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Climate Change Edition

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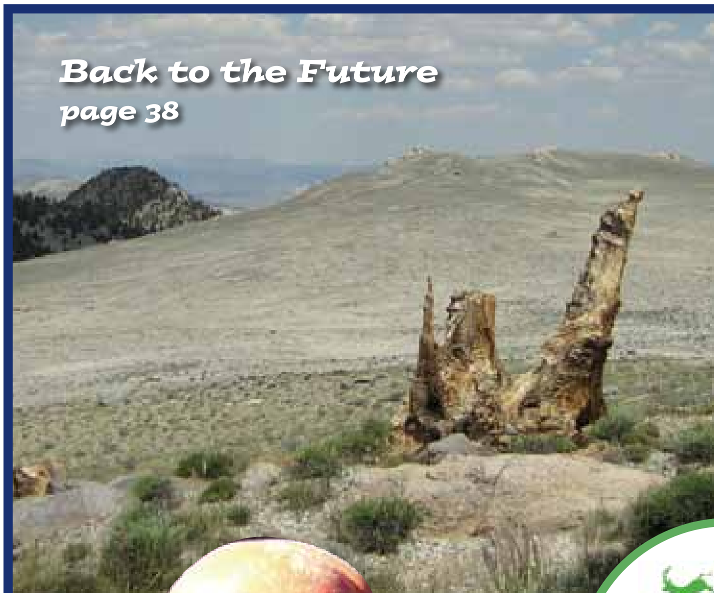

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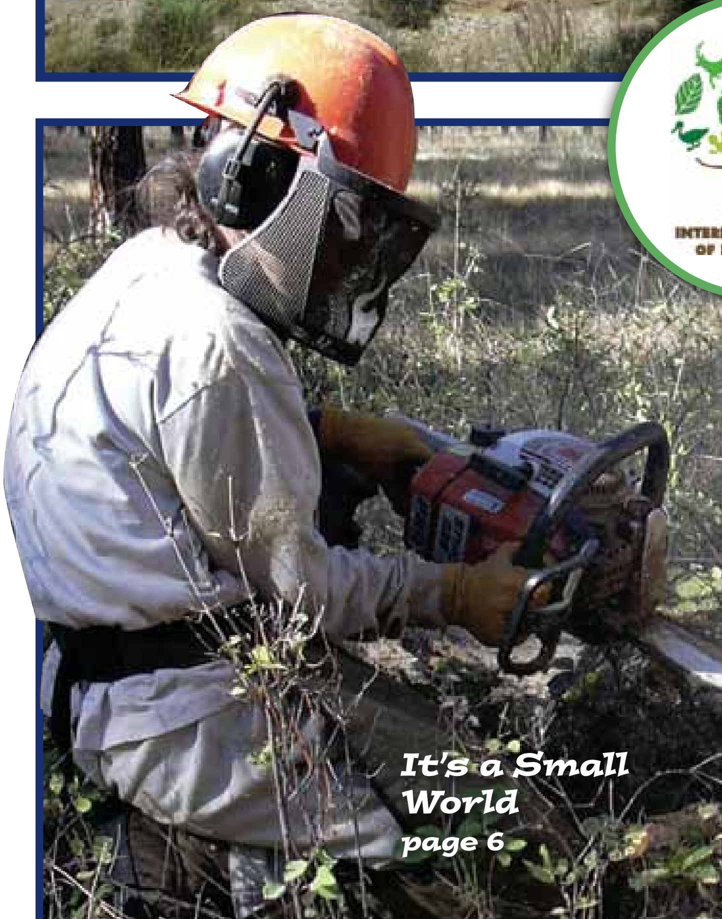
INTERNATIONAL YEAR OF FORESTS • 2011



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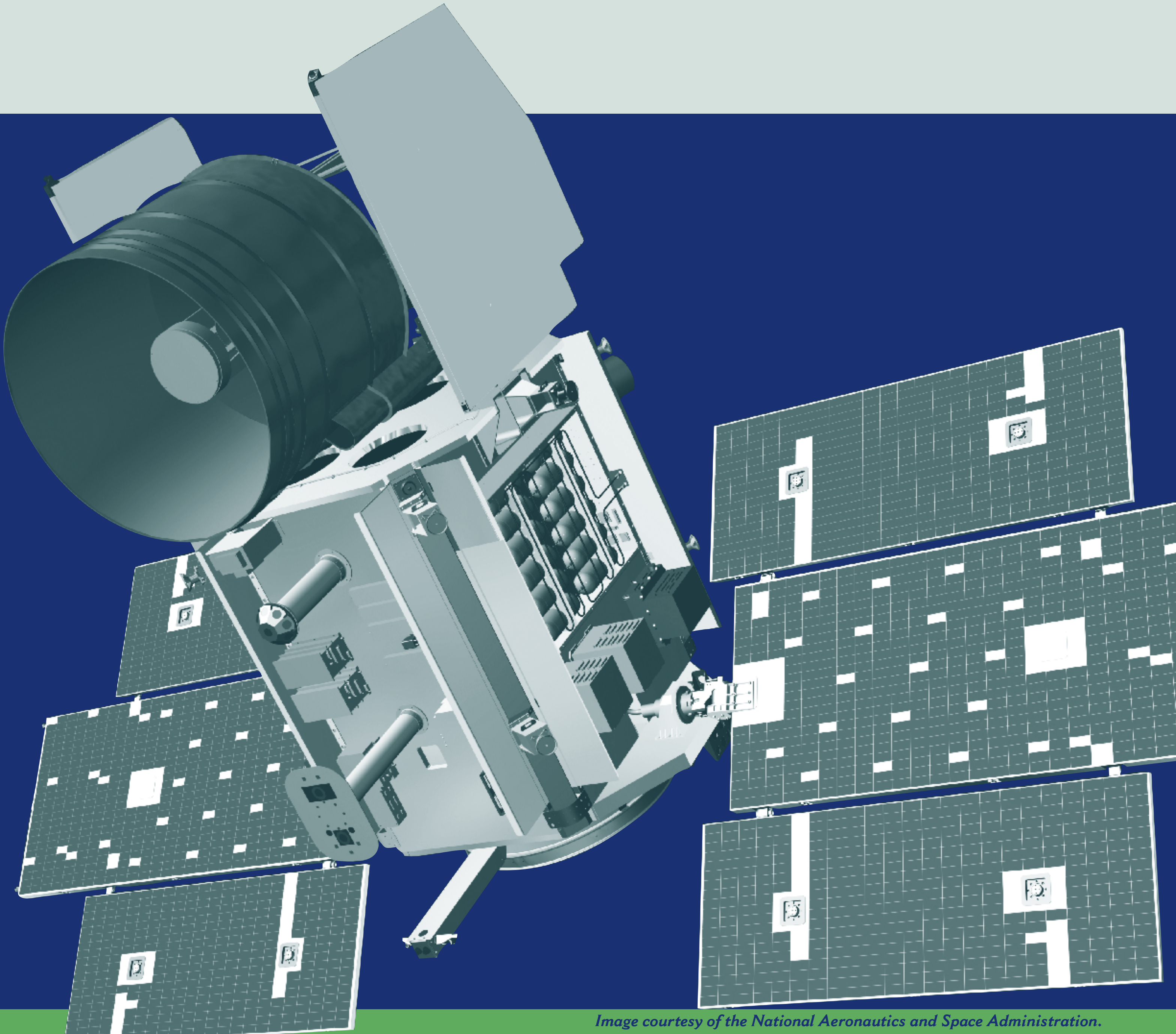


Image courtesy of the National Aeronautics and Space Administration.

Satellites and Changing Tropical Forests

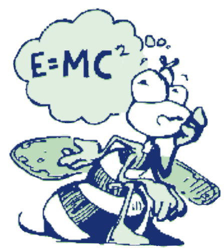
Meet the Scientists

Dr. Eileen Helmer, Ecologist: I have two favorite science experiences. The first was collecting field data on horseback in Costa Rica after a hurricane caused landslides that blocked most of the roads. The second was climbing Nevis Peak on Nevis Island in the Caribbean to find out how high on the mountain the cloud forests occurred.

Dr. Dar Roberts, Geographer: My favorite science experience was climbing a 44-meter tall tower to access tree canopies. I had a $70,000 instrument strapped on me to measure how light changes from the ground to the top of a forest. I have other favorite experiences, of course. I enjoyed flying in a small plane less than 500 meters over the Amazon rain forest, renting a small boat in Brazil where we saw sloths and pink dolphins, and building my own 20-meter tower to access tree canopies, then climbing it.

Thinking About Science

All life on Earth depends on sunlight to survive. Humans, however, also use light for convenience and to meet modern needs. In recent years, the use of light has increased. Light is used not just for human needs and comfort; it is also for science and technology. In the 1950s and 60s, light began to be used to improve electronic communications. Today, **optical** fibers are used for most land-based electronic communications.



Light is also used in satellite technology to communicate between Earth and space. In 2003, a satellite was launched carrying an instrument called the Geoscience Laser Altimeter (al **ti** mə tər) System, or GLAS. GLAS sends 40 beams of light every second to Earth's surface. GLAS provides continuous light beam observations of Earth. When each light beam reaches Earth, it is reflected back to the satellite. By tracking and recording the amount of time each beam of light takes to return to the satellite, GLAS can be used to calculate many properties of Earth's surface.

In this research, the scientists used GLAS to estimate the increase over time in living material, such as branches and leaves, in young and growing tropical rain forests. If this kind of research is successful, scientists will have a more accurate way to understand the world's rain forests.

Thinking About the Environment

When a large amount of carbon dioxide, or CO_2, is **emitted** into the air, it gets trapped in the atmosphere and causes the surface of Earth to warm beyond its normal range. This is happening now, partly because of the large amount of **fossil fuels** being burned for energy.

Carbon, one of the elements that makes up CO_2, is found in every living thing. As trees grow, for example, they absorb carbon from the atmosphere. Old forests also absorb and hold carbon. Because trees keep carbon on Earth, they help to reduce the rate of global warming.

Scientists need to know the location and age of forests to estimate how much carbon they absorb and hold. To do this, scientists must calculate how much living and once-living material, called **biomass**, is contained within a forest area. They also need to calculate how much the biomass of young forests is increasing as they grow. The amount of carbon absorbed and held by forests is related to the amount of biomass contained in the trees and other vegetation that make up the forests. If a forest has more trees, leaves, and other vegetation, it keeps more carbon on Earth.

Introduction

In the past, when scientists wanted to learn about a forest, they had to visit the forest in person. Although this first-hand knowledge of forests provides good information, it also limits the amount of information scientists can collect. It takes a lot of time and money to do research about forests in person, especially if the forests are located far away from home. In addition, the Earth is too large and forests too widespread for scientists to visit all of the forests.

Scientists are working to understand how forests across the world can help to address climate change. To do this, however, they need a more **efficient** way to study large areas of forest land. One way to do this is to use technology to help them do their research. They also need to know that the technology that they use will provide the same quality of information they would get if they studied each forest in person.

The scientists in this study wanted to discover whether information gathered by satellites could be used to identify the age of tropical rain forests and to estimate the increase in the amount of biomass in growing rain forests. They also wanted to know if information gathered by satellites could be used to estimate the amount of biomass held by old rain forests. The scientists wanted to know if the information gathered by satellites was as good as the information they would get if they gathered it in person.

Reflection Section

- What questions were the scientists trying to answer?
- How do you think using information gathered by satellites could be more efficient than collecting information in person?

Methods

The scientists decided to study an area in the Amazon rain forest of Brazil (**figure 1**). They decided to use this area because it contained both young and old tropical rain forests. They also used this area because other scientists had already collected the same information by doing research in person within the forests.

First, the scientists located forests in the Rondônia area. Then, for each forest they located, they estimated the forest's age. They did this to identify which forests were young and which were old. Young forests are those growing on land that had previously been cleared and had been either replanted in trees or allowed to grow back naturally. Any forest under 50 years old was considered a young forest.

The scientists used images from Landsat satellites to locate and estimate the age of each forest (**figure 2**). Landsat satellites contain technology that takes photographs of Earth as

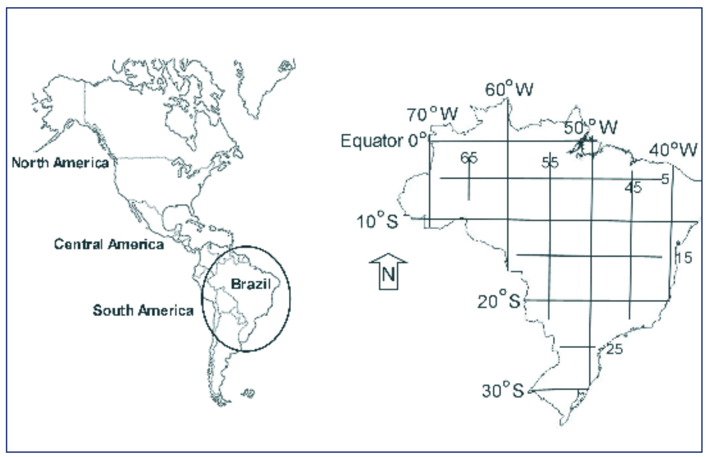


Figure 1. The scientists used **data** collected from forests in the State of Rondônia, Brazil, South America. Locate the State of Rondônia on the map using lines of latitude and longitude. Latitude and longitude are imaginary lines used to locate places on Earth. Lines of latitude are parallel to the Equator, and lines of longitude connect both of Earth's poles. Rondônia is located 10 degrees South, 64 degrees West. Is Rondônia located in the eastern or western part of Brazil?

the satellite orbits the planet (**figure 3**). The scientists used Landsat images of the Rondônia area taken between 1975 and 2003. They used photographs of the same forest areas taken over the 28-year period.

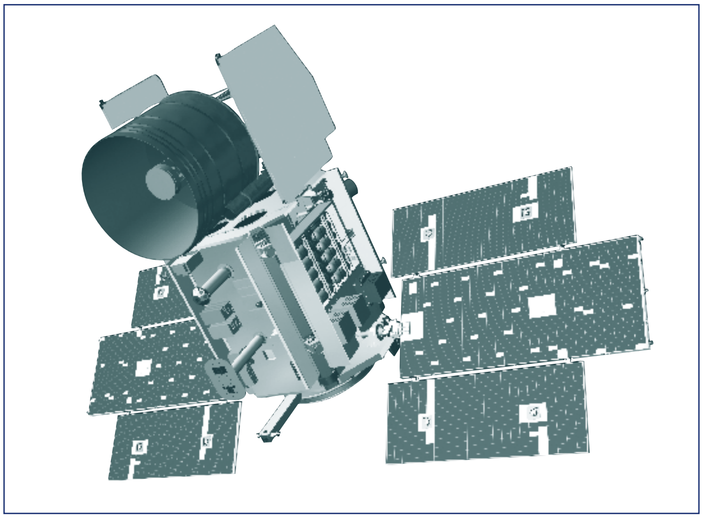


Figure 2. A Landsat satellite. Image courtesy of NASA.

Figure 3. A Landsat image of South America. Locate Brazil in this image. Now find Rondônia. (See figure 1 if you need help.)

The scientists used an **algorithm** to estimate each forest's age, which was based on the images taken over the 28 years. The algorithm's instructions were entered into a computer program. The computer program, following the algorithm's instructions, identified the changing color of the forests over time. As a forest ages, it changes from lighter to darker green. As a result, the computer program was able to use Landsat images, taken over a period of years, to estimate each forest's age.

Then, the scientists estimated the increase in the amount of biomass in each of these growing forests. To make these estimates, the scientists needed to know something about the height of the forest's trees (**figure 4**). They used another satellite to get this information.

Figure 4. The height of trees. Younger trees are usually shorter than older trees. Which tree has more biomass?

The scientists used data from a special satellite called the Ice, Cloud, and Land Elevation Satellite, or ICESat (**figure 5**). This satellite carries special equipment called the Geoscience Laser Altimeter (al **ti** mə tər) System, or GLAS (**figure 6**).

Figure 5. ICESat logo. Image courtesy of the National Aeronautics and Space Administration.

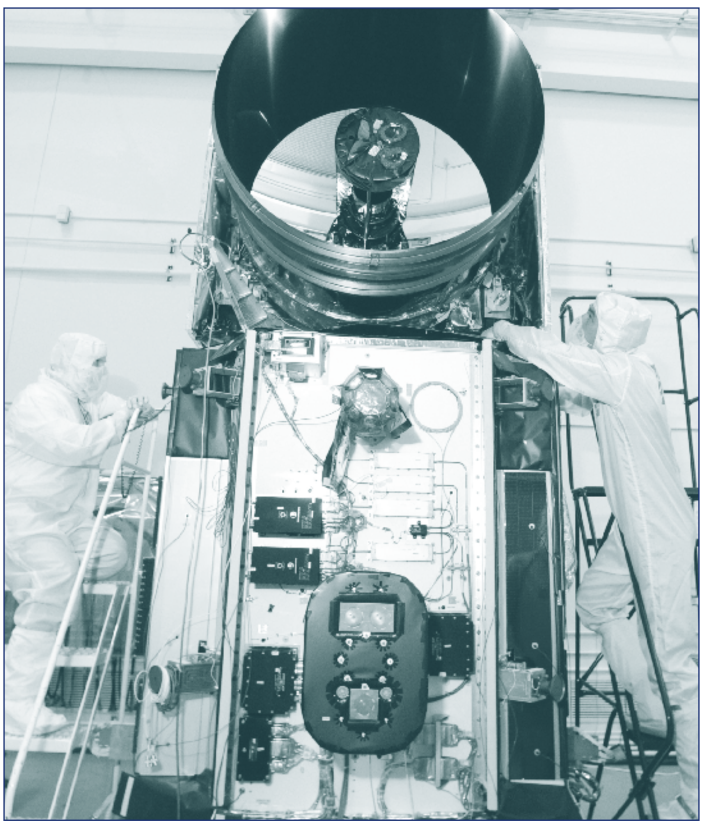


Figure 6. GLAS equipment was placed on the ICESat. Image courtesy of the National Aeronautics and Space Administration.

As ICESat orbits Earth, GLAS sends 40 light beams every second to an area of Earth's surface. These light beams reflect off of Earth's surface and back to the satellite (**figure 7**). GLAS's computer calculates how long it takes each beam of light to return to the satellite. Based on this information, scientists are able to identify the height of forest trees (**figure 8**).

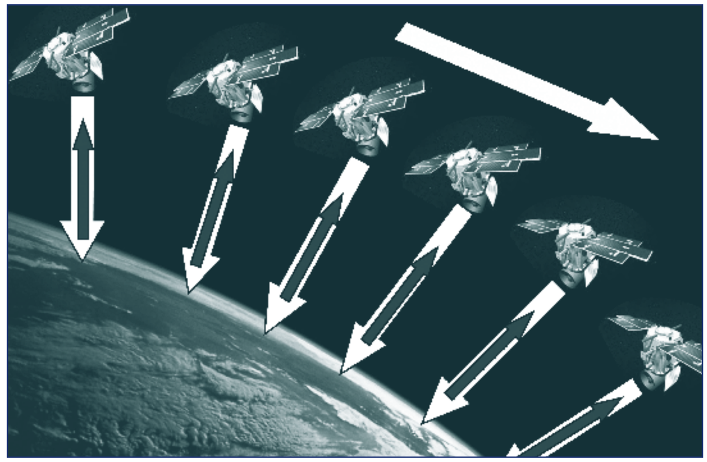


Figure 7. As ICESat orbits Earth, GLAS sends beams of light to Earth's surface. ICESat travels at 16,000 miles per hour and 370 miles above Earth.

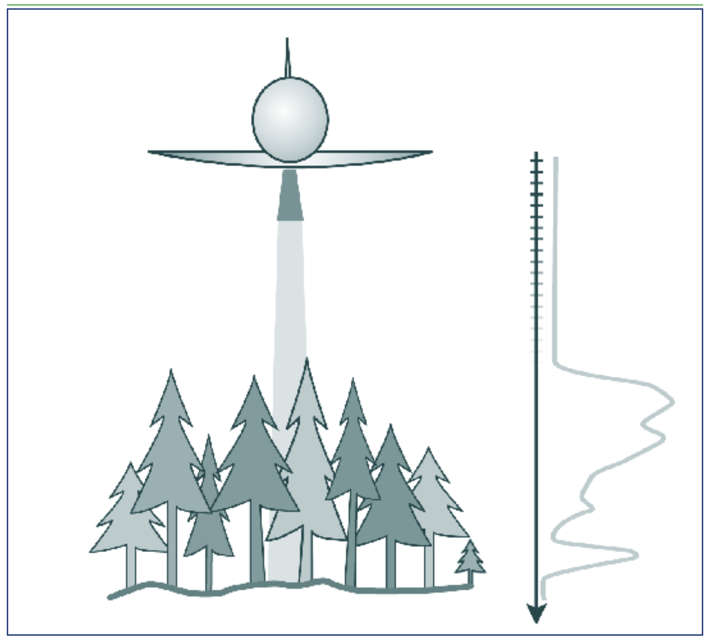


Figure 8. Scientists can calculate the height of trees based on the time it takes a light beam to travel from the ICESat satellite to Earth and back to the satellite. Scientists can do this because they know how fast light travels. The speed of light is 186,282 miles per second.

Remember that the scientists had already calculated the approximate age of each forest studied. Using another computer program and now knowing the forests' age and height, the scientists then estimated how much the biomass was increasing in young forests as they grew over time. They also estimated how much biomass was contained in old forests. The scientists then compared this information with the same information that had been collected by scientists working in person within the Rondônian forests.

Reflection Section

- Why did the scientists study an area that had already been studied by other scientists working within the forest?
- Do you think the information collected by the satellites is exact or an estimate? Why or why not?

Findings

For estimates of the forests' age, the scientists found that the algorithm's evaluation of Landsat photographs was 88 percent accurate. The algorithm had difficulty distinguishing some forms of agriculture and recently cleared forest land from young forests. Although there were some errors, the 88-percent accuracy rate was considered acceptable.

The satellite and computer estimates of the increasing amount of biomass in young forests was similar to the estimates made by scientists working within the forests. For some areas of the old forests, the satellite and computer estimates of the amount of biomass were smaller than what scientists had measured within the forests themselves. The scientists who did this study believe, however, that this difference can be explained by where the actual forest measurements were taken. When scientists were measuring biomass in person, they measured forests far from human disturbances that received more rainfall. This meant that the trees they measured were larger than trees closer to human disturbances, and therefore had more biomass.

The scientists then compared their estimates of biomass over the entire Rondônia area, including young and old forests, with estimates made by those studying the forests in person. They found that computer estimates made from the satellite data were similar to the overall estimates made within the forests of Rondônia.

Reflection Section

- Think about your own achievement of accuracy on a test. Is an 88-percent accuracy rate acceptable? Consider that the satellites collect a lot more data from all across the planet than scientists could collect by visiting forests in person. Do you think an accuracy rate of 88 percent is acceptable? Why or why not?
- Based on the results of this research, would you say that data collected by satellites may one day be used to help estimate the amount of carbon being held by the world's forests? Why or why not?

Discussion

The scientists doing this research studied tropical rain forests in the relatively flat areas of Western Brazil. They discovered that data gathered by satellites led to the same information as that gathered by scientists working within those same forests. They concluded that satellites can be used to study tropical rain forests in relatively flat areas. They do not know, however, if the method that they used to **interpret** the satellite images can be used to accurately collect the same type of information from drier, less forested, or more mountainous areas.

Tropical rain forests provide some of the most diverse habitats for plants and animals worldwide. They also contain a lot of biomass, which means that they keep a lot of carbon on Earth. It is important to understand as much as possible about Earth's rain forests. With the help of satellites and computer technology, scientists can study rain forests all around the world.

Reflection Section

- The scientists did not claim that their methods could be used to study all forests. Why do you think they did not make this claim?
- From a climate change perspective, why is it important to understand how fast the amount of biomass increases in young tropical rain forests?

Glossary

algorithm (**al** gə **ri** thəm): A step-by-step procedure for solving a problem that often involves a computer program. Usually, an operation is repeated over and over until the problem is solved.

biomass (**bī** ō mas): All the living and recently living things in a particular area.

data (**dā** tə): Factual information used as a basis for reasoning, discussion, or calculation.

efficient (i **fi** shənt): Bringing about the result wanted with the least amount of time, waste, or materials.

emit (ē **mit**): To throw out or eject.

fossil fuel (**fä** səl fyü(-ə)l): Fuel, such as coal, petroleum, or natural gas, formed from the fossilized remains of plants and animals.

habitat (**ha** bə tat): Environment where a plant or animal naturally grows and lives.

interpret (in **tər** prət): To explain or tell the meaning of.

optical (**äp** ti kəl): Relating to vision or to light.

pigment (**pig** mənt): A coloring matter in animals and plants. A substance that gives color to a material.

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

FACTivity

Time Needed

35 minutes

Materials needed per student group:

- One sheet of blank paper, 8.5- X 11-inch.
- Crayons or colored markers (brown, black, red, orange, yellow, and gray).
- Stapler.
- Scissors.

The question you will answer in this FACTivity is: How can a series of Landsat images help scientists estimate a forest's age over time?

Process:

Cut the sheet of paper into 8 equal pieces. Staple one side to make a small book. Number each sheet of paper in the lower right hand corner. The first page will be 1, the next page will be number 10. Then number each page in increments of 10 (20, 30, 40, and so on, until you have numbered all of the pages). Draw a large empty circle on each page.

Each of these numbers represents a person's age, from age 1 to 70. The circle represents the top of a person's head, as if you were looking down at them from above.

Think for a moment of a person's hair color. Hair gradually loses its **pigment** and becomes white (or gray) as a person ages.

Now color the circle (the top of a person's head) for each age. You decide when your person starts to get some gray hairs. Over time, your person becomes completely gray. Make this as realistic as possible, based on when you think most people's hair starts to become gray, and when it becomes completely gray.

As a class, complete the chart below. (You may put this chart on the whiteboard or blackboard.)

According to your class, at which age are people most likely to see their first gray hairs? At which age are they most likely to become about half gray? At which age are people most likely to become completely gray? If you had a stack of photographs of the tops of people's heads, how could you use this activity's results to help you assign an age to each head?

Compare this activity with the use of Landsat images in the study you just read. How are they similar? How are they different? Answer the question posed at the beginning of the FACTivity. What in this FACTivity is similar to the actions of scientists working within forests on the ground? What makes them similar?

Age of person	1	10	20	30	40	50	60	70
Number of heads showing their first gray hairs								
Number of half-gray heads								
Number of completely gray heads								

What You Can Do:

For every plastic and paper bag created, some CO_2 was emitted into the atmosphere. One easy way you can help to reduce the amount of CO_2 going into the atmosphere is to carry reusable cloth bags with you when you go to a store. If you do not have a reusable bag with you and you only need to buy a few items, you don't have to use a bag at all! Another easy way to reduce energy use, and, therefore, carbon emissions is to take the stairs instead of the elevator. What is one other thing you can easily do to reduce the amount of energy you use?

National Science Education Standards

Standards addressed in this article include:

Science as Inquiry:
Abilities Necessary To Do Scientific Inquiry, Understandings about Scientific Inquiry

Earth Science
Structure of Earth System

Science and Technology
Understandings about Science and Technology

Science in Personal and Social Perspectives
Science and Technology in Society

History and Nature of Science
Science as a Human Endeavor, Nature of Science

Additional Web Resource

Video Clip of Deforestation in Rondônia, Brazil
http://www.youtube.com/watch?v=CwPq1CBTAx0

If you are a PLT-trained educator, you may use Activity #86: "Our Changing World."

For more information about carbon and forests, see the *Natural Inquirer* "World's Forests" edition, Inquiry 3: "How Much Carbon Is Being Held By the World's Forests?"

"The GLAS is Half Full" was taken from a well-known question: "Is the glass half empty or half full?" It is thought that people who see the positive side of things will say that a half-filled glass is half full. People who see the negative side of things will say that a half-filled glass is half empty. In reality, you cannot label a person as positive or negative from his or her answer to just one question.

Adapted from Helmer, E.H.; Lefsky, M.A.; and Roberts, D.A. 2009. Biomass accumulation rates of Amazonian secondary forest and biomass of old-growth forests from Landsat time series and the Geoscience Laser Altimeter System. *Journal of Applied Remote Sensing*. Vol. 3, 033505. http://www.tropicalforestry.net/Members/ehelmer/2009-mapping-amazonian-forest-type-age-and-secondary-forest-biomass-accumlation-rates-from-landsat-time-series-and-glas/.