Using Dendrochronology for Place-Based K-12 Paleoclimate Lessons

Grace Raffa, Department of Geological Sciences, SUNY Geneseo,
1 College Circle, Geneseo NY, 14454, gmr11@geneseo.edu

GENESEO
THE STATE UNIVERSITY OF NEW YORK

Abstract

Dendrochronology focuses on using trees as archives of past climatic changes for a given region. This project focuses on creating a paleoclimate-centered accessible learning experience for K-12 teachers that integrates local climate proxies in the classroom creating place-based experiences connecting students to the effects of climate change. Four tree species: Beech, Sugar Maple, Black Locust, and Hop Hornbeam, were collected from a local glacially-formed hill (from the Last Glacial Maximum) in Geneseo, NY. These trees died and were removed in August 2020, dried for 6+ months, and sanded (40-800 grit) until rings were visible. Annual growth rings were counted from the center of the tree ring to the inner bark for all samples to determine age. Tree ring stress rankings were developed for tree ring correlation, periods of thin ring growth indicated stress and reduced growth commonly caused by unseasonably warm periods or drought. The four local tree rings showed over 50 years of climate data marking an increase of thin tree rings from 1980 to 2020, indicating a rise in regional temperature. This dendrochronology-paleoclimate activity will be simplified for secondary classrooms focusing on local climate, demonstrating seasonal patterns, and illustrating global changes of past, current, and future climates.

What is Dendrochronology?

-Dendrochronology is the dating and study of annual rings in trees

-Founded by Andrew E. Douglass in the early 1900s (Figure 1).

-Douglass noticed a relationship between the size of the growth rings and climate factors such as precipitation and altitude.

-Trees grow one ring per year- in the spring they are light in color, known as early wood, and as growing slows down in the fall, the band becomes dark in color, known as late wood (Figure 2).

Figure 1: Andrew Ellicott Douglass (left) discussing tree ring analysis with fellow researcher in front of a wheel section of sequoia at the University of Arizona (McGraw, 2000).

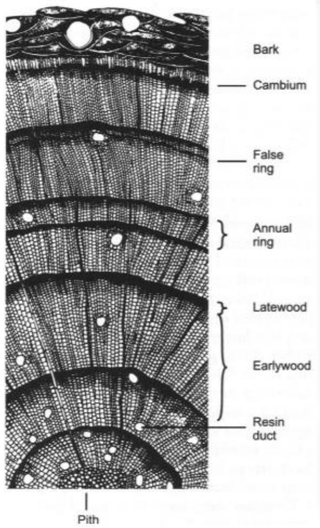


Fig. 2: Tree Ring anatomy drawing of cell structures along a cross section of a tree (McGraw, 2000).

Methods

Sample Preparation
•Cut in August 2020
•Dried until February 2021 in a fume hood
•Sanded from 40-800 grit using an orbital sander
Sample Data Collecting
•Measured radius of each ring sample
•Number of tree rings were counted and measured (mm) at every latewood
•High-definition pictures taken using Canon 5D Mark IV for better counting accuracy

Results

Figure 3: Beech

Radius: 11.0cm
Age: 49
Year Born: 1972
Years of Stress: 1998-2002, 2006, 2011, 2017-2020
Thickest: 3.8 mm
Thinnest: 0.7 mm

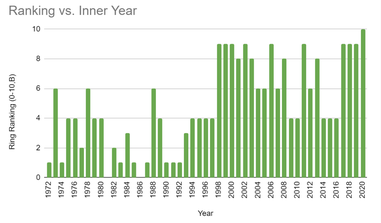


Figure 4: Sugar Maple

Radius: 7.4cm
Age: 86
Year Born: 1934
Years of Stress: 1935-36, 1938, 1941, 1989-2004, 2009-2020
Thickest: 2 mm
Thinnest: 0.05 mm

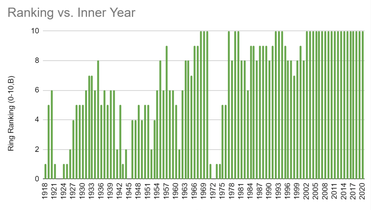


Figure 5: Hop Hornbeam

Radius: 8.0cm
Age: 102
Year Born: 1918
Years of Stress: 1957, 1968-70, 1977, 1979, 1980, 2002-2020
Thickest: 3 mm
Thinnest: .05 mm

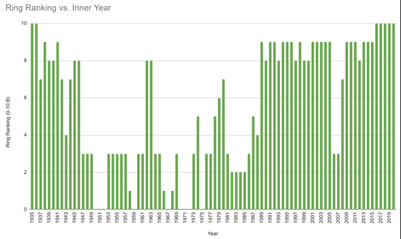
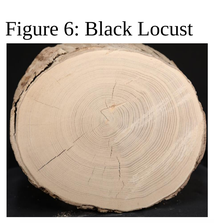
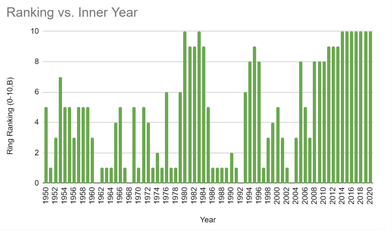


Figure 6: Black Locust



Radius: 9.8cm
Age: 70
Year Born: 1954
Years of Stress: 1980-1984, 1995, 2011-2020
Thickest: 4 mm
Thinnest: 0.1 mm



Analysis & Discussion

All tree rings that were collected in 2020 show a gradual increase of thin annual rings towards the present.

All tree rings illustrate:
•Thin rings from early 2000s onward.
•Correlation of thin rings with lower precipitation (Figure 3).
•Some rings showed thin growth in the 1960s also corresponding to precipitation and Palmer Drought Severity trends.
•Rings show volatility in growth that correlates to climate volatility in the region.
•Thickest tree rings in each sample correspond to unseasonably high precipitation.

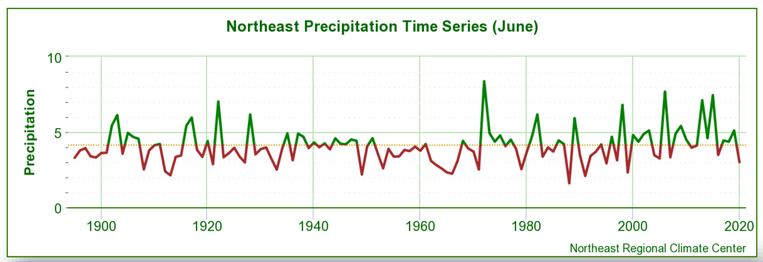


Figure 7: Northeast Regional Climate Center Data recording June's average monthly precipitation in inches, which was then compared with the collected tree rings from Geneseo. Green lines indicate above average precipitation and brown lines indicate below average precipitation (www.nrcc.cornell.edu)

K-12 Lesson

Objectives:
•Students will analyze tree rings and calculate their life span in order to gather data on climate change stresses throughout the tree's life.
•Students will be able to connect the impact of climate on annual tree ring growth patterns such as wetter and dryer seasons.
•Students will learn that paleoclimate data can be gathered from sources beyond long term weather observations.

Plan:
Each group gets a laminated version of the oldest tree (Ash) as a comparison. Students will then work together to note similarities with years of stress in comparison to other group's trees. They will mark the years of stress all the way to the pith.

Students will apply real world events to the life of the tree, by cutting and pasting historical dates on the tree ring (as seen below).

Figure 7:Ash tree taken from same Geneseo region as the other four samples. Tree is approximately 185 years old with ring thickness varying from 0.05mm to 6mm. Every 10 years is marked for reference while students are comparing and analyzing stresses of all five rings as well as adding historical dates. Pen for scale.

Conclusion

-These four samples illustrate the stresses of local precipitation on regional tree growth.

-This analysis and system of assessing paleoclimate using tree rings will help create a lesson plan that can be used for place-based learning.

-More studies should be done to further connect each species type and their sensitivity to precipitation and temperature variations.

Acknowledgements

Thank you to Dr. Wittmer-Malinowski for helping me with my research including personally sanding the samples to make it easier to collect data. Also, thank for Dr. Over for providing the tree samples.

References

McGraw, D., 2000, Andrew Ellicott Douglass and the Big Trees: American Scientist, v. 88, p. 440, doi: 10.1511/2000.5.440.
NRCC Summary Tables Cornell.edu, http://www.nrcc.cornell.edu/regional/tables/tables.html (accessed April 2021).