

Back to the Future:



Photo courtesy of Connie Millar.

Using Dead Trees To Predict Future Climates

Meet the Scientists

Dr. Connie Millar, Research Climate Ecologist: Recently, I had a great science treasure hunt in the wild lands of Nevada. We were looking for the lowest **elevation** living bristlecone pine. The bristlecone pine is known for its long life. These trees can live more than 5,000 years. The tree that we were hunting for had been documented in a remote canyon in 1984. We had a picture of the tree and knew its general whereabouts, but even though we searched and searched we couldn't find it.

We kept trying to match the picture to the canyon, and, finally, I ran ahead to an old dead skeleton of a tree. Sure enough, there were disintegrated bristlecone pine cones on the ground. We **cored** the tree and found that it had died during a drought more than 10 years ago. We are determined to set another low-elevation record with a live bristlecone pine!



▶ **Dr. Robert Westfall**, Quantitative Geneticist (**kwän tə tā tiv jə ne tə sist**): Dr. Millar and I were searching for pika in a boulder field on Warren Bench, above Mono Lake, California. Pika are small mammals in the same family as rabbits. We noticed tips of pine branches on the ground. This was evidence of pika because they like to eat the tender pine branches. Then, I found more pine tips hidden in the rocks. Dr. Millar and I wondered how the little pika got the pine tips because most of the pine branches were so high off the ground. I looked in a clump of pines up from the rocks—no clipped tips on the ground. Then I looked at a bunch of clipped pine branches that were 6 feet off the ground. The little pika had scampered across the deep snow that spring to collect the needles and tender spring buds.

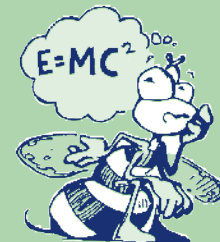


◀ **Ms. Diane Delany**, Biological Technician: When I was a little girl I loved to collect things in nature. I collected rocks, shells, bird nests, and pine cones. I collected them everywhere I went. I would sort my collections, put them in order, and look for patterns. Now that I am a scientist, my favorite scientific experiences are those where I am collecting, observing, and taking notes with the smell of the trees and the mountain air all around me. I love working with our team of scientists to find answers in our observations, collections, and data.

Thinking About Science

Often, scientists have to understand the past to predict what might happen in the future. The scientists in this study examined trees that died during a volcanic explosion in 1350. How many years ago was that? The scientists wanted to discover what the **climate** was like during the trees' lifetime. They wondered if knowing this would help them to make predictions about our future climate.

Climate change is a topic that scientists are interested in understanding. Climate change refers to the change in Earth's climate over time. One way to predict our future climate is to understand the patterns of past climates, including those long ago and those more recently. Think of one other situation where learning about the past can help us to predict the future.



Thinking About the Environment

Volcanoes are powerful forces of nature that can quickly change the way Earth looks. In this study, many trees were killed by an eruption from Glass Creek Vent in the Inyo Craters in California (**figure 1**). A vent is the opening of a volcano through which magma comes to the surface. After they were killed, the trees near the Glass Creek Vent were **preserved** by tephra that came from the explosion of the volcano. Tephra is the volcanic rock that is blasted into the air from the explosion (**figures 2a and 2b**). The amount of tephra can vary widely. Between 1 and 8 meters of tephra fell on the area that the scientists studied, burying the lower portions of the tree trunks. These well-preserved tree trunks helped the scientists learn a lot about this area's past.



Figure 2a and 2b. Notice how the tephra covers the land under the trees and partially buries the tree trunks. Photos courtesy of Connie Millar, Forest Service.

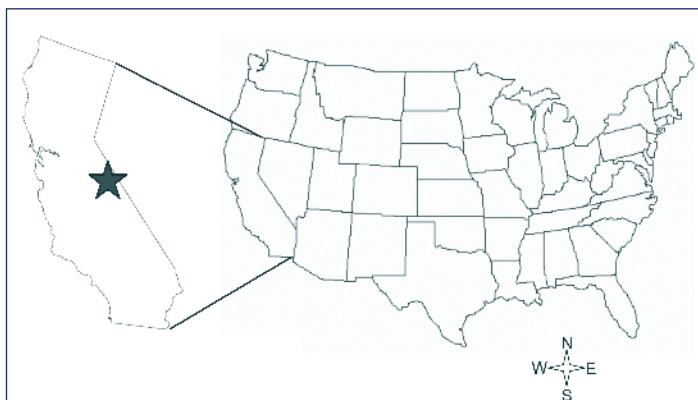


Figure 1. The area the scientists studied.

Number Crunches

How many feet of tephra fell? Multiply the number of meters by 3.28 feet.

Introduction

The tree line is the edge of a habitat at which trees are capable of growing (**figure 3**). In this study, the scientists wanted to examine dead trees that they found above the current tree line. These dead trees are known as deadwood. The deadwood found above the current tree line indicated that the climate during the trees' lifetime was different than it is now. The scientists were interested in learning about the climate that existed when these trees were alive.



Figure 3. Notice the line above which trees cannot grow. Photo courtesy of Connie Millar, Forest Service.

Methods

The scientists studied two areas close to Glass Creek Vent. One area was Whitewing Mountain and the other area was San Joaquin Ridge (**figure 4**). To better understand the area, the scientists created a map that showed the location of all deadwood in the area. The scientists identified the location where the deadwood was greater than 1 meter in length and 10 centimeters in diameter (**figure 5**). They only mapped deadwood located above the current tree line. They mapped 1,675 dead trees from Whitewing Mountain and 60 from San Joaquin Ridge.



Figure 4. Whitewing Mountain. Photo courtesy of Connie Millar, Forest Service.

Reflection Section




-  What was the question the scientists were trying to answer?
-  Think of an example of something that happened to you in the past that helped you better understand something in the future. For example, last week you did not study for your science quiz and failed, so this week you studied.
-  Why did the existence of the dead trees above the tree line indicate that the climate might have been different when the trees were alive?



Figure 5. Trees varied in size and length. Photo courtesy of Connie Millar, Forest Service.

The scientists used a Global Positioning System (GPS) to determine the location of each piece of deadwood. In addition to mapping the deadwood, the scientists examined the tree rings (**figure 6**). The tree rings helped the scientists understand how old the trees were and how well they grew. The tree rings also helped the scientists to learn about the climate conditions in which the trees were growing. The study of tree rings to help understand climate and the environment is called dendrochronology (**den drō krə nă lə jē**). You will learn more about dendrochronology in the FACTivity at the end of this article.



Figure 6. Tree rings tell a story about the tree. Tree rings show how old a tree is and provide clues to what the environment was like during its lifetime.

Reflection Section

- Why did the scientists only map the deadwood above the tree line?
- How did technology help the scientists in this study?



A Global Positioning System, or

GPS

You probably are familiar with a GPS. You might even have one in your family car! A GPS tells your exact location on Earth's surface, based on the lines of latitude and longitude. Latitude and longitude are imaginary lines on Earth, and are included on most globes and many maps. A GPS unit gives the unit's location by communicating with GPS satellites orbiting Earth. At any one time for any location on Earth, 4 of the 24 GPS satellites are above the horizon. The GPS unit communicates with three of the satellites. Each satellite sends information to the unit. The unit receives information from all three satellites, and then displays the unit's location.



Photo courtesy of United States Army.

Findings

The scientists found that a variety of trees had lived above the tree line. Some of the types of trees included whitebark pine, sugar pine, western white pine, lodgepole pine, Jeffrey pine, and mountain hemlock (**figures 7-10**).

These species currently grow much lower in elevation than the Whitewing summit where the deadwood occurs. The scientists found that the climate, when the trees were alive, was much warmer and slightly drier than the area's



Figure 7. Whitebark pine. Photo courtesy of Dave Powell, <http://www.bugwood.org>.



Figure 8. Sugar pine. Photo courtesy of Connie Millar, Forest Service.

current climate. The **mean annual** temperature was warmer by 3.2 degrees Celsius, annual **precipitation** was 24 millimeters less.



Figure 9. Lodgepole pine. Photo courtesy of Dave Powell, <http://www.bugwood.org>.



Figure 10. Mountain hemlock. Photo courtesy of Donald Owen, <http://www.bugwood.org>.

Number Crunches

- How many degrees warmer was it in Fahrenheit? To calculate, multiply the degrees Celsius by 9/5, and then add 32.
- What was the precipitation loss in inches? To calculate, multiply the number of millimeters by 0.039.

Reflection Section

- The scientists measured the change in temperature in Celsius. Why did they use Celsius to measure and report temperature rather than Fahrenheit?
- Why are these findings important to our understanding of the future?



Discussion

The scientists discovered that their climate findings from the past were similar to climate projections for California between 2070 and 2099. In earlier climate change projections, other scientists thought that an increase in temperature would cause a decrease in the amount of forest land.

The scientists in this study, however, found that a variety of trees were living in a warmer climate and at a higher elevation than they are currently found. Therefore, the scientists think that the predicted future decrease in forested area may not be as great as some earlier studies suggest. They predicted that the location where the trees may be found in the future will likely be different and the tree line will likely move higher.

Glossary

annual (an yū əl): Covering the period of 1 year.

climate (klī mət): The average condition of the weather over large areas, over a long time, or both.

core (kôr): To use a hollow drill to take a small cylindrical sample of a tree's trunk.

elevation (e lə vā shən): The height above sea level.

Global Positioning System (GPS) (glō bəl pə zī shə ning sis tem): A radio satellite navigation system that allows users to determine their position on Earth's surface.

mean (mēn): The average in a set of numbers.

precipitation (pri si pə tā shən): Rain, hail, snow, mist, or sleet that falls on Earth.

preserve (pri zərv): To keep free from decay.

Accented syllables are in **bold**. Marks are from the Merriam-Webster Pronunciation Guide

Reflection Section

- Based on this article and your own experience, why do you think it is important to study the past?
- Why do you think scientists try to predict things that will happen in the future? For example, why do you think scientists want to know what trees may be alive in the future as the climate becomes warmer?





Time Needed

2 to 3 days

Materials needed for each group of two to four students:

- A copy of the sample tree-ring cores on page 47.
- One 1-meter strip of adding machine tape or thick ribbon.
- Colored pencils and markers.
- Reference material, such as almanacs, that provide students with the dates of social, cultural, environmental, and scientific events over the past five decades.
- A notebook for recording results (optional).
- Tape and scissors.

The question you will answer in this FACTivity is: How does dendrochronology help us understand the environment in which a tree lives?

Day 1:

In this FACTivity, tree-ring core samples showing the tree-ring patterns of four trees are represented by four strips on page 47. You can imagine what real cores look like if you take a straw and draw one of the patterns on the straw. These cores are taken from a tree using an instrument borer. An instrument borer is a hand drill that pulls out a thin cylinder of wood from the trunk of a tree. The borer must go all the way to the center of the trunk to accurately read the tree-ring patterns. After the core sample is pulled, scientists seal the hole so the tree is protected from insects and disease.

Using the four core samples on page 47, each group will construct the climatic (klī mā tik) history of the trees. You will then record social, cultural, environmental, and scientific events that occurred during the lifetime of these four trees.

Process:

1. Read the background information provided at the end of this FACTivity.
2. Make sure your group of students has a copy of the four tree core samples printed on page 47.
3. Imagine that you have tree core samples from:

Sample 1: A living tree that was cored this year in Oakwood Forest.

Sample 2: A log found near the main trail in Oakwood Forest. The log was cored four years after it fell.

Sample 3: A tree that was cored 1 year before it was cut down in Oakwood Forest.

Sample 4: A barn beam from Oakwood Hollow Farm. The beam was cored this year.

4. Cut the tree core samples into four strips.
5. The left side of each tree core sample represents the first year of growth of the tree. The right side represents the bark and, just to its left, the year the tree core sample was pulled. The tree rings are represented by the rectangles making up each strip.
6. Each year of growth is represented by a larger light-colored “ring” and a smaller dark-colored “ring.” The larger light-colored ring represents fast spring growth and the smaller dark-colored ring represents slower summer (and sometimes autumn) growth. Beginning with Samples 1 and 2, match the tree ring patterns and tape the two strips together. Continue this by adding Samples 3 and 4. Sample 1 represents the youngest tree and Sample 4 represents the oldest tree that was sampled.

Now, on the strips,

7. Write the current year in space provided.
8. Counting backwards from the current year, identify the years each tree was cored. To keep track, write any year where you find room on the strip.
9. Identify the year Sample 4 tree began to grow and write it in the space provided.
10. Complete the following chart:

	Age of tree	Year tree was cored	Year growth began
Sample 1			
Sample 2			
Sample 3			
Sample 4			

11. Look for patterns in the rings. Answer the following questions:
 - a. In what years was there low rainfall or other unfavorable growing conditions?
 - b. What 2 years were the most favorable for tree growth? What might have happened in those years to support tree growth?
 - c. What overall patterns do you notice in the year-to-year weather patterns?

Day 2:

12. Make a timeline. Spread out the adding machine tape. Beginning at the left end of the tape, record each year from the earliest year identified on the tree-ring samples through the current year. After the years are recorded on the strip, identify years that were good growing years for the trees in Oakwood, and years that were poor growing years. Think of other events that might have happened during this time period such as birthdays, Presidential elections, important scientific discoveries, environmental events, cultural or social events, and record-setting sports achievements. Fill them in on the timeline. Color the timeline and illustrate it with drawings, photographs, or newspaper clippings.
13. Here are some follow-up questions.
 - Which ring on which trees represents your birth year?
 - What kind of growing season existed that year in Oakwood?
 - What buildings in your area were built during the lifetime of these trees?

Optional:

Before doing this FACTivity, the teacher may simulate tree core samples using straws. The "tree rings" may be drawn on the straws, based on the "core strips." If straws are used in place of the strips, each group of students should be given a set of four straws.



Write current year here: _____

Sample 1: Cored this year

Cut here →



Bark

Sample 2

Cut here →



Year Sample 2
tree was cored: _____

Sample 3

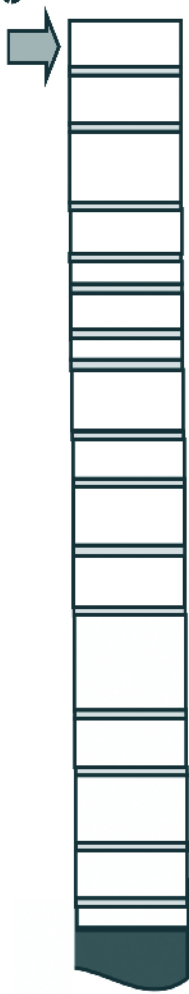
Cut here →



Year Sample 3
tree was cored: _____

Sample 4

Year Sample 4 tree
began to grow: _____



Year Sample 4
tree was cored: _____



Background

Dendrochronology is the study of tree rings to learn about climatic and environmental changes in an area surrounding a tree. Each year's tree-ring width is unique. They are like a barcode. From these rings, scientists can work backward from the present to determine climate conditions where the tree lived. Using this technique, scientists can date trees that have been dead for centuries. The tree rings help tell a story about climate because the width of the tree ring indicates something about the climate. For example, narrower rings indicate poor growing conditions and wider rings indicate more favorable growing conditions.

Reading Tree Rings

Tree rings are formed from the center of the tree outward. The ring closest to the bark is the youngest and final growth ring. The ring closest to the center of the tree is the oldest and first growth ring. Neither the outer layer of bark nor the central pith layer of a sample is counted when determining the age of a sample.

Similar ring patterns are found between trees growing under the same conditions. The most obvious feature of these patterns is varying widths. Widening of a ring indicates good growing conditions, and narrowing indicates poor conditions. Conditions can include climatic factors such as temperature and moisture and factors such as erosion, insects, fire, landslides, etc.

This FACTivity is adapted and reproduced with permission from U.S. Geological Survey (USGS). The activity can be found in USGS's Global Change Teacher Packets. This activity and others can be found at <http://egsc.usgs.gov/isb/pubs/teachers-packets/globalchange/globalhtml/time.html>

Note: For more in-depth background information and a teacher's guide, please visit the Web site listed above. This Web site is linked from the *Natural Inquirer* Web site at <http://www.naturalinquirer.org>.

Extension



Find and map the locations of some of the oldest known trees in your neighborhood. Sketch what you think a core from one of these trees might look like. To help you, research the weather history of your area.

Contact your local forestry service or science museum and obtain some actual cross-sections of trees that have been cut in your area. Use the techniques applied during this activity to "read the tree." If a tree has been cut in your neighborhood recently, look at the tree rings on the stump or ask if you can keep a small piece of the trunk.

Create some simulated core straws of your own for another group to analyze and report about.

What You Can Do:

See the light! Use compact fluorescent light bulbs. These energy-efficient bulbs help fight climate change because they reduce the amount of fossil fuels that utilities burn. You will save 100 pounds of carbon for each incandescent bulb that you replace with a compact fluorescent bulb, over the life of the bulb. (From <http://www.nature.org/initiatives/climatechange/activities/>)



FACtivity Extension

Students may compare and contrast “Moving On Up” (page 20, this edition) with this article in a class discussion.



If you are a PLT-trained educator, you may use Activity #76: “Tree Cookies” and #40: “Then and Now.”

National Science Education Standards

Standards addressed in this article include:

Science as Inquiry:

Abilities To Do Scientific Inquiry,
Understandings About Scientific inquiry

Life Science:

Populations and Ecosystems,
Diversity and Adaptation of Organisms

Science and Technology:

Understandings About Science Science and
Technology

Science in Personal and Social Perspectives:

Science and Technology in Society,
Natural Hazards

History and Nature of Science:

Science as a Human Endeavor,
Nature of Science

Additional Web Resources

USGS Pictures of Inyo Craters

http://lvo.wr.usgs.gov/gallery/InyoCraters_1.html

USGS History of Eruption

<http://lvo.wr.usgs.gov/InyoEruption/index.html>

NOVA Anatomy of a Volcano

http://www.pbs.org/wgbh/nova/volcano/anat_06.html

EPA's Kids Climate Change

<http://www.epa.gov/climatechange/kids/index.html>

Arbor Day's Life of a Tree

<http://www.arborday.org/kids/carly/lifeofatree/>

National Park Service's Webrangers Dendrochronology Activity

<http://www.webrangers.us/activities/dendrochronology/?id=04>

For more information about dendrochronology, see “It’s a Small World” in this edition of the *Natural Inquirer*.

Adapted from Millar, C.I.; King, J.C.; Westfall, R.D.; Alden, H.A.; and Delany, D.L. (2006). Late Holocene forest dynamics, volcanism, and climate change at Whitewing Mountain and San Joaquin Ridge, Mono County, Sierra Nevada, CA, USA. *Quaternary Research*. 66: 273–287. <http://www.treesearch.fs.fed.us/pubs/31776#>.