The Story in the Trees Lesson

NC State Curriculum Topics:
This lesson is geared toward middle and high school students; however, it can be modified for elementary level students. It would be appropriate for science topics such as weather, climate, climate change, plant biology, ecosystems, or environmental science. It would also be appropriate for cross curricular topics with American and North Carolina histories.

Essential Questions:
- What are the different parts of a tree's internal structure and what can those structures reveal about the tree's history and the historical climate for a region?
- How can tree rings help scientists understand and better predict weather and climate patterns in the future?
- What can scientists learn about historical cultures and events from studying tree rings and other environmental conditions?

Brief Lesson Description:
Students will be introduced to the science of dendrochronology as they explore the mystery of the Roanoke Colony on the Outerbanks of NC. Students will search for clues that could help explain the colony's disappearance while learning about tree morphology, effects of climate and weather, and how scientists can learn from the past to better understand the future.

Performance Expectation(s) and Specific Learning Outcomes:
- Correctly label the different parts of a tree (heartwood, xylem, cambium, phloem, and outer bark) from a cross section.
- Determine a tree's age using its rings.
- Relate a tree's cross section to weather, climate, or other events that occurred during its lifetime.
- "*Correlate the time it takes a tree to grow with events in human history*," (American Forestry Foundation, 2015a).

Prior Student Knowledge:
- Familiarity with characteristics of weather.
- Familiarity with the characteristics of climate and climate change.
- Basic understanding of tree anatomy.

Possible Preconceptions/Misconceptions:
- Weather and climate do not directly affect tree growth and development.
- All trees have the same rate of growth.
- All trees require the same ideal growing conditions.
- Looking at tree rings can only tell us the age of a tree and nothing else.

Materials:
Printouts from the supplemental materials
A variety of tree cookies or tree cores (1 per group)
Magnifying lenses (1 per student)
Tree Corers (Optional)
Tree Identification Guides (Optional)

LESSON PLAN – 5-E Model	
ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:	**Time: 30 minutes**

Can interpreting tree rings help us identify weather and climate events from the past?

1. Grab the class's attention with a multiple-choice question about the age of the oldest (known) trees in North Carolina:
   How old are the oldest trees in North Carolina?
   a) 500 to 1,000 years
   b) 1,000 to 1,500 years
   c) 1,500 to 2,000 years
   d) Older than 2,000 years

2. Explain to students the answer is (d). *According to a new study published May 9, 2019 in the journal Environmental Research Communications, scientists studying tree rings in North Carolina's Black River swampland have discovered a bald cypress tree (Taxodium distichum) that's at least **2,624 years old**, making it one of the oldest non-clonal, sexually reproducing trees in the world. (Clonal trees, which are vast colonies of genetically identical plants that grow from a single ancestor, can live for tens of thousands of years.) How old is 2,624 years, really? To borrow an analogy from the Charlotte Observer, that age makes this tree older than Christianity, the Roman Empire and the English language.* (Stahl et al.)
3. Ask students how we know the age of this tree? Allow for some discussion regarding how we determine the age of trees.
   a. Collect student ideas on an anchor chart. Students may suggest counting tree rings, but encourage them to think about how the trees 'know' when one year ends and the next begins?
4. Ask students if they have ever heard of the story of the Roanoke Colony on the coast of North Carolina. Show *Colossal Mysteries: The Lost Colony of Roanoke video-* https://www.youtube.com/watch?v=b6SDYZNHkXo
5. Explain to students that they will explore how the science of *dendrochronology* might help give scientists a clue as to what happened to the lost colony.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:	Time: 120 minutes

Part 1:

1. Explain to students they will be exploring a simulation to learn how to decipher tree rings and the information they can give regarding the life of the tree and historical weather and climate.
2. Facilitate as students work through the Tree Ring Simulation: https://scied.ucar.edu/interactive/tree-ring
3. When students have completed the activity, have them share out their 3-2-1 to summarize what they learned.
4. Explain to students that *temperature and precipitation* play a major role in the growth and development of trees. ***Background:*** "By counting a tree's growth rings, you can tell the age of that part of the tree at the time it was cut. Every growth season, a tree adds a new layer of wood to its trunk and limbs. Each ring has two parts: a wide, light part (early wood) and a narrow, dark part (late wood). The early wood grows during the wet, spring growing season. During the transition from the drier summer to fall and winter, growth slows and the late wood forms. The rings provide clues about the climate, or weather, of the area over time and evidence of disturbance to and around the tree, such as fires and floods," (American Forest Foundation, 2015a).

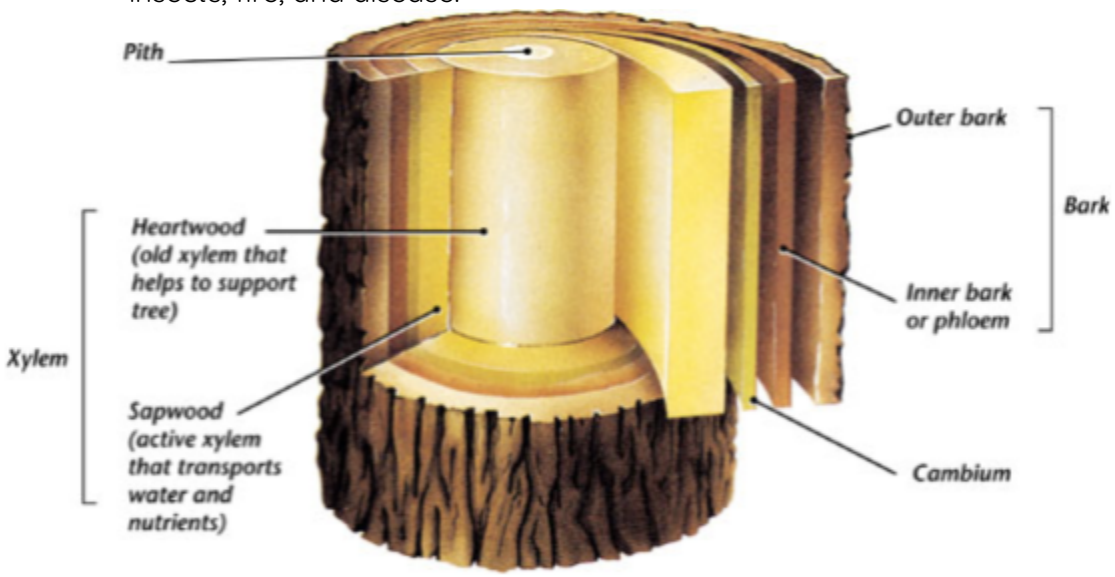
Part 2:

1. Explain that students will be doing a group activity to label the different parts of a tree cross section and practice interpreting the tree rings. Ask the students to organize themselves into groups of three to four. *If students have difficulty dividing themselves into groups, assign them to groups of 3-4.*
2. Pass out the *Tree Cookie Analysis Student Sheet* and tree cookies. Facilitate as students work through labeling and interpreting their tree cookies. *Students may want to use magnifying glasses here to better observe the tree rings.*
3. When students are finished, have them place all the cookies in one large area.
    a. Have students exchange sheets with another group and see if they can match the tree ring interpretation to the correct cookie.
    b. When they are finished, have them check with the original group to see if they have the right tree cookie.
    c. If they didn't match the right cookie, have the original group share their cookie and explain their interpretation to the new group.
4. Allow students to summarize what they learned at the end of the activity. Ask students how this might help them figure out what happened to the Roanoke Colony.

EXPLAIN: Concepts Explained and Vocabulary Defined:	Time: 60 minutes

1. Review the different parts of a tree that are identifiable in the cross section. The descriptions for these are from the Project Learning Tree "Tree Factory" Activity (American Forest Foundation, 2015b). Use a diagram (such as the diagram to the below) to assist with explaining these sections to the class.

- ***Heartwood*** is the core of a tree that provides support for the tree. This is the oldest part of a cross section.
- ***Xylem***, or sapwood, is composed of younger layers of wood. Water and nutrients travel upward through the xylem from the roots to other parts of the tree.
- The ***cambium*** is where the tree is actively growing. New cells are created here that become part of the xylem, cambium, or phloem.
- The ***Phloem***, also called the inner bark, is where food and nutrients are carried from the leaves of the tree to other parts.
- The ***outer bark*** is the outermost part of a tree that protects the tree from things like weather, insects, fire, and disease.



Source: Free Stock Photos http://bigpictures.club/resize.php?img=http://ez002.k12.sd.us/Pictures/SN2928.jpg

2. It might be important to point out to students that "The shape and width of the annual rings often differ from year to year because of varying annual growth conditions. During a moist growing season, a tree in a temperate region may produce a particularly wide ring. During a drought, a colder-than-average winter, or an unseasonable frost, a tree will produce a particularly narrow ring. In a science called dendrochronology (which literally means 'the study of tree time'), scientists have found that they can learn about past climates by studying the ring patterns of very old trees," (American Forest Foundation, 2015a).
3. Ask students if they found any other strange shapes or inconsistencies in their cross section. Explain that there are other things that may show up in a cross section. Can they identify any? (American Forest Foundation, 2015a; MDNR PLT, n.d.):
    - *Branch*: this is noticeable by a new set of rings appearing in the cross section.
    - *Drought or insect attacks* are often evidenced by very narrow rings. In contrast, "good years," where the precipitation and temperatures are conducive to growth, will be evidenced by wider rings.
    - *Fires* show up in tree rings as dark or black areas, sometimes only on one side of the cross section, that run approximately parallel with the bands.

- *Narrower rings on one side* happen when the tree is leaning. To help straighten itself out, the tree will grow wider rings on the side closest to the ground and narrower rings on the side facing away from the ground.

ELABORATE: Applications and Extensions:	**Time: 120 (+) minutes**

Part 1:

1. Have students think back to the opener for this lesson: the oldest known trees in North Carolina are over 2,600 years old (Stahl et al., 2019). These are bald cypress trees (*Taxodium distichum*), and the species is native to eastern NC and other parts of the southeastern US. Scientists have used baldcypress tree rings to reconstruct historical climates of the southeastern US.
2. Show students image #1 from the Blackwater River tree cross section.
    a. Ask students if they can interpret the rings at 1587 and 1606. *Hopefully, students will observe that the rings in these areas are very narrow, indicating a severe drought during those years.*
3. Show students image #2.
    a. Explain to students these dates revealed the two worst droughts to impact eastern North Carolina and Virginia in a roughly 800-year record coincided with the years 1587-1589 and 1606-1612 (Stahle et al., 1998).
    b. Ask students if any of them know what human events happened during those years? Explain that these droughts coincided with two early English attempts at colonization in the New World: the Roanoke Colony, also known as the Lost Colony, and the Jamestown Colony. *Information about historical climate and weather events gleaned from tree rings have increased our knowledge about the conditions these early colonists faced. In both cases, the colonists likely did not know that they were experiencing a drought because they had no knowledge of conditions in prior years for comparison. With the aid of tree rings, we're able to understand more about the events that shaped early English colonization in North America.*
4. Ask students to discuss reasons why a drought might have contributed to the disappearance of the Roanoke Colony.
    a. Have students read excerpts from the article *Extreme Droughts Played Major Role In Tragedies At Jamestown, "Lost Colony"* for more information: https://www.eurekalert.org/pub_releases/1998-04/CoWa-EDPM-240498.php. *It might be helpful to incorporate a reading strategy here such as a symbol read or a jigsaw using different parts of the article.*

Part 2:

1. Ask students what questions could they answer about their area's own climate history if they could take core samples from trees around their school. Collect student questions on the anchor chart from the beginning of the lesson.
2. Have students access the weather data for a 20 year period for their region in the State Climate Office's Cardinal database. *Use the Cardinal Tutorial located in the supplemental materials for help with navigating the Cardinal tool.*
    a. Have students analyze the data by creating graphs in the Excel spreadsheet. Have students look for trends in their data, as well as weather anomalies such as droughts and floods.

   b. Have students create a predictive cross section of a tree based on the weather data they collected from Cardinal.
3. Have students summarize the life events the tree went through as it grew and developed during these weather events.

***Optional* Part 3:**

1. If you have access to tree borers for your classroom, have students go out and take sample cores from trees around the campus.
   a. Have students research which trees are ideal for studying tree rings.
   b. Once students have a better understanding of the ideal trees to study, allow students to go outside and select a tree to sample. *Note: Trees that have been specifically planted and well maintained for landscape purposes will not be beneficial to this activity as their rings will not accurately reflect environmental conditions.*
   c. As they are sampling, have students use tree guides to accurately identify the species of tree they are sampling.
   d. After sampling, have students research the ideal growing conditions for their tree species. *The ideal growing conditions vary widely across species, so this information may be helpful as they are analyzing the rings of their sample.*
2. Give students the opportunity to analyze their core samples and create a tree timeline.
3. Have students compare their tree ring data to their predictions they made in Part 2 for the past 20 years of weather data. Have students consider the following questions:
   a. Can they match up any of the anomalies?
   b. How are their predictions different from the actual tree rings? What might account for these differences?
   c. What other environmental factors may have played a role in tree development for this region?
   d. Have students think about the age of their tree. If the tree is older than 20 years, what do its rings show prior to the 20 years of data analyzed? If it is younger, what might the tree rings look like in another 5 to 10 years?
4. When finished, have students share their results. How do their results compare across species? *We recommend allowing students to keep their notes and observations in their notebooks, but it might be a good idea to compile the class data into a spreadsheet so students can compare similarities and differences across groups.*

EVALUATE:	**Time: Throughout Lesson**

Formative Monitoring (Questioning / Discussion):

Formative assessment can be conducted throughout the lesson.

Summative Assessment (Quiz / Project / Report):

Summative assessment can be conducted during the investigation, elaborate, and extension activity.

Elaborate Further / Reflect: Enrichment:	Time: 60 minutes

1. In our example, tree rings from bald cypress trees told a story that helped reveal information about human historical events. Explain to the class that they will now get to practice telling the story of some trees using their rings.
2. Each group has been given a tree cookie from a tree that was cut down in North Carolina in 2017. Explain that their tasks are to:
    a. Determine the approximate age of the tree.
    (Instructor's note: each tree cookie will be from the same tree, so they should have approximately the same number of rings – 30).
    b. Write a story about their tree.
        i. The story can be written in full sentences, bullet points, a timeline, or even a picture.
        ii. It must include at least *two events* (such as a drought or branch) and it must tie these to the approximate age of their section of the tree at that time.
        iii. Inform them that they can take artistic license with this activity: they can tell the story from the perspective of the tree, personifying it, or they can relate events within the tree's history to events in their own lives. The important part is that they relate the information provided by the tree's rings to the age of the tree or year of occurrence.
3. *Provide an example of a tree story:*
This is my story of a Fraser Fir tree. "I started to grow in 2001. When I was eight, I grew a branch, but by the time I was eleven, that branch had died and I had hidden the scar behind several layers of xylem. In my late childhood to early pre-teen years, I did a lot of growing. But then I was cut down in late 2015 to become a Christmas Tree."
4. While groups are working, walk around and offer help where needed.
5. Once groups have finished, allow some to share the age of their cross section and their tree story with the class (2-3 minutes, if time allows).

Other Resources

There are a variety of ways this lesson could be extended. Below are some other resources that could be used to extend/supplement/support this lesson.

Trex Tree Ring Expeditions: https://serc.carleton.edu/trex/index.html

International Tree Ring Database:
https://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring

Data Contribution for the National Centers for Environmental Information:
https://www.ncdc.noaa.gov/data-access/paleoclimatology-data/contributing

Analyzing Tree Ring Data Sequences: https://scied.ucar.edu/activity/learn/dendrochronology-sequence

Tree Rings and Climate Timeline Simulation: https://scied.ucar.edu/interactive/dendrochronology

Illustrated Graphs:
https://www.sciencefriday.com/educational-resources/illustrated-graphs-using-art-enliven-scientific-data/

Teaching Climate Change with Ice Cores:
https://www.sciencelessonsthatrock.com/blog/teaching-climate-change-with-ice-cores

Finding Relative Age of Rock Layers:
https://dashboard.dublinschools.net/lessons/?id=fe7d1bef7e57465643367f82f80bfdaf&v=1

References and Acknowledgements

American Forest Foundation. (2015a). Tree Cookies – Activity 76. In *Project Learning Tree: PreK-8 Environmental Education Activity Guide* (pp. 327-331).

American Forest Foundation. (2015b). Tree Factory – Activity 63. In *Project Learning Tree: PreK-8 Environmental Education Activity Guide* (pp. 269-272).

Blanton, D. B. (2000). Drought as a factor in the Jamestown Colony, 1607-1612. *Historical Archaeology,*

34(4), 74081. doi:10.1007/bf03374329

MDNR (Minnesota Department of Natural Resources) Project Learning Tree (PLT). (n.d.). How to read tree cookies. Retrieved from: http://files.dnr.state.mn.us/education_safety/education/plt/activity_sheets/treeCookie.pdf

NPS (U.S. National Park Service). (2015). Historic Jamestowne. Retrieved October 10, 2017, from https://www.nps.gov/jame/index.htm

NPS (U.S. National Park Service). (2017). Fort Raleigh National Historic Site. Retrieved October 10, 2017, from https://www.nps.gov/fora/index.htm

SERC (Science Education Resource Center at Carleton College. (2021, July 6). Webinar: Using Tree-Ring Research to Develop Critical Scientific Thinking Skills in Undergraduate Students. TREX Guides. https://serc.carleton.edu/trex/labs/using_tree_rings.html.

Stahle, D. W., Cleaveland, M. K., Blanton, D. B., Therrell, M. D., & Gay, D. A. (1998). The Lost Colony and Jamestown Droughts. *Science, 280*(5363), 564-567. doi:10.1126/science.280.5363.564

Stahle, D W, et al. "Longevity, Climate Sensitivity, and Conservation Status of Wetland Trees at Black River, North Carolina." *Environmental Research Communications*, vol. 1, no. 4, 2019, p. 041002., doi:10.1088/2515-7620/ab0c4a.

TNC (The Nature Conservancy). (2017). Protecting the ancient. Retrieved October 16, 2017, from https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/northcarolina/publications/the-black-river.xml