Name___________________ Date____________________

Dendrochronology- A Guided Tour
Lesson 1: Reading the Landscape

Directions: As you read, study the diagrams and answer the questions.

1. Here are some pictures - what do you notice, what do you wonder?

Write any features you notice in the trees and landscape.

(Mazur, 2024)

(Mazur, 2024)

Hints of Past Storms in the Landscape

The pictures that you examined are of trees in the Harvard Forest tract known as Slab City in Petersham, MA. This forest experienced two known windstorm events - The Hurricane of 1938 (sustained winds 85-100mph) and the 1953 Worcester Tornado (winds 207-260 mph). Trees change their structure in response to wind, showing both physical clues of their past experiences and their resilience. Some of the trees that you observed in the previous images were damaged and then recovered, possibly in these storms.

Trunk Breaks

The twisting and bending forces of high wind can cause a tree's trunk to snap completely off, typically at a height of 15-20 feet. Trees respond to this stress by sprouting new growth at the site of the break, which can develop into a v-shaped trunk,

Leaning Bases

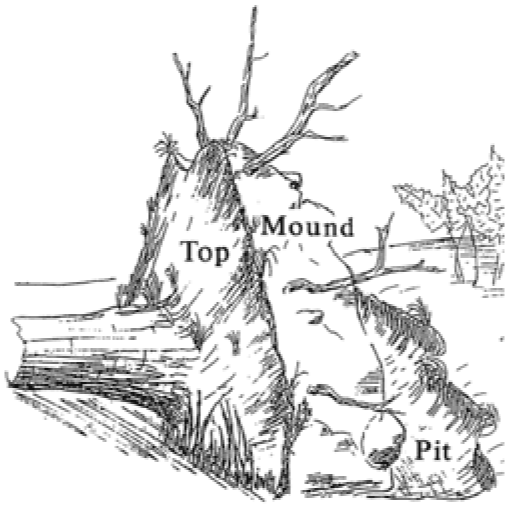
Trees can remain upright as long as most of the mass of the tree remains above its supporting trunk and roots. Gravity is constantly pulling all parts of the tree downward while its strong wood holds it upright. High winds push on the trunk and branches, which can loosen roots and the surrounding soil, rocking the root mass. If the force of these winds push the upper parts of the tree far enough from its supporting base, the tree will lean or topple. If enough root area remains in the soil, trees can survive, and the new growth at the top of the main stem (trunk) grows vertically and straight.

The direction of the lean or toppled tree can tell us the direction from which the wind blew. Trees that are laying or leaning in the same direction indicate a past hurricane. In contrast, trees that are laying in various directions could be caused by past tornados, or a series of wind events over time.

Nurse Logs

Have you noticed a line of trees growing closely together? These trees may have gotten their start on a nurse log. Conifer trees, such as pine and hemlock, are slow to rot, giving moss plenty of time to grow. This moss creates a damp, protective place for tree seeds to sprout along a fallen tree's length. You may see hints of a nurse log in the form of a long moss-covered mound with remnants of rotten branches peeking through. Or, the log may have decayed completely, leaving this next generation of trees' roots elevated above the ground.

Pits and Mounds
Can you find evidence of the trees that fell in past wind storms on the ground? One way is to look for pits next to mounds on a forest floor. The pits could have been created when the tree roots lifted soil from the ground as the tree fell. As these vertical roots decayed and dropped this soil to the ground, mounds were created. If you stand on the mound and turn toward the pit, you are facing the direction from which these storm winds blew.



(Fox, 2017)

2. *Now that you have read about past windstorms hidden in the landscape, take another look at the two images at the beginning of this assignment. Write down any new details you notice that might indicate windstorm damage from the past.*

Name__________________ Date___________________

Dendrochronology- A Guided Tour

Lesson 2: Natural History

Directions: As you read, study the diagrams and answer the questions.

Some natural history events impacting tree growth in a forest may be drought, unexpected frost, windstorms, wildfire, logging, or flooding. Comparing tree cores, and finding similar periods of good or poor growth, can help to pinpoint with certainty the date of rings in a core sample.

Natural History Jigsaw

In your small group, choose an environmental natural history event from the list that could impact tree growth in the Slab City Forest in Petersham, Massachusetts.

1. Read the article with your group.
2. Take notes using the chart below: What happened? How did it impact trees? Share a key idea or takeaway.
3. Create a brief slideshow of 2-3 slides, based on your notes. Include bulleted text in your own words and an image on each slide.
4. Be prepared to present to the class.
5. As each group presents, use the table to record key information about each event.

Natural Events

1. 1938 New England Hurricane
2. 5-year Drought (1963-1967)
3. 1953 Worcester Tornado
4. 1981 Spongy Moth Outbreak

Environmental Event	**What happened?**	**How do you think it impacted trees?**	**Other takeaways?**
1938 New England Hurricane			
1953 Worcester Tornado			
5-year Drought (1963-1967)			
1981 Spongy Moth Outbreak			

Name___________________ Date____________________

Dendrochronology- A Guided Tour
Lesson 3: Types of Growth Rings

Directions: As you read, study the diagrams and answer the questions.

Key Vocabulary

Dendrochronology- the branch of science that dates events and variations in the environment from the past by comparative study of growth rings in trees and aged wood.

Increment Borer- a tool used to remove a small core sample of wood from a tree

(Trapp, 2024)

Conifers- trees that form seeds in cones; often have needles

Vessel Elements- tissues that transport water in plants

Photosynthesis- process plants use to convert sunlight to energy in the form of sugar

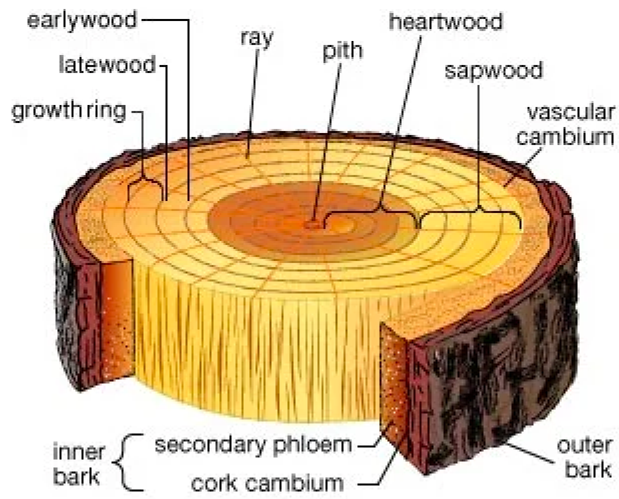
Embolism- air bubble in plant vessel element

When walking in your neighborhood or local park, have you ever looked at an interesting tree and thought about all of the history the tree has witnessed? If only the tree could tell you the stories of all it has seen. What stories would trees tell if they could talk? Trees might not be able to talk using the language you and I use, but they do write down their stories for us to find in their growth rings.

Dendrochronology is the branch of science that dates events and variations in the environment from the past by comparative study of growth rings in trees and aged wood. (Merriam Webster Dictionary). Dendro is the Latin root that means tree. Chron is a Latin root that means time. So dendrochronology literally means the study of trees moving through time.

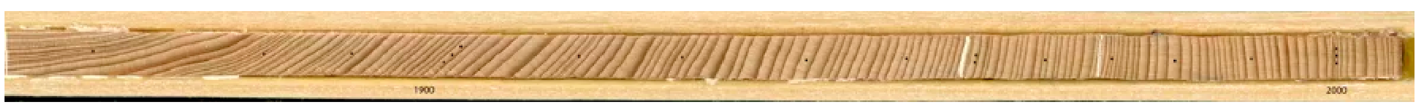
Sampling Tree Rings

There are two ways to see and study a tree’s rings. If the tree is already dead, a cross section of the tree’s trunk can be used.



© 2006 Merriam-Webster, Inc.

If the tree is living, then a small sliver of the trunk can be extracted using an increment borer. It drills into the tree to its pith, or center, and removes a small core of the tree about the size of a drinking straw. This process does not hurt the tree.

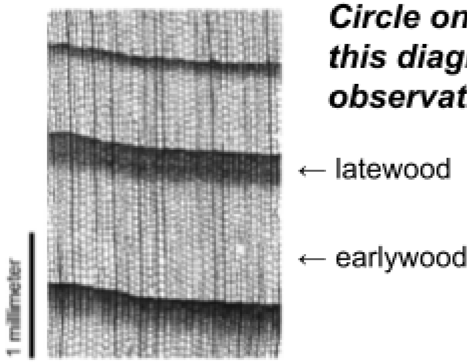


(SERC, 2017)

The core can then be sanded down to reveal the tree’s rings. Typically a tree adds one new ring to the outer part of the tree under the bark each growing season. So for each year a tree is alive, its trunk gets one ring thicker. Different tree species have different types of ring structures. On a tree core, rings resemble vertical stripes.

Coniferous Ring Structure

The simplest ring structure to decipher is the kind made by conifers (), which include pines and hemlocks. The lighter earlywood is formed in the spring, and consists of wide thin walled cells. The darker band shows the narrower thick walled, dense cells of the latewood formed in summer and fall. Earlywood and latewood together equals one year growth. These rings are typically the easiest type to see and understand.

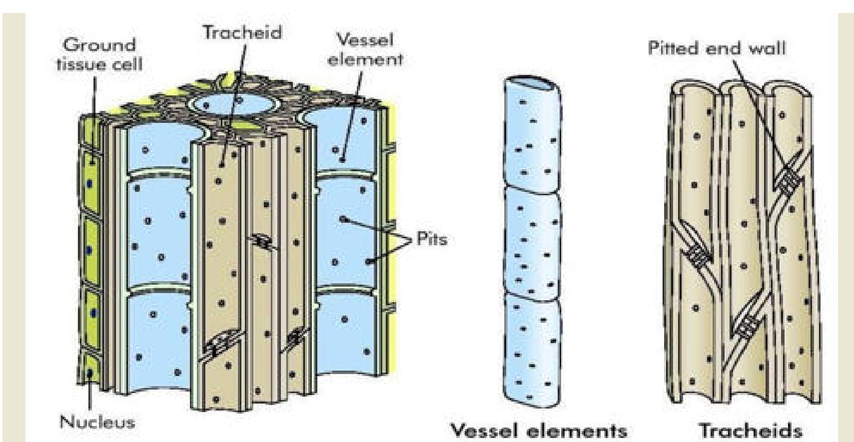


Circle one year's growth (one growth ring) on this diagram. Then, write one related observation or question in the box below.

(Dendrochronology, 2022)

Ring Porous Ring Structure

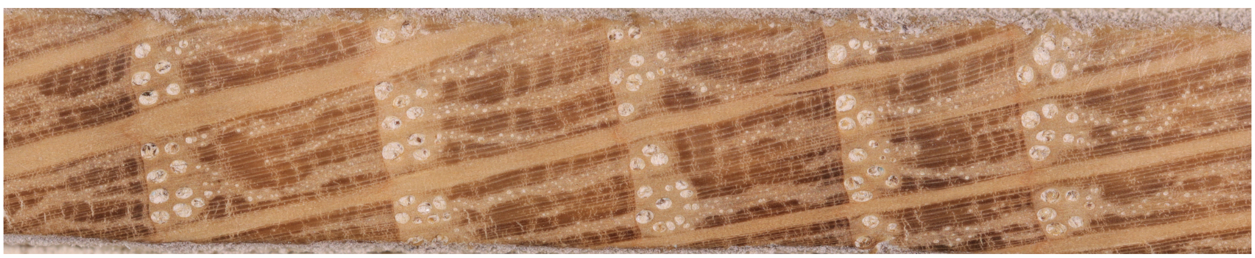
The next ring type to learn is the ring porous type, a ring structure more common to oaks and hickories. Trees with this type of ring structure evolved after conifers, and make up about 18% of tree species in the northern region. The earlywood is made of densely packed large vessel elements or pores which allow for rapid water transport to fuel upcoming photosynthesis. This part of the ring resembles a light colored bubble filled layer. The bubble-like pores can be thought of as drinking straws the tree uses to transport water and nutrients from the roots to the buds and leaves. Ring porous trees create this new earlywood first, then grow leaves second.



Xylem structure (side view) *(QS Study https://www.biologyonline.com/dictionary/xylem)*

For energy to make its earlywood, trees must first draw from sugar reserves previously stored in the roots and other tissues, as no photosynthesis happens in a deciduous tree before leaves emerge.Therefore, any stress in the growth season before or in the current spring, such as spring drought, frost after leaf out, even windstorms, can interfere with a tree's ability to do this growth. Large pores need an ample water supply to function. Freeze events and droughts can cause air bubbles, or embolism, to develop in the transport process, causing the cell to stop functioning. Think of what happens when using a straw to consume water. When the water level becomes low, air is sucked into the straw. The same process happens in the pores of the earlywood.

Earlywood
(Notice the white pores)
↓

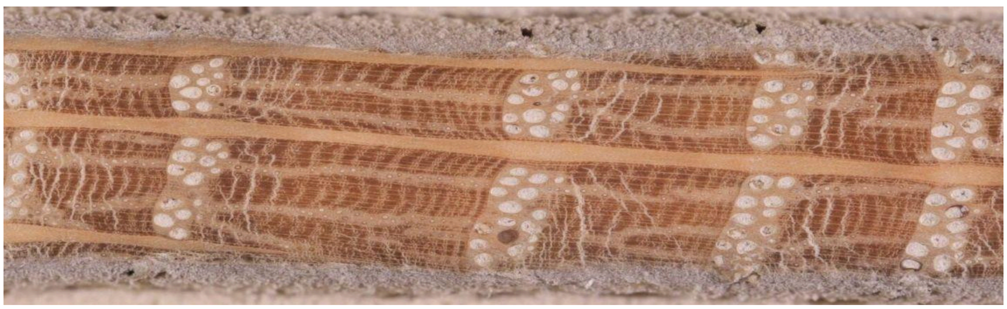


↑
Latewood
(Notice the darker color)

(Mazur and Murphy, 2024)

The latewood in ring porous trees appears dark, and contains much smaller, more stress resistant pores. Think of these vessel elements as much thinner coffee stirrers. While still able to suck up water through a plastic coffee stirrer, less water moves up the stirrer at one time. However, when water levels are low, it is easier to drink up every last drop without getting air in the smaller stirrer. During this latewood period of growth the tree obtains its energy primarily through photosynthesis. Therefore, more resources are available to form cells for structural support of the tree. Horizontal rays can also be seen through the rings. These rays add additional pathways for food and water transport and are not used for dating the tree.

In the image below of a ring porous core, draw a circle around any earlywood you see. Draw a bracket to show any latewood you see. How many years' growth do you see represented in this image?



(Mazur and Murphy, 2024)

Draw an arrow pointing to a horizontal ray. What do you notice about the color of the ray compared to the color of the earlywood and latewood?

Diffuse Porous

The last ring type is diffuse porous. Diffuse means spread out. This ring type, found in maples and birch, can be very challenging to interpret. At first glance, the wood appears to be one continuous substance. These rings have many small pores spread throughout. These pores can be thought of as very small straws. This structure protects against freeze events, but creates some vulnerability to summer droughts. The pores from the previous growth season continue to be able to transport some water the next season. This adaptation allows the tree to grow leaves quickly in the spring. There is not as much visual differentiation between early and latewood. Upon examination with a microscope, the darker lines marking the boundary between growth rings can be seen.

How many pores do you see within the growth ring shown between the arrows below?

↑ ↑

(Mazur and Murphy, 2024)

Why do you think this pore structure may create problems for the tree during drought periods?

Name___________________ Date____________________

Dendrochronology- A Guided Tour
Lesson 4: Crossdating Rings
Directions: As you read, study the diagrams and answer the questions.

Key Vocabulary
Microring- an extremely small growth ring often just a few cells wide
Pith- tissue in the heart of the tree around which growth rings are formed
Deciduous- type of tree that lose their leaves in the fall
Spongy Moth- an invasive insect non-native to North America

Spongy moth caterpillars eat and defoliate many types of leaves
source:https://www.aphis.usda.gov/plant-pests-diseases/spongy-moth

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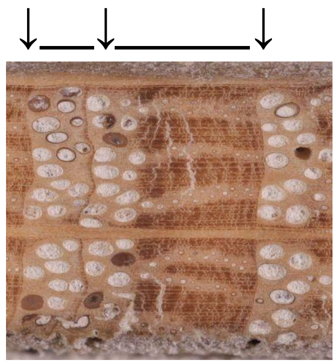
Crossdating Rings

There are many factors that complicate the process of determining the true age and growth of trees. For starters, in times of stress, trees might make a microring, or no ring at all. Core samples might miss the tree's pith, or miss the existence of microrings altogether. To confidently read the story of the tree, the rings must be cross dated and not simply counted.

The natural history of the tree's forest reveals clues about the events that may have impacted the formation of tree rings. Researching the history, in addition to cross referencing with many core samples, allows the rings to tell the tree's story. For example, virtually all deciduous trees in the Northeastern United States were affected by the extensive spongy moth outbreak of 1981. The spongy moth quickly ate their way through most of the leaves of affected trees. Trees without leaves to fuel photosynthesis lose their ability to grow. The extremely narrow 1981 growth ring can be easily located in most tree cores.

The image below is of the 1981 and 1982 growth ring of an oak tree. Measure the two rings. What is the difference between the two rings? Round to the nearest tenth of a millimeter.

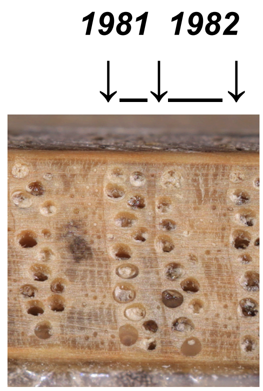
1981 1982



(Mazur and Murphy, 2024)

Write additional observations- what do you notice about the appearance of the oak's 1981 ring?

The image below is of the 1981 and 1982 growth ring of a Shagbark Hickory tree. Measure the two rings. What is the difference between the two rings? Round to the nearest millimeter.



(Mazur and Murphy, 2024)

Write additional observations- what do you notice about the appearance of the hickory's 1981 ring?

Name___________________ Date____________________

Dendrochronology- A Guided Tour
Lesson 5 : Crossdating Cores Activity

Directions: As you read, study the diagrams and answer the questions.

Now you have the background information needed to cross date a core sample from a tree. The images you are about to receive are of cores that were taken from trees with suspected wind damage from the forest of Slab City in Petersham, Massachusetts. Follow the below procedure for each core sample. Use the digital files found in this link: https://storm-stories.netlify.app/

1. Examine one core from the four linked here. Look at it as a whole. What ring structure do you see? (Circle one)

   Coniferous **Ring Porous** **Diffuse Porous**

2. Continue looking at your core as a whole. Do you see groups of rings that are very close together? If so, write an "N" for narrow in the box below marking the approximate locations of the narrow groups.

   Bark Pith

3. Now look for groups of rings that seem very far apart. If you see a series of wide rings, write a "W" for wide in the box above marking the approximate locations of the wide groups.

4. Now start at the end of your core that is adjacent to the bark. These cores were taken in the year 2024. The earlywood you see next to the bark is the 2024 growth ring. Why do you suppose there is no latewood for 2024?

5. Count back 4 rings to make a hypothesis about which ring represents the year 2020. Do one of the following:
   - ☐ Screenshot this ring and digitally place a mark on its earlywood.
   - ☐ Or draw a detailed sketch of this ring in its approximate location.

Bark	Pith

6. Now count back towards the pith in sets of 10 rings to make a hypothesis about which ring represents 2010, 2000, 1990, and 1980. Do one of the following:
   - ☐ Screenshot these rings and digitally place a mark on its earlywood.
   - ☐ Or draw detailed sketches of these rings in their approximate locations.

Bark	Pith

7. Test your hypothesis by counting one ring towards the bark from the ring you hypothesized was from 1980. Did you find a narrow ring showing poor growing conditions during the extensive spongy moth infestation? If so, then your hypothesis is supported. If not, you should look for this 1981 ring, and examine your core carefully for rings you missed. Magnification helps!

8. Once you have identified the 1980 ring with certainty, continue to count backwards towards the pith in sets of 10. Note the rings you hypothesize represent 1970, 1960, and 1950. Test your hypotheses by examining the rings representing 1963 - 1967. Are they narrower than the rings around them, showing stress from drought? If so, then your hypotheses are supported.

9. Now count forward towards the bark 3 rings from 1950. Does it show evidence of atypical growth after the June tornado1953? What do you see? Do one of the following:
   - ☐ Screenshot this ring and digitally place a mark on its earlywood.
   - ☐ Or draw a detailed sketch of this ring in its approximate location.

Bark	Pith

10. Look carefully at the years representing 1954 - 1960. Are they narrower, the same, or wider than the rings around them? What long term effects did this tree experience from the 1953 tornado? Do one of the following:
    - ☐ Screenshot these rings and digitally place a mark on its earlywood.
    - ☐ Or draw detailed sketches of these rings in their approximate locations.

Bark	Pith

11. Go back to the ring representing 1950, and continue counting back in sets of 10 until you reach the pith of your core. Examine the year that you hypothesize shows the growth for 1938. Does it show evidence of interrupted growth in 1938? What do you see? Do one of the following:
    - ☐ Screenshot these rings and digitally place a mark on its earlywood.
    - ☐ Or draw detailed sketches of these rings in their approximate locations.

Bark	Pith

12. Now that you have carefully hypothesized and crossdated the rings of your core, what year does the pith of your sample represent?

Crossdating Cores Post Activity Discussion

The core samples all show evidence of 1981 spongy moth infestation. When leaves or needles are consumed, trees lack the energy needed to produce new growth. Other years of spongy moth infestation in Slab City include 2017, and 1945. The growth ring of 1953 is similarly impacted in the samples.

The tornado striking early in the growing season may have damaged the tree by snapping off its top, blowing off its leaves, or by felling major branches. Anytime a tree loses a significant amount of leaves or needles, its ability to photosynthesize and grow is impacted. The decade of the 1930's seemed to be a poor growing season for the sampled trees. The narrow rings preceding 1938 make it hard to discern the hurricane's effect on the growth of the sampled trees. Wide rings in the year following a windstorm event may show the tree experienced growth release. Growth release happens when nearby trees fall, allowing for more space and sunlight, increased photosynthesis, and a resulting wider growth ring. While trees may sustain damage in a windstorm, they are resilient, and often have growth opportunities in the years that follow. An event with short term damage may end up yielding long term benefits.

(Mazur, 2024)

Write a reflection about life lessons we can learn from the trees.