TREE RINGS: LIVING RECORDS OF CLIMATE

DESCRIPTION

In this lesson, students analyze tree rings to draw conclusions about precipitation patterns in the past. They also compare their own analysis with actual precipitation data (from NASA) to determine similarities and differences in precipitation patterns gathered over a given time period. These activities provide context for understanding how scientists can examine natural materials such as trees to learn about climate conditions in the past, before widespread measurement of temperature and rainfall.

A tree adds a new layer of wood every year called a tree ring. Scientists examine these rings to learn about past climate conditions. **Image source**: U.S. EPA, *A Student's Guide to Global Climate Change* website

BACKGROUND

Scientists use a variety of methods to collect data about the Earth's weather and climate. Weather stations, balloons, buoys, and satellites help researchers gather information about Earth's current weather conditions. Scientists learn about Earth's *climate* in the past by studying historical records as well as clues that remain in rocks, ice, trees, corals, and fossils. These clues not only tell us how the Earth's climate has changed, but they can also help scientists understand why these changes came about. Knowing how the Earth's climate has changed over time can help scientists determine whether the changes that are occurring now are part of the Earth's natural pattern or caused by human activities.

One way scientists are learning about past climate is by studying tree rings. This field of research is known as dendrochronology. Scientists can use tree rings to measure the age of a tree and learn more about the local climatic conditions the tree experienced during its lifetime.

In temperate areas, like most of the United States, trees only grow during the part of the year called the growing season. The length of this growing season depends on the climate in a particular location. During each growing season, the trunk of the tree grows thicker, producing a layer of new wood called a tree ring. It's possible to see the boundary between one ring and the next because of differences in the color of the wood. Early in the growing season, trees grow relatively quickly and produce less-dense, paler wood. Near the end of the growing season, they produce more dense, darker wood.

Trees generally grow more during wetter growing seasons with favorable temperatures, forming wider rings. Narrow rings may be caused by stressful periods such as droughts. Although tree rings only record conditions during the growing season (in other words, not during the winter in most of the

TIME: 60 minutes

LEARNING OBJECTIVES:

Students will:

- Learn how scientists gather information about the Earth's past and present weather and climate.
- Understand how past climate patterns can help us understand the changes we are experiencing today.
- Learn that tree ring patterns can be used to study weather and climate in the past.
- Learn how to locate, access, and compare different kinds of data.
- Use these data to help understand what the climate was like at a particular location in the past.

NATIONAL SCIENCE STANDARDS:

- Content Standard A: Science as inquiry
- Content Standard C: Life science
- Content Standard D: Earth and space science

ADAPTED FROM:

National Aeronautics and Space Administration (NASA): https://mynasadata.larc.nasa.gov/preview_lesson_nostds.php?&passid=95.

United States Environmental Protection Agency

United States), droughts can build up over many months or even many years, so a lack of rain or snow in the winter can lead to poor growing conditions in the spring.

Tree ring patterns provide information about precipitation and other conditions during the time the tree was alive. Scientists can learn even more about precipitation and temperature patterns by studying certain chemicals in the wood. Modern trees can be interesting to compare with local measurements (for example, temperature and precipitation measurements from the nearest weather station). Very old trees can be even more interesting because they offer clues about what the climate was like before measurements were recorded. In most places, daily weather records have only been kept for the last 100 to 150 years. Thus, to learn about the climate hundreds to thousands of years ago, scientists need to use other sources such as trees, corals, and ice cores (layers of ice drilled out of a glacier or ice sheet—mostly in Greenland and Antarctica).

By studying tree rings and other clues in our environment, scientists have learned that there have been times when most of the planet was covered in ice, and there have also been much warmer periods. In general, climate changes prior to the start of the Industrial Revolution in the 1700s can be explained by natural causes, such as changes in solar energy and volcanic eruptions. Recent climate changes, however, cannot be explained by natural causes alone. Instead, human activities are very likely responsible. Tree rings alone cannot tell us whether human activities are responsible, but they do help by revealing patterns that scientists can investigate further.

MATERIALS

- Drawings of simulated tree rings, which are included in this lesson or accessible at the following locations:
  - Jackson, Mississippi: https://mynasadata.larc.nasa.gov/docs/Jackson_Tree_Ring.pdf
  - Columbia, Missouri: https://mynasadata.larc.nasa.gov/docs/Columbia_Tree_Ring.pdf
  - Boston, Massachusetts: https://mynasadata.larc.nasa.gov/docs/Boston_Tree_Ring.pdf
  - Seattle, Washington: https://mynasadata.larc.nasa.gov/docs/Seattle_Tree_Ring.pdf
- A copy of the “Tree Ring Analysis Worksheet” for each student
- Computer with Internet access

VOCABULARY

Climate:
The average weather conditions in a particular location or region at a particular time of the year. Climate is usually measured over a period of 30 years or more.

Climate change:
A significant change in the Earth's climate. The Earth is currently getting warmer because people are adding heat-trapping greenhouse gases to the atmosphere. The term "global warming" refers to warmer temperatures, while "climate change" refers to the broader set of changes that go along with warmer temperatures, including changes in weather patterns, the oceans, ice and snow, and ecosystems around the world.

Precipitation:
Rain, hail, mist, sleet, snow, or any other moisture that falls to the Earth.

Tree rings:
Trees add a new layer of wood every year. When you cut across the trunk, each layer looks like a ring. Each ring represents one year. Rings generally grow wider in warm, wet years and thinner in cold, dry years. Tree ring records can go back hundreds to thousands of years, depending on when the tree lived and how old it was. Scientists examine tree rings to learn about past climate conditions.

Weather:
The condition of the atmosphere at a particular place and time. Some familiar characteristics of the weather include wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. Weather can change from hour to hour, day to day, and season to season.

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INSTRUCTIONS

Part 1: Discussion: Climate Clues

1. Remind students about the differences between weather and climate.
   [Answer: Weather is a specific event or condition that happens over a period of hours or days. For example, a thunderstorm, a snowstorm, and today's temperature all describe the weather. Climate refers to the average weather conditions in a place over many years (usually at least 30 years). For example, the climate in Minneapolis is cold and snowy in the winter, while Miami's climate is hot and humid.]

2. Instruct students to go to the "Think Like a Scientist" page on EPA's *A Student's Guide to Global Climate Change* website (http://www.epa.gov/climatechange/students/scientists/index.html). Ask them to explore how scientists gather information about the Earth's current weather and past climate by selecting "learn more" in "A Scientist's Toolbox" section on the right side of the screen.

3. Ask students why gathering information about past climate is important.
   [Answer: Knowing what the planet's climate was like in the past—and the kinds of changes that have occurred in the Earth's climate over time—can help us determine whether changes that are occurring now are part of the Earth's natural pattern or caused by human activities. We can also look at these patterns to help us anticipate future changes that could occur.]

4. Discuss tree rings and how they provide information about weather and climate, using an example for illustration. You can use one of the drawings from the end of this lesson plan, or you can use an actual tree stump if you have a good example available nearby. Explain that the light-colored rings are the wood that grew in spring and early summer, while the dark rings indicate growth in late summer and fall. Thus, a light ring and dark ring together represent one year of growth. Tree ring records can go back hundreds to thousands of years, depending on when the tree lived and how old it was. Because tree rings are sensitive to local climate conditions such as precipitation and temperature, they give scientists some information about an area's past local climate or "micro-climate." For example, rings generally grow wider in warm, wet years and thinner in cold, dry years. When faced with extremely stressful or unfavorable conditions, a tree might hardly grow at all.

Part 2: Analyzing Tree Rings

1. Explain to students that they will be examining two sets of data to learn about precipitation patterns during a given time period: 1) tree rings and 2) data from NASA.

2. Hand out the simulated tree ring drawings. Pass out a "Tree Ring Analysis" worksheet to each student.

3. Have students observe the rings in each tree ring slice and examine the width of the rings.

4. Remind students that the width of the rings indicates the quality of the growing conditions during that season. If all tree rings have consistent thickness, it is possible that the local conditions were also consistent through the life span of the tree. Narrower rings might indicate stressful conditions. Ask students to if they can think of a stressful condition that affects plant growth.
   [Most obvious answer: Drought. In the United States, droughts have caused massive food shortages and costs billions in crop damage in recent years.]

5. Have each student (or group of students) choose one of the four tree samples and fill out Part I of the "Tree Ring Analysis Worksheet" for that tree. Have students determine the age of each tree. Have them begin counting only the dark rings from the center of the tree, working toward one edge. The outermost green (dark) layer represents the late season wood from the most recent growing season, and the light layer just inside corresponds to the

spring growth from that season. Count each dark ring only once. This corresponds to the number of years the tree was alive. To determine the year in which the tree was planted, subtract the number of dark rings (age of tree) from the year in which the tree was cut.

Part 3: Computer Activity: Comparing Tree Ring Data With Precipitation Data

1. Have the students access the MY NASA DATA website at: https://mynasadata.larc.nasa.gov/las/getUI.do.

2. If students are not automatically prompted with parameter choices, have them select "Choose Dataset" in the upper left-hand corner of the screen. Then select "Atmosphere," then "Precipitation," and then "Monthly Precipitation (GPCP)."

3. From the menu on the left side of the screen, have students select "Time Series" from the "LINE PLOTS" options. Then have them click on the box next to "Update Plot" found at the top of the screen above the navigation map.

4. Have students change their time range to suit their tree sample. Note that the records in the database begin in 1979.

5. Have students use the "Zoom" button to zoom in on North America, or have them enter the latitude and longitude for their selected location. To find their location, students can also adjust the position of the cursor until the coordinates match the area where the tree grew. Students can enter the coordinates directly in the compass box shown.

6. Have students fill out Part II of the "Tree Ring Analysis Worksheet." For the calculation portions of the exercise, have the students click "Save As." A dialogue box will appear titled "Download Data." Change the format to "ASCII" and click "OK." A new window should appear with all the data. Students can compute the average daily precipitation for an entire year by adding the monthly data points and dividing by the number of points (i.e., 12).

7. As a class, discuss the results. Did the NASA data confirm your tree ring analysis? If not, what might account for the differences between the two measurements?
   [Answer: Results will vary based on each tree ring cross-section. Differences between the two measurements could be due to other factors that influence the growth of the trees, such as temperature, sunlight, and wind. Additional factors could include local-scale "microclimate" conditions and disturbances such as competition from neighboring trees, run-off fertilizer from a nearby farm, or an insect outbreak that may affect the growth of the tree.]

8. Can you suggest where one might find data to examine other factors that could influence tree growth?
   [Answer: One can also look at other climate factors that affect tree growth, such as temperature and wind. National or local weather stations can provide these data.]

9. Tree ring patterns can help shed light on local climate conditions during the growing season. What are the challenges involved in trying to determine *global* climate from tree rings?
   [Answer: Not every place has trees. The oceans obviously do not have trees, and neither do deserts, polar regions, or high mountains. Trees in the tropics grow year-round, so they do not have visible rings. And temperate trees can't tell us much about winter conditions. Still, if trees in many different parts of the world show similar patterns, it can provide a good indication of a global change.]

EXTENSION

After scientists get data from primary sources (such as tree rings) or secondary sources (such as MY NASA DATA), they analyze the data and communicate their results through graphs or charts. In this extension, students will use Microsoft Excel 2007 or similar software to create a chart of the precipitation data they obtained from MY NASA DATA.

After students have completed step 5 of the lesson plan, guide them through the following steps, which include importing information from MY NASA DATA into Microsoft Excel and creating a chart.

1. "Save as" ASCII or text file, as explained in Part 3, Step 6, above.
2. Click the link and save the file to the Desktop or a folder.
3. Close out of the MY NASA DATA site and open Microsoft Excel.
4. Under the "Data" menu, scroll down and select "Get External Data."
5. Select your saved text file (ASCII) and import into Excel.
6. Delete the first few rows with information about the data such as "Variables" and "Latitude." You should only have two columns, containing the date and the amount of precipitation. At the top of each column, make sure you label "Date" and "Precipitation (mm)."
7. Create a chart by exploring the different options in the "Chart" tab under the "Insert" menu.
8. Save or print your table and chart.

Have students compare their charts with their tree ring analysis results.

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TREE RING ANALYSIS WORKSHEET

NAME: ________________________________ **DATE:** ____________________

Part 1: Tree Ring Analysis

1. Tree ring location: _______________
2. Tree ring location: _______________
3. Number of dark rings (age of tree): ___________
4. Year tree was planted (subtract age from year harvested): ___________

Select one ring that seems to reflect below-average precipitation for the growing season, based on its width. Determine the corresponding year by counting the rings, starting with the youngest ring, which is closest to the bark. List the year you have selected: _______

Part 2: Computer Analysis

(from MY NASA DATA website: https://mynasadata.larc.nasa.gov/las/getUI.do)

1. Navigate to the website above. Your browser should automatically open a box titled “Datasets.” If not, select “Choose Dataset” in the upper left-hand corner of the screen to open that box. Then select “Atmosphere,” then “Precipitation,” and then “Monthly Precipitation (GPCP).”

2. From the menu on the left side of the screen, select “Time Series” from the LINE PLOTS options. Then click the box next to “Update Plot” at the top of the screen above the map.

3. Change the time range to suit your tree sample. Note that the records in the database begin in 1979. Use the “Zoom In” button to zoom in on North America, then onto your tree’s city, or enter the latitude and longitude for the selected location in the compass box.

4. Click “Save As.” A “Download Data” box will appear. Change the format to “ASCII” and click “OK.” A new window should appear with all the data. You can calculate the average daily precipitation for an entire year by adding the monthly data points and dividing by the number of months (12).

5. Find the average precipitation (in millimeters per day) for the year you have selected from MY NASA DATA, and enter the information below.

   Year: _______ Precipitation: _______

6. Compare your result with the average precipitation rates listed on your sample handout. Was the year you selected actually drier than normal, at least during the growing season?

   Yes: _______ No: _______ (explain)

7. What other factors might influence tree growth, besides total precipitation? Which factors do you think are most important? Where could you find data to confirm this?

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TREE RING ANALYSIS WORKSHEET—ANSWER KEY

For Tree Ring Sample From Boston, Massachusetts (Harvested In Fall 2000)

NAME: ______________________________ **DATE:** ______________

Part 1: Tree Ring Analysis

1. Tree ring location: _Boston, MA_
2. Tree ring location: _Boston, MA_
3. Number of dark rings (age of tree): ____19______
4. Year tree was planted (subtract age from year harvested): ___1981__

Select one ring that seems to reflect below-average precipitation for the growing season, based on its width. Determine the corresponding year by counting the rings, starting with the youngest ring, which is closest to the bark. List the year you have selected: __1994___

Part 2: Computer Analysis

(from MY NASA DATA website: https://mynasadata.larc.nasa.gov/las/getUI.do)

1. Navigate to the website above. Your browser should automatically open a box titled "Datasets." If not, select "Choose Dataset" in the upper left-hand corner of the screen to open that box. Then select "Atmosphere," then "Precipitation," and then "Monthly Precipitation (GPCP)."

2. From the menu on the left side of the screen, select "Time Series" from the LINE PLOTS options. Then click the box next to "Update Plot" at the top of the screen above the map.

3. Change the time range to suit your tree sample. Note that the records in the database begin in 1979. Use the "Zoom In" button to zoom in on North America, then onto your tree's city, or enter the latitude and longitude for the selected location in the compass box.

4. Click "Save As." A "Download Data" box will appear. Change the format to "ASCII" and click "OK." A new window should appear with all the data. You can calculate the average daily precipitation for an entire year by adding the monthly data points and dividing by the number of months (12).

5. Find the average precipitation (in millimeters per day) for the year you have selected from MY NASA DATA, and enter the information below.

   Year: _1994___ Precipitation: 3.70 mm/day

6. Compare your result with the average precipitation rates listed on your sample handout. Was the year you selected actually drier than normal, at least during the growing season?

   Yes: _YES_____ No: _______ (explain)

7. What other factors might influence tree growth, besides total precipitation? Which factors do you think are most important? Where could you find data to confirm this?
   [Answer: Other environmental factors such as temperature and access to sunlight can influence tree growth, and thus affect ring width. Stress from fire, insects, or disease could reduce growth in certain years. To examine these other factors, we can get temperature and wind data from the national or local weather bureaus, and we can get land use and forest health information from state or national forestry organizations. We can gather additional data by sampling more than one tree per site. Looking at the previous year is helpful because severe drought conditions can persist over many months, and a relative lack of precipitation in one year can reduce the amount of moisture in the soil in subsequent months or years.]

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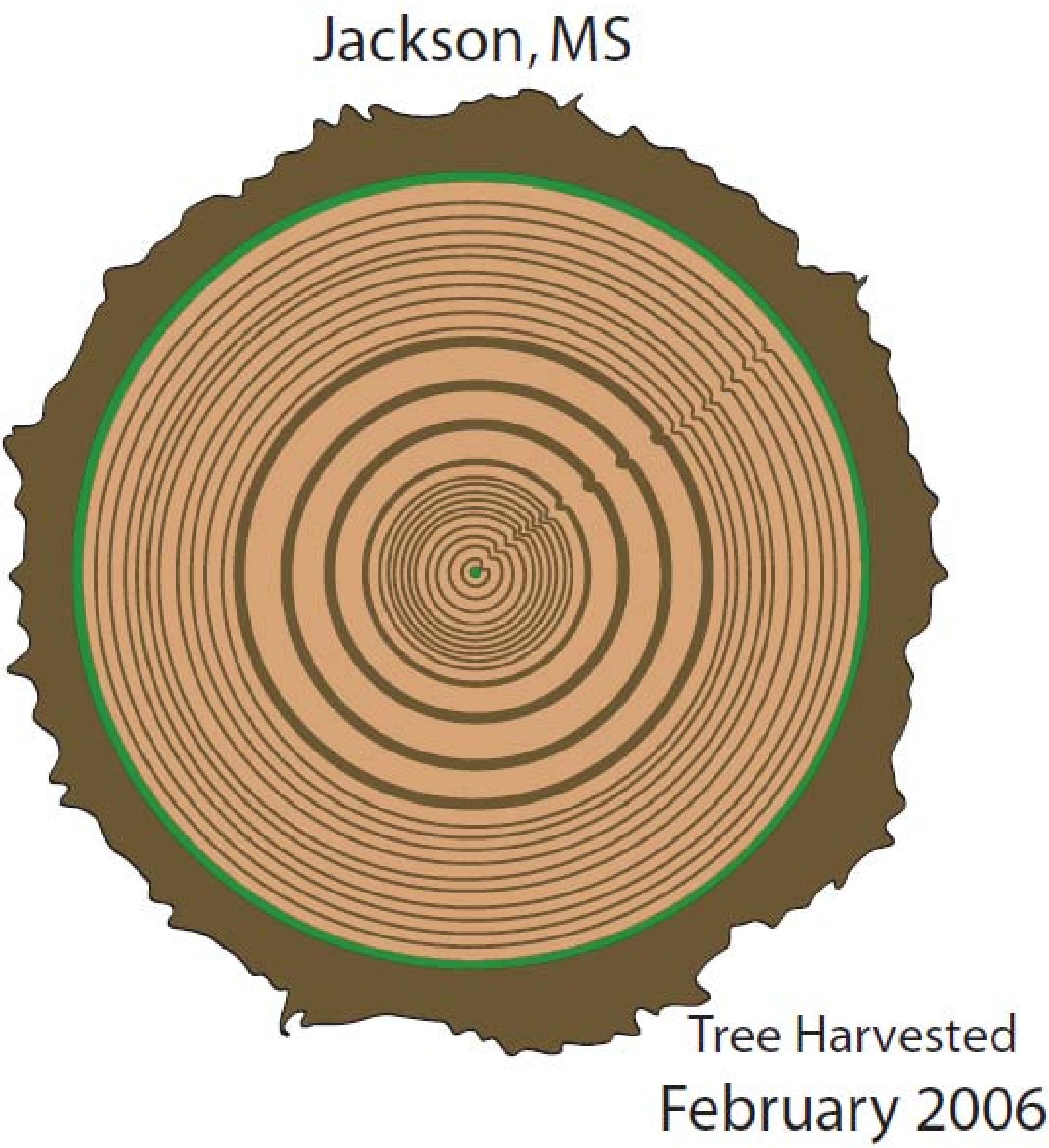
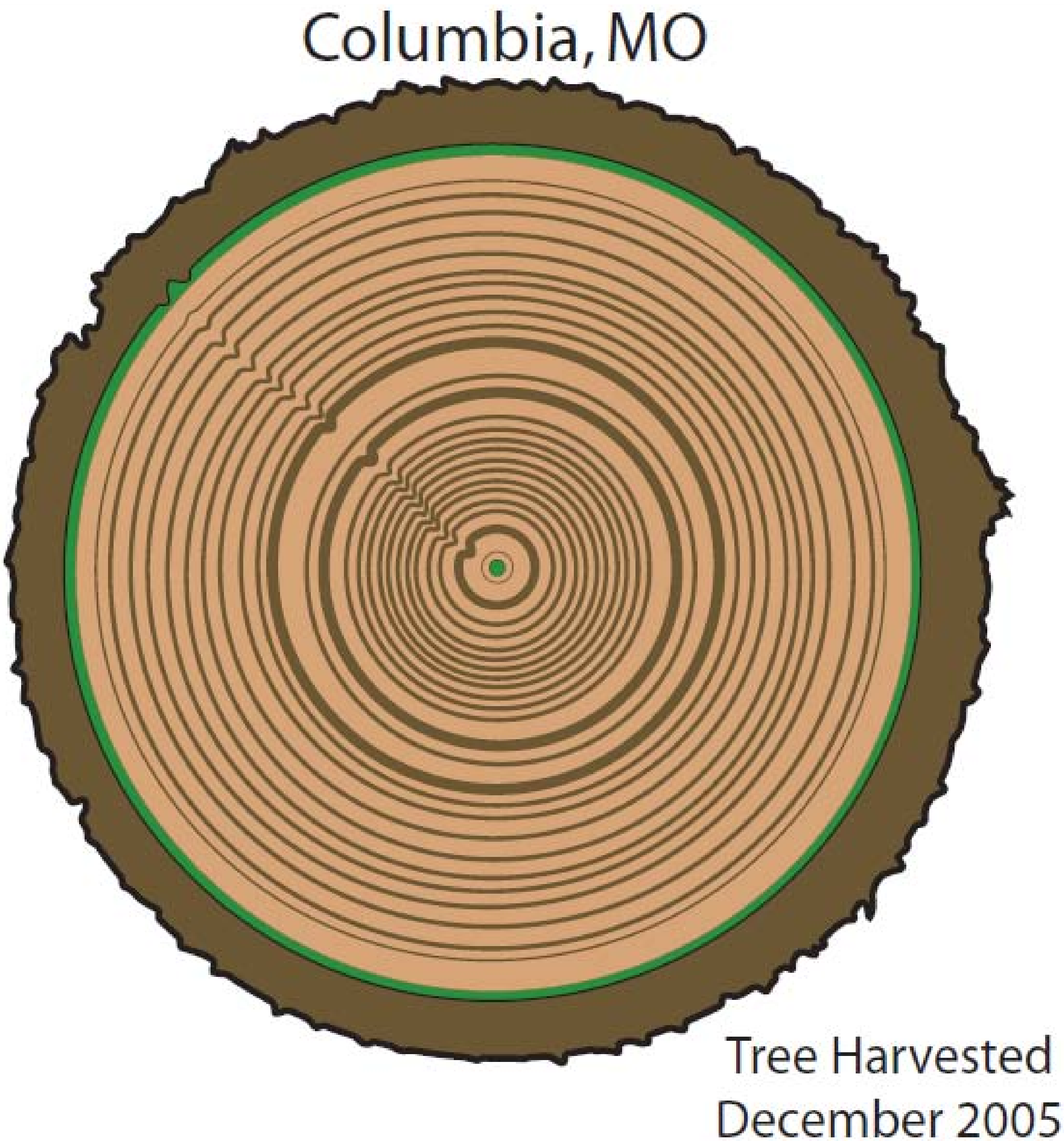


Jackson, Misissippi

https://mynasadata.larc.nasa.gov/docs/Jackson_Tree_Ring.pdf

Approximate coordinates: 32°N, 90°W

Average daily precipitation in Jackson, MS, 1979–2007: 3.73 mm/day

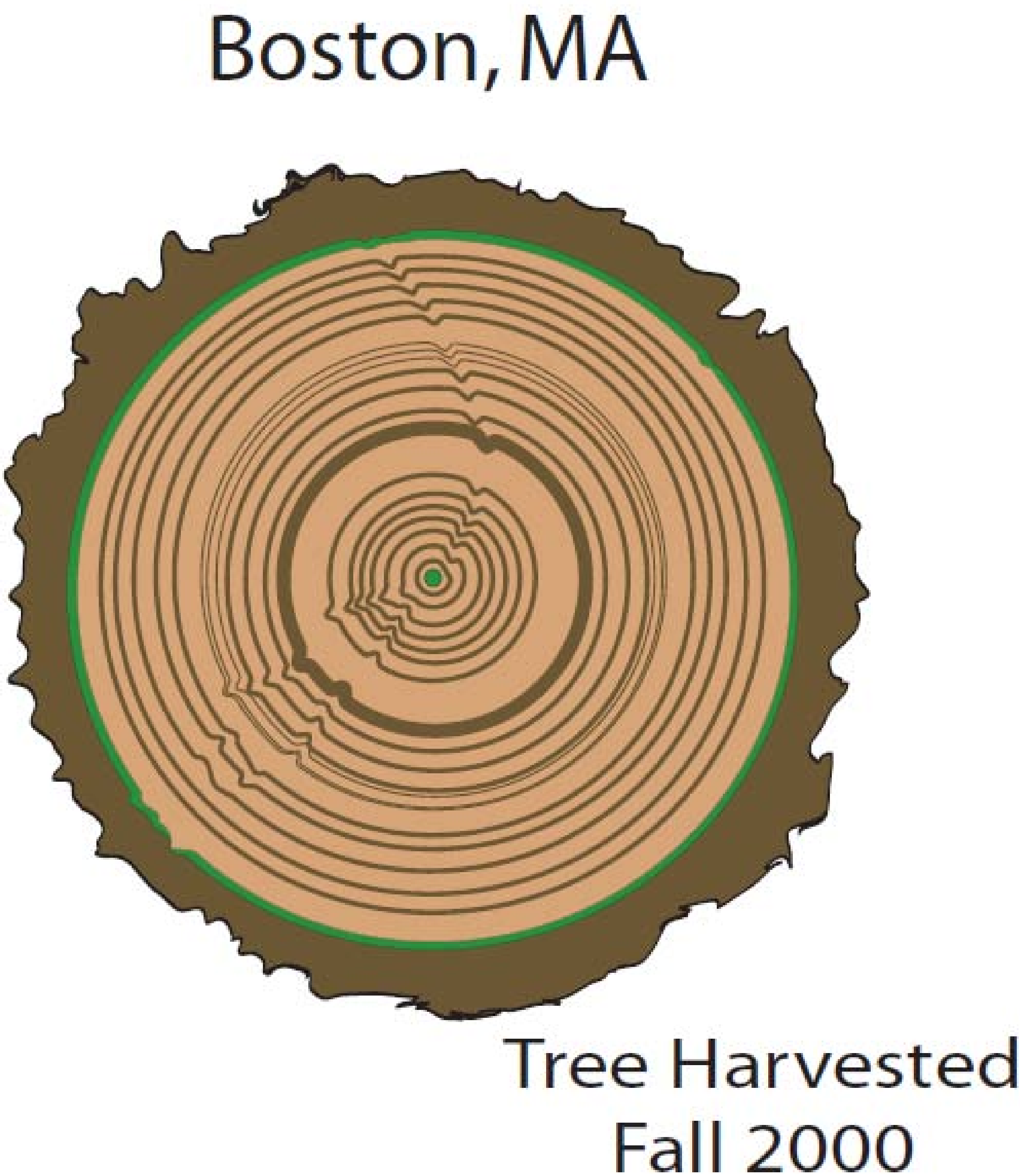


Columbia, Missouri

https://mynasadata.larc.nasa.gov/docs/Columbia_Tree_Ring.pdf

Approximate coordinates: 39°N, 92°W

Average daily precipitation in Columbia, MO, 1979–2007: 3.0 mm/day



Boston, Massachusetts

https://mynasadata.larc.nasa.gov/docs/Boston_Tree_Ring.pdf

Approximate coordinates: 42°N, 71°W

Average daily precipitation in Boston, MA, 1979–2007: 3.76 mm/day

Seattle, Washington

https://mynasadata.larc.nasa.gov/docs/Seattle_Tree_Ring.pdf

Approximate coordinates: 47°N, 122°W

Average daily precipitation in Seattle, WA, 1979–2007: 3.5 mm/day