**figure 7**). These forests have a high degree of **biodiversity** and are characterized by a lack of a winter and the occurrence of only two seasons: a wet season and a dry season. In particular, the **drainage** areas for the watersheds the scientists studied are located in a tabonuco (tä bə **nü** kō) forest. This type of forest has tall trees and very little light reaches the forest floor. The tabonuco tree (*Dacryodes excelsa*) **dominates** the tabonuco forest. The tabonuco tree can grow up to 100 feet tall (**figures 8a and 8b**).

Figure 7. The Equator is an invisible line around the middle of planet Earth. It is located at zero degrees latitude. The Equator divides the planet into the Northern and Southern Hemispheres. Illustration by Stephanie Pfeiffer.

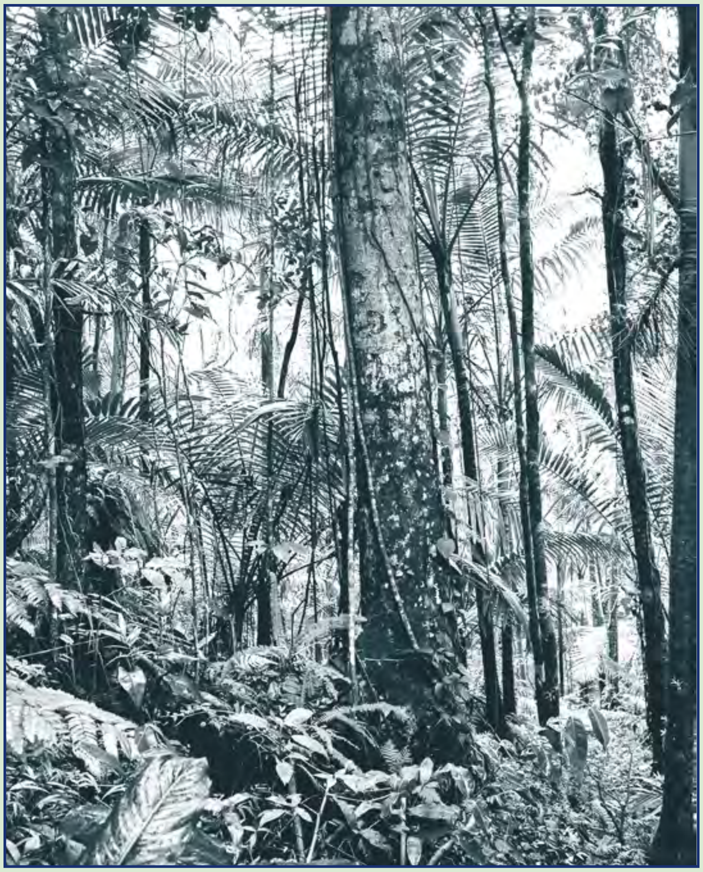


Figure 8a. The tabonuco tree can grow up to 100 feet tall. In Puerto Rico, the tabonuco tree is found mostly in lower elevations of mountainous areas. Photo courtesy of Jerry Bauer.

Figure 8b. The tabonuco tree oozes sap. Photo courtesy of Jerry Bauer.

Number Crunch

- How tall can the tabonuco tree grow in meters? (Hint: 1 foot = 0.3048 meters.)

Introduction

The scientists chose to study two of the Bisley Experimental Watersheds in the Luquillo Experimental Forest (**figure 9**). Luquillo Experimental Forest shares its boundaries with El Yunque (**ū(ng)** kā) National Forest. Because the watersheds are located within the Luquillo Experimental Forest, the scientists could observe and record how things changed over a long period of time. For this research, the scientists studied particulate **organic** matter (POM).

POM consists of small pieces of twigs, leaves, soil, and other items found in the water (**figure 10**). POM measurements are important for several reasons. For example, POM is a source of food and energy for many animals. POM keeps some environmental pollutants out of the water by binding heavy metals and **pesticides**. POM also serves other roles in an **ecosystem** such as being an important part of the food web. POM is a part of the **decomposition** process of the food web (**figure 11**).

In this research, the scientists examined the amount and types of a particular type of POM called **coarse particulate organic matter** (CPOM). CPOM is the pieces of organic material that falls into or is carried into the river. CPOM is generally greater than 1 millimeter (mm) in size. Examples of CPOM are leaves, sticks, and other pieces of plant material. Because CPOM is an important component of an ecosystem and food webs, the scientists wanted to figure out how the amount and quality of CPOM changed over a period of time.

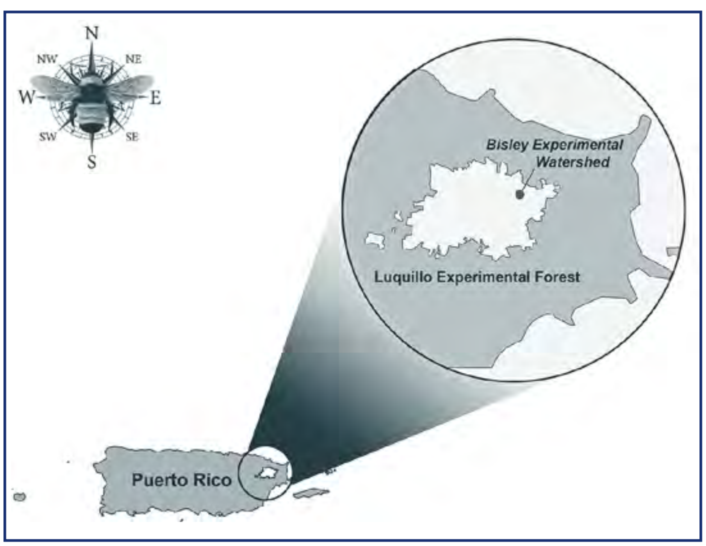


Figure 9. Bisley Experimental Watersheds are located in the Luquillo Experimental Forest. Map by Carey Burda.

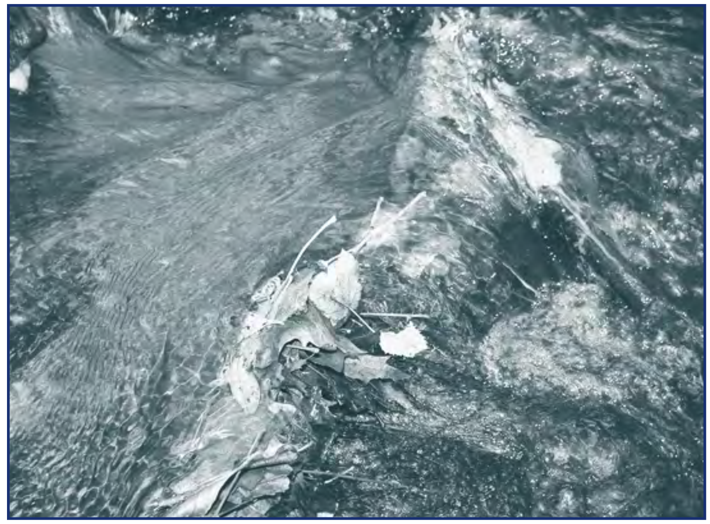


Figure 10. Particulate organic matter (POM) is an important component of an ecosystem and the food web. Photo courtesy of Babs McDonald.

Reflection Section

- In your own words, what is the question the scientists wanted to answer in this study?
- The scientists studied two watersheds in the experimental forest. What is one reason the scientists wanted to study two watersheds instead of only one watershed?

Number Crunch

- CPOM is generally greater than 1 mm in size. Is 1 mm smaller or larger than 1 inch? How do you know?

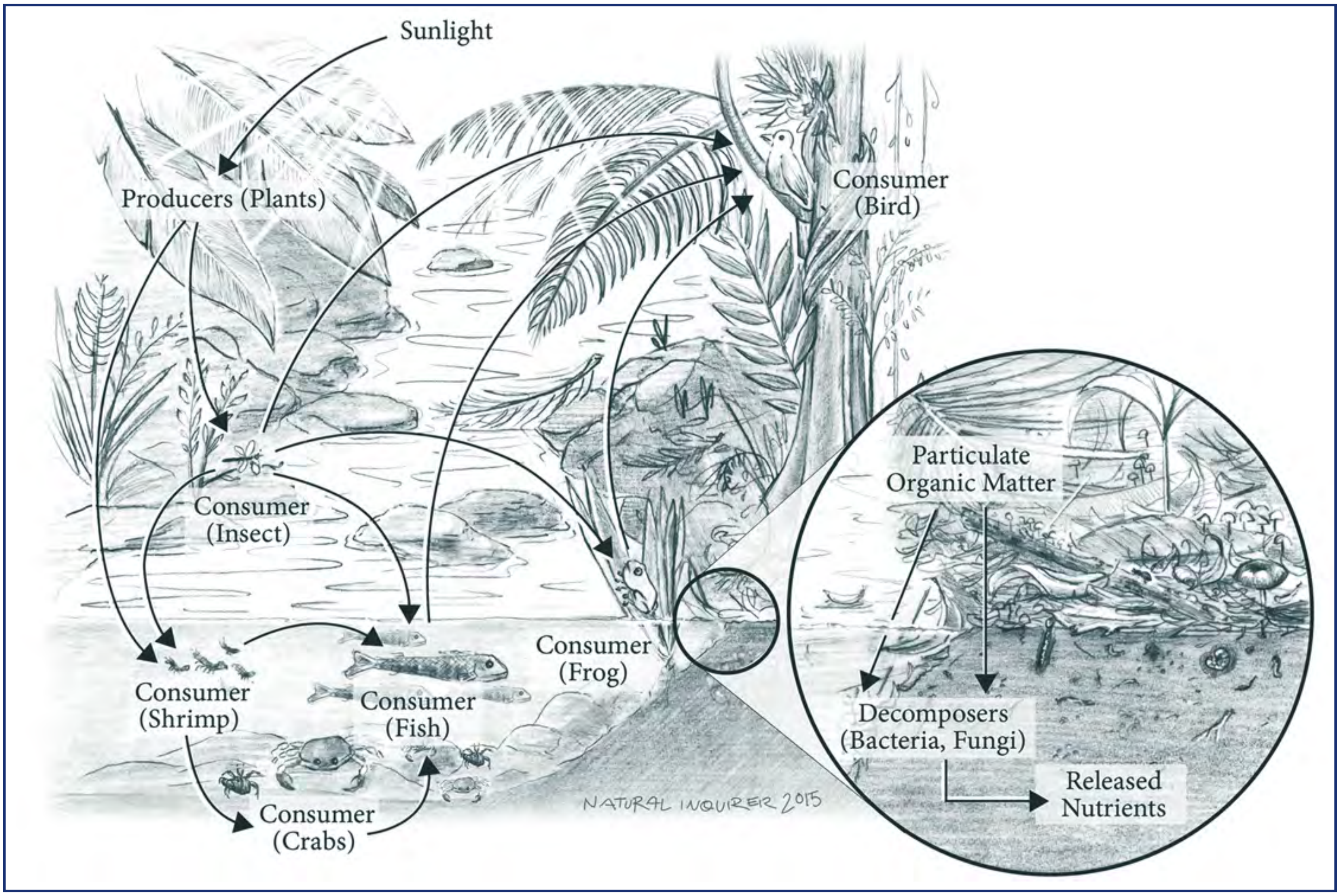


Figure 11. Particulate organic matter (POM) is part of the decomposition process of the food web. Illustration by Stephanie Pfeiffer.

Methods

The scientists collected data from the two watersheds from 1987 to 2005. The scientists collected mean annual rainfall, size of watershed area, stream channel length, as well as dates of hurricanes and other natural disturbances, such as drought (**figure 12**).

The scientists wanted to know how much CPOM was being **exported** from the watersheds. After CPOM is in the water, it undergoes some amount of decomposition. The amount that actually leaves the watershed is the amount that is exported. From 1987 to 2005, scientists collected CPOM that was trapped in metal mesh traps that they placed in the streams.

The scientists collected CPOM every other Tuesday and following large storms. The metal mesh traps were placed across the stream channels (**figure 13**). Scientists tested several mesh traps and sizes from 1987 to 1989. These test traps broke during periods of high water flow. Since 1989, however, the traps the scientists designed did not break. These traps recorded accurate measurements of CPOM by collecting all the CPOM going into the trap.

The scientists also completed chemical **analysis** on some of the samples to see what kinds of elements were in the CPOM. Elements are important to both living and nonliving things. For example, approximately 96 percent of the human body is made up of four elements: carbon, oxygen, hydrogen, and nitrogen. In this study, the scientists measured elements such as carbon, nitrogen, phosphorus, potassium, and calcium in the CPOM.

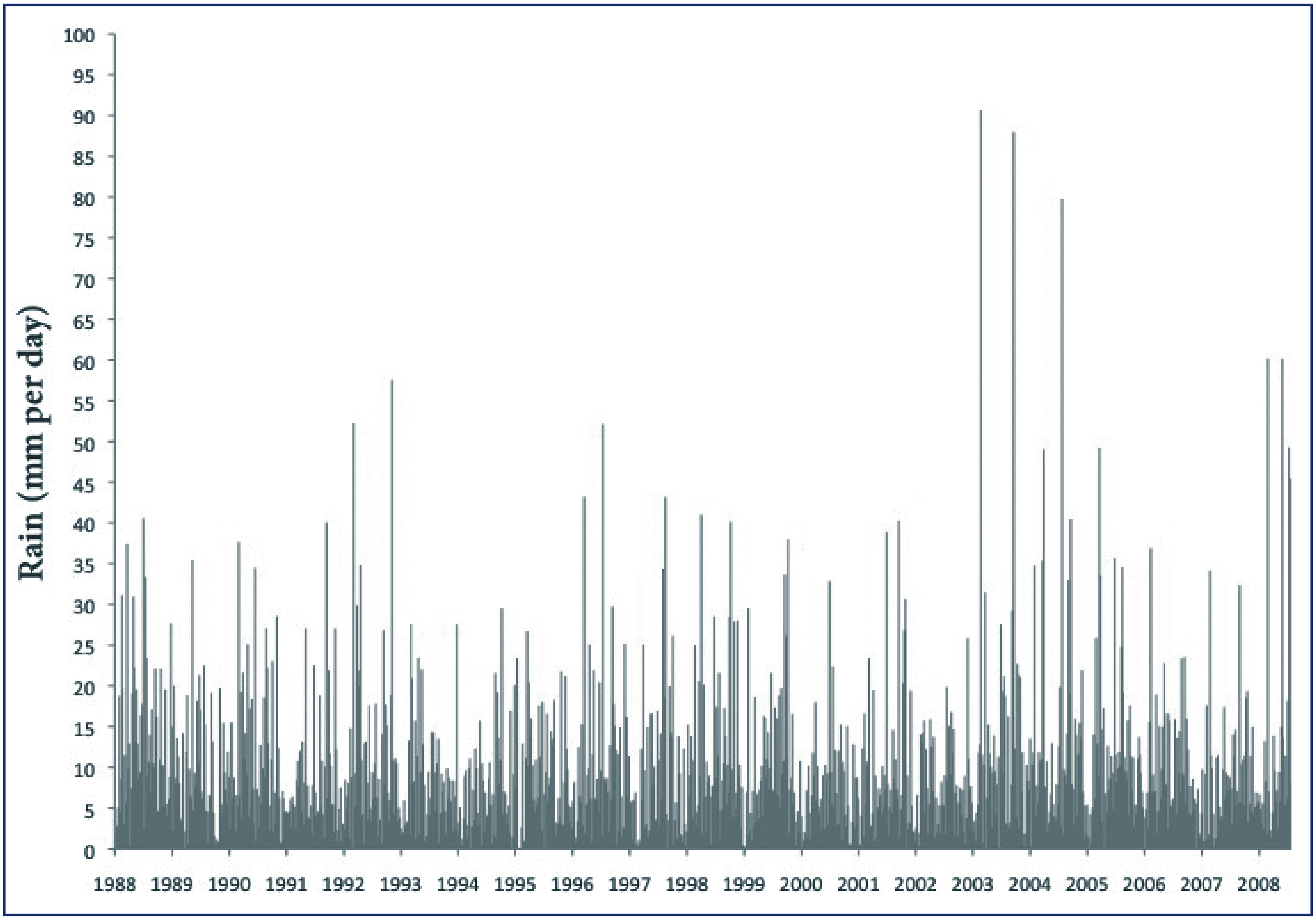


Figure 12. A lot of data change over time. In this graph, you can see what happened to the mean annual rainfall at the study site between 1988 and 2008. Illustration by Stephanie Pfeiffer.

Figure 13. Mesh traps were placed across the stream channels to collect coarse particulate organic matter (CPOM). Photo courtesy of Tamara Heartsill Scalley.

The Periodic Table and Symbols

The periodic table (**figure 14**) is a table that arranges the chemical elements by atomic number. Each element has a letter or several letters that identify it in a simpler way and is called a symbol. For example, the symbol for carbon is C and the symbol for oxygen is O. Look at the periodic table and find the symbols for the elements the scientist studied: nitrogen, phosphorus, potassium, calcium, aluminum, magnesium, iron, and manganese.

1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Galium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton

Figure 14. This table is a shortened form of the periodic table of elements. For a full table, search the Internet for "periodic element table" or look for it in your science book. The complete periodic table contains 118 elements.

Reflection Section

- The scientists collected CPOM after large storms. Why do you think these collections were a good idea?
- The scientists had to test several different types of metal mesh traps to collect the CPOM until they found a design that worked. Think of a time that you have tried to make something or do something and it didn't work. What did you do? What are some characteristics that you think are important for scientists to have in order to overcome obstacles? (Hint: Take a look at some of the *Natural Inquirer* scientist cards at http://www.naturalinquirer.org/scientists-v-92.html. Look at the back of the cards and read about important scientist characteristics. See if you think any of those characteristics apply to this situation.)

Findings

During the 18-year study period, the scientists found several things. The highest CPOM export through the watershed occurred before and during Hurricane Hugo. The scientists found that other tropical storms and hurricanes after Hurricane Hugo did not create as much CPOM export as during the time of Hurricane Hugo.

Relatively high exports of CPOM were recorded from 1995 to 2000 (**figure 15**). The greatest export of leaves (which are part of CPOM) occurred during April, May, and September. These months have the most intense rain showers and the greatest number of plants with falling leaves. During this time, the leaves

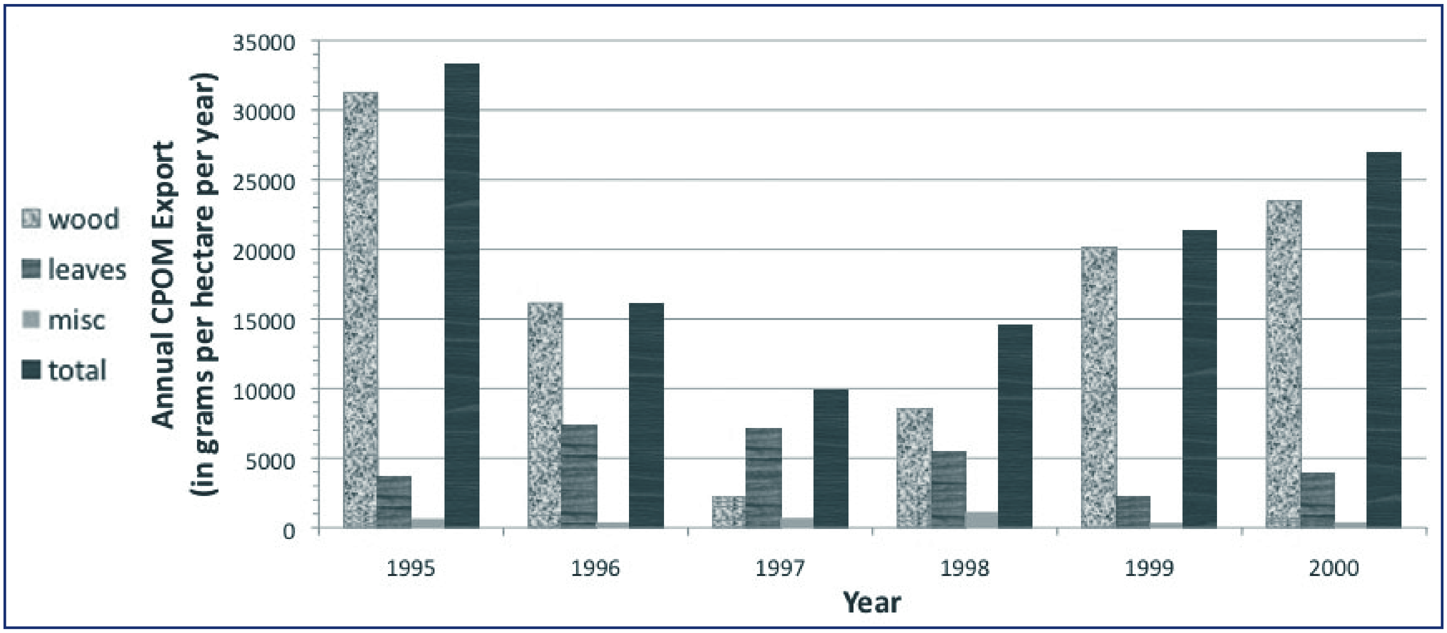


Figure 15. Scientists measured coarse particulate organic matter (CPOM) exports from 1995 to 2000. What do you notice about CPOM export during this time? Graph by Stephanie Pfeiffer.

are mostly falling because of storms, wind, and rain, and they are still green when they fall. Therefore, these leaves have different nutrients and different chemical composition than leaves that fall in the dry season from natural aging.

Low CPOM export occurred during 1990–1991, 1993–1994, and 2000–2002. The lowest amounts of CPOM export were during times of drought. The months of December, January, and February also show low CPOM exports.

Watershed 1 had higher values of potassium than watershed 2. Watershed 2 had higher levels of calcium, magnesium, aluminum, and iron. The scientists found no difference between the two watersheds for levels of nitrogen, phosphorus, and manganese. The scientists thought that the types of leaves and the amount of **decay** that the leaves had undergone may have affected the elements they found in the watersheds.

Reflection Section

- CPOM export was lowest during times of drought. Think about the stream and the surrounding environment during these times. Brainstorm some ideas as to why you think CPOM export could have been low. You may want to research one of your ideas to see what you can find out about it.
- December, January, and February had low CPOM export. Why do you think this low level may have occurred?

Hurricane Hugo

Hurricane Hugo (**figure 16**), which made landfall in September 1989, created some of the highest stormtide heights that had ever been recorded on the east coast of the United States. Hugo was a category 5 hurricane in the Atlantic Ocean and then became a category 4 storm that went through the Caribbean. Hurricane Hugo had maximum sustained winds of 135 to 140 miles per hour. During that time, Hugo was the strongest storm to hit the United States within a 20-year period, and it created approximately $7 billion ($7,000,000,000) in damage (**figure 17**). To learn more, visit http://www.weather.gov/chs/HurricaneHugo-Sep1989.

The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed (**figure 18**). The National Oceanic and Atmospheric Administration explains that "this scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures."

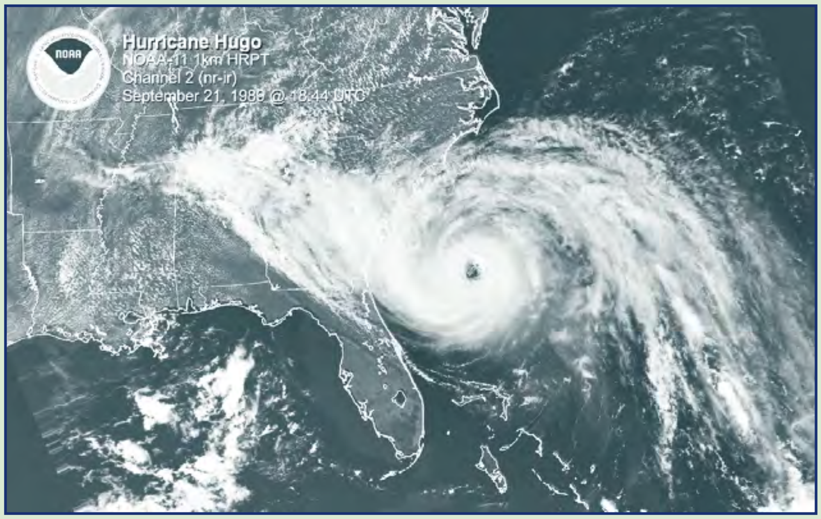


Figure 16. Hurricane Hugo. Photo courtesy of National Oceanic and Atmospheric Administration.

Figure 17. Pre- and post-Hugo photos at Folly Beach, South Carolina. Photos courtesy of National Oceanic and Atmospheric Administration.

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74–95 mph 64–82 kt 119–153 km/h	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96–110 mph 83–95 kt 154–177 km/h	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111–129 mph 96–112 kt 178–208 km/h	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130–156 mph 113–136 kt 209–251 km/h	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher 137 kt or higher 252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

mph = miles per hour. kt = knots. km/h= kilometers per hour.

Figure 18. The Saffir-Simpson Hurricane Wind scale. Courtesy of the National Oceanic and Atmospheric Administration.

Discussion

The export of CPOM generally followed a seasonal pattern that was a combination of the monthly rainfall pattern and seasonal patterns for leaves falling from plants and trees. The scientists found that one of the greatest events of CPOM export was during Hurricane Hugo. The scientists also found that tropical storms and hurricanes after Hurricane Hugo did not create as much CPOM as during the time of Hurricane Hugo.

The scientists believe that this finding has to do with the fact that, during Hurricane Hugo, the forest was more mature. A more mature forest means that it is an older forest with larger trees and more growth. After Hurricane Hugo came through, parts of the forest were destroyed and fewer large trees remained. When tropical storms or other hurricanes came through the area after Hurricane Hugo, less organic material was available to fall and export into the streams. Therefore, the **frequency** and intensity of hurricanes and tropical storms, along with the age of the forest, had a measurable effect on the export of CPOM through the watersheds.

Reflection Section

- In your own words, what did the scientists learn from their study?
- Why are natural disasters and other large weather events important to study? What information can they provide for the future management of the natural systems?

Glossary

analysis (ə **na** lə səs): A careful study of something to learn about its parts, what they do, and how they are related to each other.

biodiversity (**bī** ō də **vər** sə tē): The existence of many different kinds of plants and animals in an environment.

bryophyte (**brī** ə fīt): Any of a division (Bryophyta) of nonflowering plants comprising the mosses, liverworts, and hornworts.

coarse particulate organic matter (CPOM) (kōrs pär **ti** kyə lət ȯr **ga** nik **ma** tər): CPOM is the pieces of organic material that falls into or is carried into a river. CPOM is generally greater than 1 millimeter (mm) in size. Examples of CPOM are leaves, sticks, and other pieces of plant material.

decay (di **kā**): To break down, rot, or undergo decomposition.

decomposition (**dē** kəm pə **zi** shən): The slow destruction of something (such as dead plants and the bodies of dead animals) by natural processes, chemicals, etc.

dominate (**dä** mə nāt): To have a prominent place or position.

drainage (**drā** nij): (1) The act or process of draining something; (2) The act or process of removing water or liquid from a place or thing.

ecosystem (**ē** kō **sis** təm): Community of plants and animal species interacting with one another and with the nonliving environment.

export (**ek** spȯrt): To carry away.

fauna (**fä** nə): All the animals that live in a particular area, time period, or environment.

frequency (**frē** kwən(t) sē): The number of times that something happens during a particular period.

obscure (äb **skyu̇r**): Not clearly seen or easily distinguished.

organic (ȯr **ga** nik): Of, relating to, or obtained from living things.

pesticide (**pes** tə sīd): A substance that is used to kill animals or insects that eat plants or crops.

statistical (stə **tis** ti kəl): Based on statistics, a branch of mathematics that deals with analyzing and interpreting data.

sustain (sə **stān**): Continuing for an extended period.

trend (**trend**): A general direction of change.

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 Heartsill Scalley, T.; Scatena, F.N.; Moya, S.; Lugo, A.E. 2012. Long-term dynamics of organic matter and elements exported as coarse particulates from two Caribbean montane watersheds. Journal of Tropical Ecology. 28: 127–139. http://www.treesearch.fs.fed.us/pubs/41610.

FACTivity

Time Needed

One class period

Materials

(for each student or group of students)

- Pencil
- Graph paper
- "Caribbean Cruise" article in this *Natural Inquirer* edition

The question you will answer in this FACTivity is: What can you learn from data about gage height and streamflow for a stream for an extended period of time?

Methods

In the article you just read, the scientists examined a variety of different types of data from the Bisley Experimental Watersheds in the Luquillo Experimental Forest. The table of data provided in the following table is from the Rio Sabana in Luquillo Experimental Forest and El Yunque National Forest. The data have been collected for 33 years. The gage height is the height of the water above zero on the water gage. A water gage is an instrument used to find the depth or quantity of water or to indicate its surface height. Streamflow is the water released from a stream. Streamflow is measured in cubic feet per second. Examine the data in table 1. On the graph paper provided (on page 123), create a graph for either the gage height data or the streamflow data (**figure 19**).

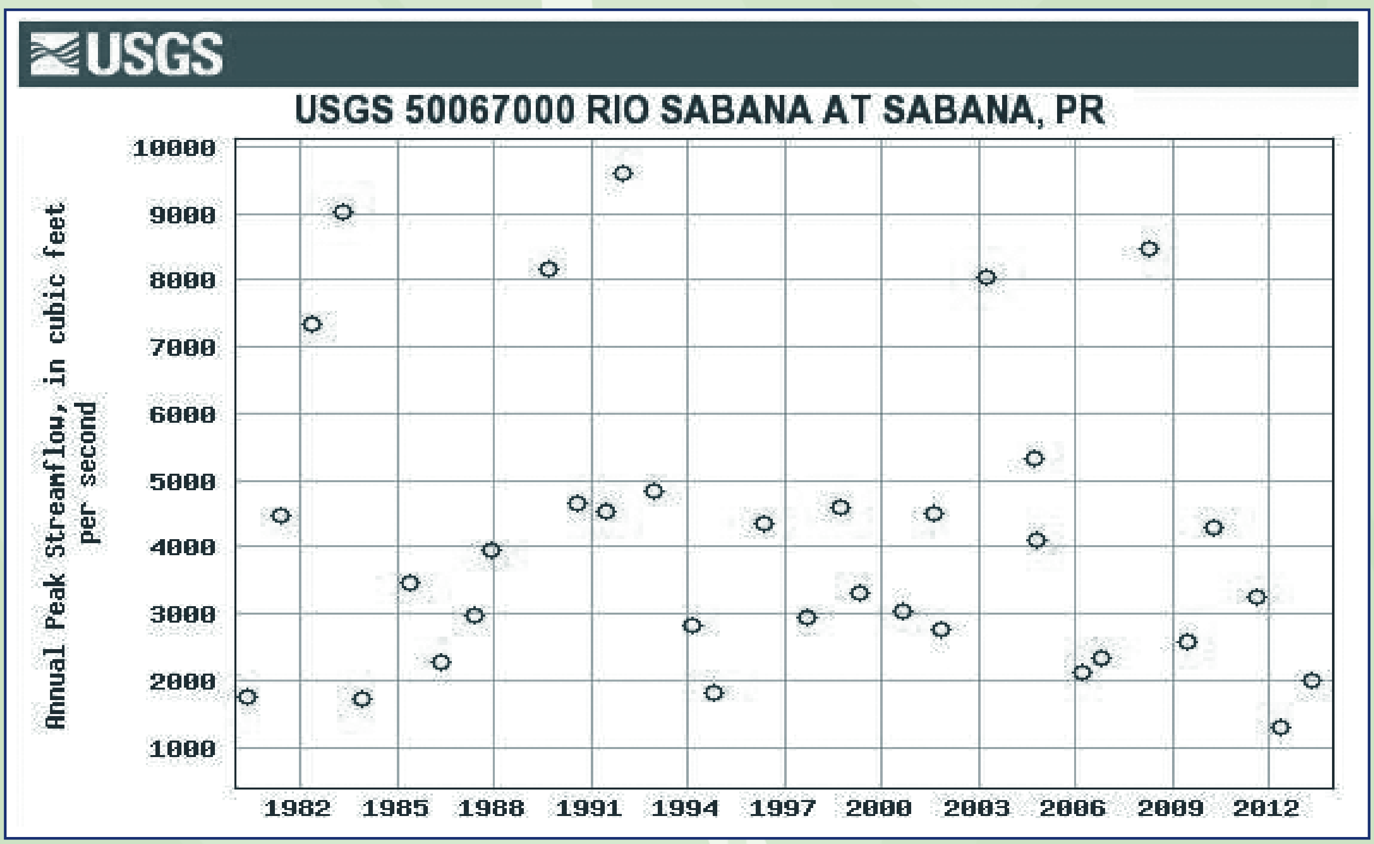


Figure 19. A sample graph of the peak streamflow data from Rio Sabana. Graph courtesy of the U.S. Geological Survey.

Year	Date	Gage Height (feet)	Streamflow (cubic feet per second)
1980	May 22, 1980	12.55	1,760
1981	May 19, 1981	15.77	4,480
1982	May 10, 1982	18.17	7,340
1983	Apr. 21, 1983	19.35	9,010
1984	Dec. 02, 1983	12.50	1,730
1985	May 17, 1985	14.73	3,470
1986	May 13, 1986	13.27	2,260
1987	May 25, 1987	14.16	2,970
1988	Nov. 27, 1987	15.23	3,940
1989	Sep. 18, 1989	18.77	8,170
1990	Aug. 13, 1990	16.08	4,660
1991	Jun. 30, 1991	15.80	4,520
1992	Jan. 05, 1992	19.74	9,600
1993	Dec. 29, 1992	16.11	4,840
1994	Feb. 19, 1994	14.00	2,830
1995	Nov. 07, 1994	12.62	1,810
1996	May 13, 1996	15.64	4,350
1997	Sep. 26, 1997	14.15	2,960
1998	Sep. 21, 1998	15.86	4,580
1999	May 08, 1999	14.56	3,310
2000	Aug. 23, 2000	14.24	3,030
2001	Aug. 22, 2001	15.79	4,500
2002	Nov. 09, 2001	13.91	2,760
2003	Apr. 17, 2003	18.69	8,050
2004	Sep. 15, 2004	16.55	5,330
2005	Oct. 29, 2004	15.41	4,120
2006	Apr. 05, 2006	13.07	2,120
2007	Oct. 20, 2006	13.35	2,320
2008	Apr. 27, 2008	18.99	8,480
2009	Jun. 12, 2009	13.67	2,570
2010	Apr. 13, 2010	15.58	4,290
2011	Aug. 22, 2011	14.50	3,260
2012	May 10, 2012	11.82	1,300
2013	May 10, 2013	12.89	1,990

Table 1. Gage height and streamflow data from Rio Sabana in Puerto Rico. Data courtesy of U.S. Geological Survey.

After you have created the graph, compare the data over the 33-year time period.

- Circle any points that seem to be very high or very low.
- Name at least two things from the data that seem important. Why do you think the data from these two times may be important? What do you think the data from these times may indicate?
- How did creating a graph from the data help you to analyze and understand the data?
- Share and discuss your results with your classmates. Did they notice similar points in the data? How were your graphs and analysis of the graphs similar and different?

Natural Inquirer Connections

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

- "Leaf Me Alone" in the Tropical Forest edition of *Natural Inquirer.*
- "Don't Litter the Stream" in the Hawai`i-Pacific Islands edition of *Natural Inquirer.*
- "I'll Huff and I'll Puff and I'll Blow Your Trees Down!" in the Tropical Forest edition of *Natural Inquirer.*
- "Swimming Upstream Without a Ladder" in the Tropical Forest edition of *Natural Inquirer.*

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

What's in a Word?

One of the many questions that people have asked from time to time is the spelling of the word "streamgage" versus spelling it with a "u" as in "streamgauge." Page 50 of the U.S. Geological Survey report, *A History of the Water Resources Branch, U.S. Geological Survey: Volume I, From Predecessor Surveys to June 30, 1919* (http://on.doi.gov/USGSWaterHistory) includes a reference giving credit to the change in spelling to F.H. Newell around 1892. The author wrote:

> At about this time, F.H. Newell adopted the spelling "gage" instead of "gauge." As he informed the writer, "gage" was the Saxon spelling before the "u" was inserted as a result of Norman influence on the language.

Ever since then, the U.S. Geological Survey has spelled the word without the "u."

Web Resources

International Institute of Tropical Forestry
http://www.fs.usda.gov/iitf/

U.S. Geological Survey Water Data for Rio Sabana
http://waterdata.usgs.gov/nwis/inventory/?site_no=50067000&agency_cd=USGS

A Distance Learning Adventure: America's Rainforests—Caribbean National Forest/Luquillo Experimental Forest
http://rainforests.pwnet.org/americas_rainforests/caribbean.php

El Yunque National Forest
http://www.fs.usda.gov/elyunque

Luquillo Long-Term Ecological Research Program
http://luq.lternet.edu/

Tabonuco Trees
http://www.na.fs.fed.us/pubs/silvics_manual/volume_2/dacryodes/excelsa.htm

University of California Museum of Paleontology: Tropical Forests
http://www.ucmp.berkeley.edu/exhibits/biomes/forests.php#tropical

History of Fort Valley Experimental Forest
http://www.foresthistory.org/ASPNET/Places/ResearchSites/FortValley.aspx