

# Dendrochronology



## Teacher Reference Unit

**The Laboratory of Tree-Ring Research  
The University of Arizona  
1215 E. Lowell Street  
Tucson, Arizona 85721 © 2015**



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# Foreword

The lessons in this teacher reference unit were created for the STEMAZing “Branching Out” Dendrochronology Workshop held at the Laboratory of Tree-Ring Research on December 19, 2015. These lessons were designed to be used by K-12 educators who have completed training through the University Of Arizona Laboratory Of Tree-Ring Research Outreach Program.

*Pamela J. Pelletier*

Pamela Pelletier, M.S.  
Director of Outreach  
[pamela@email.arizona.edu](mailto:pamela@email.arizona.edu)

*Arin C. Haverland*

Arin C. Haverland, Ph.D.  
Outreach & Research Assistant  
[arin@email.arizona.edu](mailto:arin@email.arizona.edu)



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# Acknowledgements

We would like to acknowledge the UA Laboratory of Tree-Ring Research team of researchers and docents that have contributed to this project. We would also like to thank DaNel Hogan and her amazing team of educators. Your generosity and enthusiasm has enabled our educational team to provide innovative curriculum and training for Arizona STEM educators that ” branches out” and brings tree-rings to classrooms, and beyond. Thank you for giving us the opportunity to grow with you.



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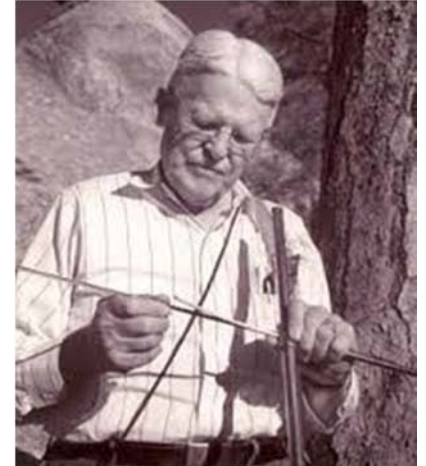
# Andrew E. Douglass and Dendrochronology

## *An educator's guide to Dendrochronology in Arizona*

### Our History

In 1937 A. E. Douglass, founder of the modern science of dendrochronology, established the Laboratory of Tree-Ring Research at the University of Arizona. The Tree-Ring Lab is recognized worldwide as a preeminent center for the advancement of tree-ring techniques and the broad application of dendrochronology in the social and environmental sciences.

Dendrochronology is the dating and study of annual rings in trees. Dendrochronologists use tree rings to answer questions about the natural world and the place of humans in its functioning. The practical applications of the study of tree rings are numerous. Dendrochronology is an interdisciplinary science, and its theory and techniques can be applied to many applications.



### Our Facilities and Programs



The new Bryant Bannister Tree-Ring Building (BBTRB) offers a fabulous opportunity to engage and educate UA students and their families, visitors and the public. Many superlative specimens and the science stories behind them are on display in the new building for all to learn about, enjoy and to be inspired by. We're on our way to hosting more than 7,000 visitors per year. Great discoveries in archaeology, climatology, geology and ecology have been made at LTRR. Continuing work at LTRR is on the cutting edge of research and teaching in water, earth, fire, and archaeological sciences.



Our faculty, students, and scientific staff are engaged in a diverse array of research programs which include fire history and fire ecology, paleoclimatology, archaeology, paleoecology, biogeochemistry, geomorphology, numerical and statistical modeling, and even public health.



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# How You Can Join the Laboratory of Tree-Ring Research!

We offer volunteer and docent opportunities at the new Bryant Bannister Tree-Ring Building, providing tours of the building and showing the main exhibit floor, working behind the scenes, helping with K-20 group tours and other special outreach events.

## 1. *Become a Docent*

Docents are volunteer educators. They work at the Laboratory of Tree-Ring Research with visitors of all ages, helping them learn about dendrochronology and the interdisciplinary research taking place at the Laboratory. Docents must be 18 years of age or older, and must attend at least one of our training sessions offered throughout the year. Docents should be willing to commit to volunteering for at least 6 hours per semester, for at least one year after training is completed. If you are a UofA student, you may also be able to enroll in an independent study course for credit hours. All docents are provided a Laboratory of Tree-Ring Research t-shirt, name badge, and **free** parking!



- They take tree-ring samples and artifacts to an exhibit and use those props to engage Laboratory guests in conversation.
- They may provide hour-long tours throughout the exhibit hall and Laboratory.
- They may assist with special events at the Laboratory or at off-campus events, including educational presentations.
- They may conduct a presentation in our educational classroom, either with schoolchildren or adults.

## 2. *Become a Junior Docent*

Junior Docents are teen volunteer educators. Teen volunteers may be 13-17 years old, and must attend at least one of our training sessions offered throughout the year. Junior Docents should be willing to commit to volunteering for 6 hours per semester, for at least one year after training is completed. Junior docents serve in the same capacity as docents, based on their age and interests.



All Junior Docents are provided a Laboratory of Tree-Ring Research t-shirt, a name badge, and **free** parking!



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### **3. Become involved Behind-the-Scenes and Beyond-the-Lab**

The Laboratory participates in several events throughout the year including the Tucson Festival of Books. We need assistance in the following areas:

- Ticket Attendants for events such as Open House tours. Duties include explaining Lab tours, directing guests, handing out and collecting tickets.
- Photographer: Taking pictures of events, asking guests to sign a media release form.
- Set Up for events: Placing linen on tables, putting signs up, setting up chairs, and other small set up needs.
- Representation at information tables at events.
- Office duties: Help with mailings, typing spreadsheets, shredding, cutting flyers, sorting documents, filing, making copies, etc.
- Miscellaneous duties: include handing out drinking water to staff, volunteers, and vendors; counting tickets; keeping an eye on children; handing out flyers; answering guest questions; and much more!

#### **Laboratory of Tree-Ring Research Outreach Website:**

<http://ltrr.arizona.edu/outreach>

#### **Laboratory of Tree-Ring Research Calendar:**

<http://ltrr.arizona.edu/calendar/month>

#### **Contact Information:**

Pamela Pelletier, Director of Outreach  
520-621-0984 or [pamela@email.arizona.edu](mailto:pamela@email.arizona.edu)



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# Overview of Lesson Titles and Unit Objectives

## (4 Lessons)

### **Lesson 1: From Seeds to Giants**

#### *Objectives:*

- Identify the parts of the tree
- List the nutrients and processes necessary for tree-growth
- Label structural components of annual tree-rings in conifer species
- Define the term Dendrochronology

### **Lesson 2: Observing the Past**

#### *Objectives:*

- List ecological events that may impact tree-growth
- List anthropogenic (human) activities that may impact tree-growth
- Identify tree adaptations
- Describe several techniques used to analyze tree-growth

### **Lesson 3: Rings of Fire**

#### *Objectives:*

- Label the Fire Triangle
- Define a Fire Regime
- Describe relationships associated with droughts, fires, and insects
- Make conclusions about fire by analyzing tree-rings

### **Lessons 4: The Tales Trees Tell**

#### *Objectives:*

- Describe how humans have used/interacted with trees throughout human history
- List descriptive words and emotions that are related to trees
- Demonstrate a connection between art and science by creating artwork that analyzes and interprets one or more aspects of tree-rings



# Basic Equipment and Realia by Lesson

These are the items that you will need for teaching the lessons in this unit. You will also find a list of additional and optional resources at the end of the lesson. At the end of the teaching reference unit we have provided a list of resources that will assist you in checking out equipment, ordering supplies, finding a scientist to visit your classroom, scheduling a class visit to our lab, or scheduling to attend a training workshop for additional skill building.

## Lesson 1: From Seeds to Giants

- Branching Out Bellwork cards
- “Related” and “Unrelated” Cards
- Tree-ring cross sections (or copies of laminates)
- Tree-ring cores (or paper cores)
- Macro lenses or magnifying glasses
- Note cards or other method for students to record observations

## Lesson 2: Observing the Past

- Tree-ring cross sections (or copies of laminates)
- Paper Cookies/Cores
- Crayons or colored pencils
- Cross-Matching Tree-Core Sets

## Lesson 3: Rings of Fire

- Fire Ecology Exercise by Daniels 2008
- Paper Cookies
- Paper Map
- Overhead or PowerPoint to work on fire mapping samples as a group

## Lesson 4: The Tales Trees Tell

- Art Supplies
- Poster board
- PowerPoint/Video Capture (option to have students create a video or slide show)
- Tree-Ring Imagery
- Tree-Ring Vocabulary List
- Audience Rubric
- Timer





# A Practical Guide to Our Lesson Plan Format

(Listed by Sections A-K with explanations in blue)



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1215 E. Lowell Street

Tucson, AZ 85721

<http://ltrr.arizona.edu/>

Area(s): TBD by Educator (fits well in plant and earth sciences as well as geography)

Dendrochronology Lesson 1: Branching Out

A. *Academic Standards and Performance Objectives which are cross-walked across disciplines to meet the State of Arizona Reading, Math and Science Standards (ADE, 2015)*

ACADEMIC

STANDARDS:

Unit (ADE Standard):	Reading	Math	Science
*ADE is Arizona Department of Education			

INDICATORS:

Lesson Title (ADE Measurement Criteria):			

Objectives: (ADE Measurement Criteria):	PO:	PO:	PO:

B. Need: *How students may benefit from and apply this lesson.*

C. Time: *Instruction time for this lesson.*

D. Resources: *Resources used to create content for this lesson that may be used for obtaining more information about the lesson topics.*

**E. Realia (Tools, Equipment, and Supplies):** *A list of supplies that you will need for the lesson, and suggestions for lesson props (also known as realia) that bring the lesson to life in the classroom and help make lesson concepts more valuable and interesting for you and your students.*

**F. Key Terms:** *Terms that students will need to know for the lesson as well as terms that will help the instructor to stimulate discussion.*

**G. Bellwork:** *A 3-5 minute activity which is posted at the beginning of each class so that students are immediately engaged in the learning process through a simple “bellwork” task or assignment. Bellwork may be used to create discussion, to get students to ask questions, or even to help remind students of key concepts learned in previous lessons.*

**H. Interest Approach:** *This is a method to “hook” students into the lesson and get them engaged in the lesson and excited about the topics you will cover in this lesson.*

**I. Transition:** *This is a method for transitioning into other areas of the lesson.*



**J. Learning Moment or E-Moments** *These moments are often included in the “Interest Approach” and “Activity” sections of each lesson and are highlighted by use of the light bulb icon. E-Moments assist the instructor in continuing to build upon key concepts through teaching those concepts in multiple ways so that a variety of learning styles may be addressed throughout the entire lesson. Each of us learns in different ways, therefore it is essential to have these moments which maximize comprehension and provide collaborative and experiential learning opportunities. (A complete listing of E- Moments may be found on the “E-Moments Explained” page.)*



**K. Earth Friendly Tips:** *These are “green” tips to help you, your students, and your classroom to be environmentally friendly. Earth friendly tips are highlighted by the use of the recycling icon.*

**L. Summary of Content and Methodology:** *In this section you will find: the learning objectives and activities which support the learning objectives, an instructor summary, a student conclusion, and methods for evaluation including assessment tools and optional extended lesson applications.*

**Objective:** *A task or set of tasks which students will be able to do upon completion of this lesson.*

**Activity:** *An activity which actively involves the students in learning.*

**Summary (Teacher):** *A suggested method for summarizing what the lesson has covered.*

**Conclusion (Student):** *An activity or task that the student will do to complete the lesson which is often presented in the form of a “ticket out” symbolizing that the student has completed the objectives in the lesson.*

**Applications:** *Suggestions on how to relate this activity to all of your students in other ways, which expands learning potential inside and outside of your classroom.*

Evaluation: *A suggested tool for evaluating teaching effectiveness and the attainment of learner centered objectives.*

## E-Moments Explained



E-Moments are highlighted in **blue text** for each lesson and are notated by a light bulb icon as shown here. E- Moments are moments which captivate students and engage them in the learning process. E-Moments were developed by a group of innovative educators and are used to help deliver lessons in multiple ways so that every learning style may be addressed. The E-Moments presented in this reference unit are used to help excite you as an instructor, and to help you engage your students in active learning. Feel free to combine and experiment with these moments, in fact you may even want to create your very own!

**E- Moments Defined** (as discussed in “Strategies for Great Teaching: Maximize Learning Moments” by M. Reardon and S. Derner, published in 2004, by Zephyr Press: Chicago)

1. **Almanac and Encyclopedia Moment** – *learners use resource materials such as encyclopedias*
2. **Cartographer Moment** – *learners use maps to research concepts and express ideas*
3. **Crayon Moment** – *learners draw images to support concepts and create visual connections to the lesson*
4. **Descartes Moment** – *learners create “why” questions for examining what they know, what they think they know and what they need or want to know to evaluate a task or process*
5. **Dickens Moment** – *learners act out or create scenes to reinforce concepts*
6. **Einstein Moment** – *learners create a mathematical equation*
7. **Eyewitness Moment** – *learners interview and report on an event*
8. **Go Get It Moment** – *learners retrieve research or resource materials from a variety of places*
9. **Go With The Flow Moment** - *learners create flow charts to organize information or concepts*
10. **Hieroglyphic Moment** – *learners create their own symbols to express an idea*
11. **Hole in One Moment** – *learners visualize each step and imagine their end result or “hole in one”*
12. **Picasso Moment** – *learners create a learning gallery and share visual representations or artwork*
13. **Me, You, Us Moment** – *learners think of an idea, share it with a partner and then with the class*
14. **Little Professor Moment** – *learners teach others about what they have learned*



# Tree-Ring Vocabulary Terms

The following is a list of vocabulary terms that are related to dendrochronology and the study of tree-rings. This list is meant to be an introductory list and should be supplemented as needed based on the course and grade level you are teaching.

Annual Ring  
Anthropogenic  
Bark  
Branch  
Cambium  
Carbon Cycle  
Cell  
Cellulose  
Climate  
Core  
Cross Dating  
Cross Section  
Dendrochronology  
Disturbance  
Drought  
Earlywood  
Evapotranspiration

Fire Regime  
Fire Scar  
Fire Severity  
Fire Triangle  
Geography  
Geology  
Hardwood  
Increment Borer  
Insect  
Instrumentation  
Interdisciplinary  
Latewood  
Limiting Factor  
Master Chronology  
Nutrients  
Palmer Drought Severity  
Index (PDSI)

Phenology  
Phloem  
Photosynthesis  
Precipitation  
Proxy  
Ray  
Resin Duct  
Sapwood  
Signal  
Skeleton Plotting  
Standardization  
Tree-Cookie  
Topography  
Variability  
Vessel  
Wildland Urban Interface  
Xylem



# Dendrochronology Questions and Concepts

1. What are the parts of the tree?
  - a. Bark, Cambium, Annual Rings, Pith, Xylem, Phloem, Sap/Hardwood, Early/Latewood, Resin Ducts, Rays, Branches, Leaves, Roots
2. What do trees need to grow?
  - a. Sunlight, Nutrients, Water
3. What processes are involved in tree growth?
  - a. Photosynthesis, Evapotranspiration, Carbon Cycle
4. How does a tree adapt to its environment?
  - a. Bark, Leaves, Roots, Cells, Structure, Seed Dispersal: all determined by Geography/Topography
5. What types of event might a tree experience in its lifetime?
  - a. Fires, Lightning, Insects, Drought, Disease, Harvesting, Development, Earthquakes, Competition, Pollution and other events
6. What does the tree-ring record tell us?
  - a. Proxy or “record” for past events in areas where we have documented tree-ring growth and tree-ring chronologies
7. What are the limitations of using tree-rings?
  - a. Incomplete or unavailable records in some regions, not all trees are ideal for dating, we don’t always have all the information we need to date a sample
8. How do we apply what we find in the tree-ring record?
  - a. Forestry management and policy,
  - b. Fire management
  - c. Add to historical records,
  - d. Collaborate with other disciplines such as Physics to triangulate radio-carbon dating techniques,
  - e. Learn more about complex processes such as the carbon cycle and jet stream fluctuations.



# Introduction to Dendrochronology Lessons

## Lesson 1: From Seeds to Giants

This lesson introduces basic concepts of tree growth and encourages learners to make observations and draw conclusions about events that occur during the lifetime of a tree. A review of tree growth processes and the structure of annual tree-rings is also covered in this lesson.

## Lesson 2: Observing the Past

This lesson helps learners understand how events are recorded in tree-rings as well as review basic adaptations of trees. Analysis and interpretation of tree-ring data is also covered in this lesson through two hands on activities.

## Lesson 3: Rings of Fire

This lesson introduces basic concepts of the fire ecology, fire regimes and the fire triangle. Through a reconstruction exercise learners discover the complexities of fire through exploration of events recorded in the tree-ring record.

## Lesson 4: The Tales Trees Tell

This lesson emphasized the human connection to tree-rings and encourages learners to use the tree-ring record to understand the events that the tree-ring record records. This lesson also offers learners an opportunity to “branch out” and explore their creative side by creating a public service announcement to demonstrate their new understanding of dendrochronology.







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**Lesson 1 Title: Seeds to Giants:  
 An Introduction to Dendrochronology (the study of tree-rings)**

**Area:** \*This section related to ADE standards is to be completed by the K-12 educator. The study of tree-rings fits in to every strand/concept and can be connected to any subject area from Art History to Zoology! Need materials? Contact us at [outreach@ltrr.arizona.edu](mailto:outreach@ltrr.arizona.edu)

ACADEMIC STANDARDS:			
<b>Unit (ADE Standard):</b>	R__	M__	SC__
INDICATORS:			
<b>Lesson Title (ADE Measurement Strand/Concept Criteria):</b>	S_C_	S_C_	S_C_
<b>Objectives:</b>	PO:	PO:	PO:
1. <b>Identify</b> the parts of the tree 2. <b>List</b> the nutrients and processes necessary for tree-growth 3. <b>Label</b> structural components of annual tree-rings in conifer species 4. <b>Define</b> the term Dendrochronology			

**Need:** Students will review the basic parts of the tree, tree growth, processes related to tree growth, and annual ring formation. Students will also be introduced the study of tree-rings - also known as dendrochronology, and learn the structure of annual rings. Students will make observations about ring patterns using real tree cross sections or copies of samples.

**Time: 50 minutes**

**Online resources:**

**Realia (Tools, Equipment, and Supplies):**

- Seeds to Giants Lesson Presentation
- Branching Out Cards
- Bellwork Option 1 or 2 (You can also use the branching out activity as bellwork)
- “Related” and “Unrelated” cards

- Cross-Sections or copies of laminated Douglas Fir and Gambel Oak images for making observations
- Magnifying glasses or macrolenses (for use with cell phone cameras)
- Ring Structure image

**Key Terms:** (This is a comprehensive list of the vocabulary that may be helpful to review or introduce for this lesson and you may choose the terms that make sense for your grade level and classroom needs from this list for this lesson.) annual ring, bark, branches, cambium, canopy, carbon cycle, climate, dendrochronology, disturbance, earlywood/latewood, evapotranspiration, geography, geology, hardwood/sapwood, leaves, natural/anthropogenic, nutrients, observations, perturbation, photosynthesis, pith, precipitation, proxy, roots, soil, sunlight, temperature, topography, tree cookie, tree cross-section, trunk, water

**Bellwork Option 1:** Ask students to draw a tree AND label the parts of the tree (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 1 folder on your memory drive).

**Bellwork Option 2:** Ask students to list what trees need to grow. (Note: A bellwork handout has been made for you and is included with this lesson and is in your Lesson 1 folder on your memory drive).



**Interest Approach: You-Me-Us Moment: This moment enhances interpersonal, intrapersonal, and linguistic intelligences.** The “Branching Out” Activity: Ask students to work with a partner to read each card and then divide their set of “branching out” cards in two distinct piles. One pile is designated as fields of study that are “related” to tree-rings, the other pile is designated for fields of study that are “unrelated” to tree-rings. Remind students to be ready to share why and how they made these decisions when called upon. To assess, ask students to share which disciplines they felt were unrelated to tree-ring science and why they made this decision. Help students connect each unrelated discipline to tree-rings in some way to emphasize how so many fields of study are connected to tree products and tree-rings and how closely or distantly related each of the fields of study they examined are related to trees and tree-rings.

### Summary of Content and Methodology



**Earth Friendly Tips:** Ask students to bring in realia for you to save on gas and carbon emissions, print double sided handouts without color, have students view handouts on computers, or laminate handouts to reuse with other classes and give students dry erase markers which can be wiped off after each use, reuse old magazines for images and scratch paper for recording observations for this lesson.



**Activity: Dickens Moment: This moment helps learners act out or create scenes to reinforce concepts.** Ask students to stand up and use their bodies to demonstrate the parts of the tree: canopy, branches, leaves, trunk, and roots.

Ask: What do trees need to grow? Water, nutrients and sunlight that the tree uses through processes such as photosynthesis, evapotranspiration and the carbon cycle.

Ask: Has anyone ever observed the rings of a tree? What did you notice? What did you wonder?

State: Patterns, size, shape, scars, and differences in ring width and color are great observations!  
State: Now let's take a look at two samples!

Have the Gambel Oak and Douglas Fir images ready to view.

Ask students to make observations and then share what they noticed.

Ask: now that we have observed two samples, let us review the structure of the annual rings!

Demonstrate the pith, annual ring, early and late wood, hard and sap wood, cambium and bark. Then have the students label a paper image of the ring structure.

Here is an animation of ring growth at the cellular level:

- [http://dendro.cnre.vt.edu/forestbiology/cambium2\\_no\\_scene\\_1.swf](http://dendro.cnre.vt.edu/forestbiology/cambium2_no_scene_1.swf)

Now that we have made observations and discovered the patterns and structure of tree-rings, we should think about the events that a tree may experience.

Ask: What natural and human events might a tree experience?

- Natural: fire, drought, insects, stress from competition or lack of resources
- Anthropogenic (human): development, logging industry, root damage due to being transplanted in a new region
- Other events?


Ask: Would you agree or disagree with this statement: Tree growth is also related to factors such as geography, geology, topography, climate and ecosystem perturbation/disturbances?

Great answers! You are correct in thinking that these factors influence tree growth, and these factors are recorded in the tree-rings! We call these records of events proxies. Coral samples, soil samples and ice cores are also considered proxies as they also record events related to these factors.

Ask: Does anyone know what you might call a scientist that studies tree-rings? That is correct! A person who studies tree-rings is also known as a Dendrochronologist. Dendrochronology is the study of tree rings and events over time!

**Summary (Teacher):** The teacher will ask questions to help the students summarize the lesson. You can also have students review the Bear Essential News DendroIntro Article in your Lesson 1 folder on your memory drive from the workshop.

**Conclusion (Student): Ticket Out Option 1:** The students will turn in a summary statement and underline key terms and concepts as their ticket out. (Note: A ticket out handout has been made for you and is included with this lesson plan in your Lesson 1 folder on your memory drive).

 **Ticket Out Option 2: Picasso Moment:** This moment helps learners interpret concepts and create a learning gallery from their individual learning style and gives them a chance to share visual representations or artwork of a scientific concept. (Note: A ticket out handout has been made for you and is included with this lesson plan in your Lesson 1 folder on your memory drive). The students will turn in a synthesis drawing in the form of a colorful drawing or art

piece of a tree cross section that reflects the same number of rings as their age (9 years old = 9 rings) as their ticket out.

**Application:** Extended Classroom Activity: Have the students make a list of careers that may be connected to the study of tree-rings. This may also be used as a topic for research, a presentation or a paper to be done by the students.

**Evaluation:** Students will be evaluated by short activities, periodic quizzes or exams based on grade level and classroom needs.



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## **Lesson 2 Title: Observing the Past**

### **Using the tree-ring record to reconstruct past events**

**Area:** \*This section related to ADE standards is to be completed by the K-12 educator. The study of tree-rings fits in to every strand/concept and can be connected to any subject area from Art History to Zoology! Need materials? Contact us at [outreach@ltrr.arizona.edu](mailto:outreach@ltrr.arizona.edu)

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INDICATORS:			
<b>Lesson Title (ADE Measurement Strand/Concept Criteria):</b>	S_C_	S_C_	S_C_
<b>Objectives:</b>	PO:	PO:	PO:
<ol style="list-style-type: none"> <li>1. <b>List</b> ecological events that may impact tree-growth</li> <li>2. <b>List</b> anthropogenic (human) activities that may impact tree-growth</li> <li>3. <b>Identify</b> tree adaptations</li> <li>4. <b>Describe</b> several techniques used to analyze tree-growth</li> </ol>			

**Need:** Students will learn about adaptation, events that impact tree growth and the utility that the tree-ring record provides to researchers studying complex interactions. Students will analyze paper tree cores and plot tree ring data in this lesson.

**Time:** 50 min.

#### **Online Resources:**

<https://www.youtube.com/watch?v=GvuLjhdEBoo>

Rex Adams talks about dendroclimatology in this great video!

<http://video.pbs.org/video/2330301577/>

Ron Towner talks about recording tree ring data

<http://www.12news.com/story/weather/talking-weather/2015/11/15/treering-time-travel/75837144/>

ABC News Phoenix talks about the tree-ring lab in Tucson

**Realia (Tools, Equipment, and Supplies):**

- Observing the Past Lesson Presentation
- Tree-ring cross sections or copies of tree-ring image laminates
- Paper cookies 1 and 2 handouts
- Crayons or colored pencils
- Core sample from your kit
- Sampling Presentation (optional)
- Cross-Matching Tree Core Sets
- Simplified Skeleton Plotting Handouts
- Connection to the internet to show a video/connect to a link (optional)
- Skeleton Plotting Worksheets and Answer Key
- Graph Paper and Scratch Paper to create your own tree rings to plot (optional)

**Key Terms:** (This is a comprehensive list of the vocabulary that may be helpful to review or introduce for this lesson and you may choose the terms that make sense for your grade level and classroom needs from this list for this lesson.) adapt, adaptation, analysis, analyze, anthropogenic, branches, canopy, chronology, climate, complacent, core, cross-dating, cross-section, Dendrochronologist, Douglas Fir tree, ecological, ecology, geography, geology, leaf structure, master chronology, Mesquite tree, natural variability, sensitive, skeleton plotting, standardization, standardizing, topography, tree species, trunk.

**Bellwork Option 1:** Ask students to answer the question of “What factors influence tree growth?”. (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 2 folder on your memory drive).

**Bellwork Option 2:** Ask students to answer the question of “What types of events might a tree experience?”. (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 2 folder on your memory drive).

**Interest Approach:**

State: We previously made observations and drew conclusions about tree growth and drew conclusion about events that impact tree growth and annual ring patterns.

Ask: What else did we talk about that is related to tree growth?

Ask: Does anyone remember what types of information is recorded in the tree-ring record?

State: Let’s make a list of the factors that impact tree growth. Great!

Ask: Is it correct to state that what we are really talking about is geography, topography, geology and even climate right?

Ask: So how does a tree adjust and react to these factors? Adaptation

Adaptation! Yes!

Ask: What does the term adaptation mean?

Ask: How does a tree adapt? Bark, leaf structure, canopy structure, branch structure etc.,.



State: From our discussion we see that trees adapt to their environment, and we describe trees as “sensitive” if they record many changes year to year in ring width and “complacent” if they have similar rings each year.

State: Let’s look as examples of sensitive and complacent trees.

Ask: Do you see the difference in the rings? Fantastic!

State: Lets look at another image.

Ask: Which of the two trees above is more likely to have **sensitive** growth? Why?

State: Noow you all get to be the Dendrochronologists – scientists who analyze tree-rings!

Ask: Do you each have two paper cookies? Which one do you feel is sensitive? Cookie 2.

Ask: Why? The dramatic series of narrow rings.

State: Take a moment to color the narrowest rings on both of your paper tree-cookies and label cookie 1 as complacent and cookie 2 as sensitive do that you can refer to it later.

State: As Dendrochronologists, ideal samples for you to study are sensitive because they yield more interesting information. Helpful clues for Dendrochronologists are characteristics of annual rings with distinct boundaries and lots of variability (sensitivity).

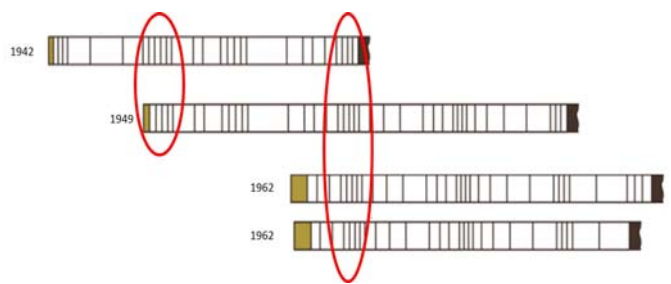
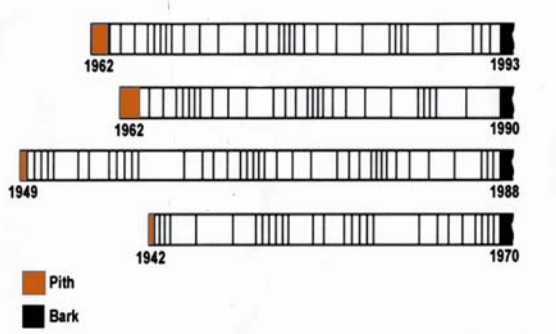
**Check for understanding:** 2 minute challenge: Ask students to: Write down 2 interesting items/concepts you have learned about dendrochronology.

State: Another way we can look at the events that occur in tree-growth is through a chronology, or a record of events over time. We are going to look at tree cores as they show the same information as we see in cross-sections or tree cookies.

Pass around the core sample from your kit. Note that the core mounted in the wooden frame is flat but when it is taken from a tree, it is sticky and round from sap. When researchers collect the cores, they are set to dry and then placed in wooden mounts and the top is cut or sanded to view more ring detail. (Note: Coring images and info is also in your folder in Lesson 2 on your memory drive. You can also sign up to bring your class to a field session and we can teach your class about coring and bring in more samples and instrumentation!)

### Activity: Cross Matching Paper Cores

Have students color in narrow rings, then have them orient the core sets with the bark on the right and the pith on the left, Next have students order the cores with the earliest year on top. Now they can match the rings and hypothesize based on narrow and wide rings what events may have occurred over time and around which years.



Ask: Did the tree ring widths and patterns match?

Ask: What was the total length in years of your chronology? 1942 to 1993 (51 years)

Ask: What did you notice?

Ask: What did you wonder?

State: One reason for the patterns is that each tree species experiences an event differently. We call that natural variability as the tree rings vary from year to year. To standardize the patterns in a way that researchers can globally share tree-ring data we use a technique called skeleton plotting to illustrate variability.

State: Here is a video about skeleton plotting: <http://www.12news.com/story/weather/talking-weather/2015/11/15/treering-time-travel/75837144/>

State: Lets look at skeleton plotting together using an image of a core, a cross section or cookie, and an image of graph paper. Note that the graph paper has numbers on the top to show years in decades or 10 years in a section. Now let's examine our core and cross section, and count the rings and label year 1 and so on.

State: Next let us identify the narrowest and widest rings. Notice that here are also numbers on the bottom that indicate year 1 through the last year the tree was alive.

Ask: Does everyone see the number 1 here? That is the first year of growth.

State: Once the narrowest and widest rings are identified we can mark marks on each year of life to show if the rings were wide or narrow. Narrow rings are the longest lines, widest rings are the shortest lines.

Ask: Does everyone see where wide, average and narrow are indicated here? Great!

Walk students through marking the narrowest rings and the widest rings.

Have students watch you label or demo the skeleton plotting. (Note that there is Skeleton Plotting worksheet in your Lesson 2 folder on your memory drive.)

State: once the narrow and wide rings are indicated by year on the graph paper we get a chronology and we can match those events to a master chronology that reflects previous research and collections of data from a series of trees in a certain location.

State: That tree ring chronology goes back 8-10,000 years in some cases! Here we can visit a link that shows where this type of information is shared:

Visit the International Tree-Ring Data Bank here:

<https://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring>

State: We can also use a process called cross-dating where we look at different sources of wood and match the events or activities that impacted the growth or use of the tree. Here is an image of the types of information that we can use to learn more about samples collected. In some cases we can

go back to the exact year, in other cases we have to use clues such as the tools used to harvest the wood, to understand how old the tree may be and perhaps we can match it to an era. Dendrochronologists also examine charcoal (fire wood) as you can see rings in some samples and petrified wood!


**Summary (Teacher):** The teacher will ask questions to help the students summarize the lesson and then has the option to show this video from ABC News:

<http://www.12news.com/story/weather/talking-weather/2015/11/15/treering-time-travel/75837144/>  
ABC News Phoenix talks about the tree-ring lab in Tucson

**Conclusion (Student):**


 **Crayon Moment :** This moment inspires learners to draw images to support concepts and create visual connections to the lesson.

Students will be asked to draw one example of an event that impacts tree growth, or b) list and draw 2 natural events, and 1 human activity that impact tree growth as their ticket out. (Note: A Ticket Out handout has been made for you and is included with this lesson plan in your Lesson 2 folder on your memory drive).

 **Go With The Flow Moment:** This moment encourages learners create flow charts to organize information or concepts.

You may also ask the students to label their drawings or create a flow chart with arrows on their drawings to demonstrate events or factors that influence or impact tree growth. (Note: A Ticket Out handout has been made for you and is included with this lesson plan in your Lesson 2 folder on your memory drive).

**Application:** Students can explore the many ways that the tree ring record is applicable. (Note that in your “readings” folder in your memory drive there are multiple samples for learners to read including the Bear Essential News Article on DendroClimate that connect tree rings to every-day items. You also have a suggested reading list within your workshop presentation on your memory drive).

 **Extended Classroom Activity:** Students can research the average age of a specific tree species that is found on school property and then examine precipitation and temperature records as well as any information on when the tree may have been planted by interviewing school staff about the tree.

**Eyewitness Moment: Interviewing school staff about what they know about the tree on the school grounds is a great way for learners to formulate questions for an interview and report on an event and then fact check using precipitation and temperature data related to trees in that area. Perhaps the tree was planted before or after the school was built and that gives you an estimate of how old the tree may be! Who knows what memories everyone has of the trees right in their own yard or on school grounds!**

 **Almanac and Encyclopedia Moment:** moments when learners use resource materials such as websites. Students may also visit the Laboratory of Tree-Ring Research

Facebook Page and research what activities we have been doing right here in Tucson!

LTRR Facebook Page <http://goo.gl/2qRGqS>

**Evaluation:** Students will be evaluated by short activities, periodic quizzes or exams based on grade level and classroom needs.



**The Laboratory of Tree-Ring Research**  
**The University of Arizona**  
 1215 E. Lowell Street  
 Tucson, AZ 85721  
<http://ltrr.arizona.edu/>

### **Lesson 3 Title: Rings of Fire**

#### **Using the tree-ring record to identify and map fire regimes**

**Area:** \*This section related to ADE standards is to be completed by the K-12 educator. The study of tree-rings fits in to every strand/concept and can be connected to any subject area from Art History to Zoology! Need materials? Contact us at [outreach@ltrr.arizona.edu](mailto:outreach@ltrr.arizona.edu)

ACADEMIC STANDARDS:			
<b>Unit (ADE Standard):</b>	R__	M__	SC__
INDICATORS:			
<b>Lesson Title (ADE Measurement Strand/Concept Criteria):</b>	S_C_	S_C_	S_C_
<b>Objectives</b>	<b>PO:</b>	<b>PO:</b>	<b>PO:</b>
<ol style="list-style-type: none"> <li>1. <b>Label</b> the Fire Triangle</li> <li>2. <b>Define</b> a Fire Regime</li> <li>3. <b>Describe</b> the phenological relationships associated with droughts, fires, and insects</li> <li>4. <b>Make conclusions</b> about fire by hypothesizing, analyzing, and interpreting fire scars in tree-rings</li> </ol>			

**Need:** Students will be able discuss fire regimes and changes in the ecosystem.

**Time:** 50 min.

**Resources:** Daniels 2008 Fire Activity, Daniels 2008 Step by Step Fire Activity

## Online Resources:

<http://www.npr.org/2012/08/23/159373691/how-the-smokey-bear-effect-led-to-raging-wildfires>

A great video about fire from NPR featuring researchers from the UA and other universities

## Realia (Tools, Equipment, and Supplies):

- Rings of Fire Lesson Presentation
- Fire Ecology exercise by Daniels 2008
- Overhead/Powerpoint of tree cookies for analyzing as a group
- Paper cookies to analyze from Daniels 2008 Full Fire Activity (each student can examine 1 or 2 cookies)
- “Smokey the Bear” fire scar image
- Images of Smokey the Bear
- Paper Map to reconstruct fire boundaries
- Green, Red, Blue Dry Erase/Wet Erase Markers to label dates on fire map
- Internet connection to play fire video (optional)
- Climate\_Drought\_Trees\_2012Article (optional)
- Bear Essential News Article about Fire and Tree-Rings (optional)

**Key Terms:** (This is a comprehensive list of the vocabulary that may be helpful to review or introduce for this lesson and you may choose the terms that make sense for your grade level and classroom needs from this list for this lesson.) analysis, anthropogenic, climate, conclusions, crown fire, disturbance, droughts, ecosystem, ecosystem response, electrical energy, fire regime fire severity, fire triangle, frequency, friction, fuel, gas, heat source, insects, ladder fuels, lightening, liquid, marker rings, narrow ring, oxygen, Palmer Drought Severity Index (PDSI), phenology, relationships, release event, solid, suppression, suppression event, surface fire, urban development, water resources, wide ring, wildland urban interface.

**Bellwork Option 1:** Ask students to answer: How are forests and fires connected? (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 3 folder on your memory drive).

**Bellwork Option 2:** Ask student to answer: What elements need to be present to create a fire? (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 3 folder on your memory drive).

## Interest Approach and Fire Mapping Activity:

State: Previously we explored cross dating using trees from different source sites. As we have noticed in our analysis of tree rings, tree-rings record events! In this session we are going to talk about dendroecology and how we can use the tree-ring record in reconstructing ecological events.

Ask: What natural disturbances and human activities may occur?

State: In this section we will focus on fire as a natural and anthropogenic events.

Ask: We are going to talk about fire, does anyone know what is needed for a fire to occur?

Ask: Has anyone ever seen a diagram of fire? Or a fire triangle?

State: The fire triangle shows that we need fuel, oxygen and heat to create fire. Understanding this fire triangle helps researchers to learn more about wildfires and fire regimes. Fires occur in different

frequencies (how often), sizes (how large) and severities (how much damage to property/lives and the ecosystem has occurred). Crown fires are more severe than surface fires.

Have students examine fire scar image: Smokey the Bear

State: Lets reconstruct the fire history with this sample. Here we see low severity surface fires that occur fairly frequently, every 5-15 years, up until the 1850s and then we have a long uninterrupted period, 100+ years with no fire scars.

Ask: So what changed? People.

State: (Human influences in the 19<sup>th</sup> century) With the completion of the railroad connecting the east coast to the west coast and many people immigrated in to this southwestern United States. With them they brought goats and sheep.

Ask: What do these grazers eat? Grass.

State: Lets refer back to the fire triangle. We need fuel, heat, and oxygen, if you remove the fuel source you cannot have a fire. In this era the cattle and sheep ate the grass and removed the surface fuels and large fires were unable to spread.

State: Moving in to the human influences of the 20<sup>th</sup> century we know that in the 1950s the National Forest Service began implementing active fire suppression which is also known as the “Smokey the bear” campaign or effect. Land managers actively suppressed any human or natural fire from spreading. So this changes the landscape. Small shrubs and trees that may have otherwise burned were allowed to grow. Now we see increased competition between tree species for resources and a change in the structure, stand population and tree density. The combination of surface and canopy fuels has resulted in a different type of fire known as the crown fire. When these fires occur, they cause more tree mortality then a surface fire and often destroy the forest and the soil. Today the tree ring lab works closely with the fire managers to implement fire management strategies that consider the data found in tree-rings for a more proactive forest management policy.

State: Fire and drought also distinctively linked. The Palmer Drought Severity Index (PDSI) uses Temperature and Precipitation data to estimate relative dryness which changes over time. Note the changes over the years in states such as California that are susceptible to both drought and fire.

State: Here is what we see when we combine fire and drought over time – the PDSI maps drought and fire sites. Brown sites are drier and you can see the increase in fire scar sites over time. Note that the proceeding years are wet.

Ask: Has anyone visited Mt Lemmon recently? Did you see evidence of a fire?

Check for understanding: Ask: From what we know so far, do you believe fires are harmful or beneficial? Why?

State: Today we are going to analyze a series of fire scars and then recreate a fire event. To do so we must look at marker rings. Marker rings are indicators. Lets review what marker rings tell us: Narrow rings are when tree growth was limited, and multiple narrow rings mean prolonged stress. Wide rings are years when resources were available for tree growth. Now we will examine the patterns of wide and narrow on our sample. A release event has wide rings following a series of narrow rings. A suppression event has narrow rings followed by a series of wide rings. So now lets



look at a map and examine each tree as the fire occurred and then we will map the path of the fire. This will help us to create a reconstruction of WHERE the fire burned and WHEN.

Pass out the paper cookies

State: Lets look at a cookie together – we will examine tree number 1 to determine:

Ask:

1. How old is this tree - if the outer ring was 2001?
2. Does the tree have a marker ring, if so in what year?
3. Does the tree have a fire scar, if so in what year?
4. Did the tree have a release event, if so in what year?

Have students analyze their paper tree cookie to find the same data and answer the same 5 questions as above.

Have map displayed: Have different colors to notate: Fire Scars = Red, release event = green, new trees = blue

State: Lets use the marker rings to check the quality of our data:

Ask:

1. How many tree have a narrow ring? (all have a marker ring)
2. What year is this marker ring? (1989)
3. How many trees have a fire scar? (8 trees: tree 1, 5, 6, 9, 10, 11, 12, 13)
4. What year did the scar form? (1984)

Ask:

1. When did these events occur : 16 through 20 – Year 1984)
2. Why might trees release after a fire? Some trees die off leaving more resources

Map the release trees location on the map (5 trees: 16 through 20 – Year 1984)

Ask:

1. If trees establish AFTER the fire, what is the year of their pith? (1984 or later)
2. How old are these trees? (18 or younger when sampled in 2001)
3. Which trees established in 1984? (7 trees: 21 through 27)

Map the location of these trees. Note new trees are in groups near large dead trees.

Ask:

1. Are there trees without scars or release events? (10 trees: 2, 3, 4, 7, 8,14, 15,28, 29, 30)
2. How old are these trees? ( greater than 18 years when sampled in 2001)
3. Why don't these trees record forest fire information in their annual rings? They were NOT in the boundary of the fire.

Map the location of these trees: (10 trees: 2, 3, 4, 7, 8,14, 15,28, 29, 30)

State: Now we can determine the boundary of the fire.

Ask: What year did this fire occur? (Spring, 1984)

State: Great Job! Now lets take a look at a video about fire regimes in the southwestern United States:

<http://www.npr.org/2012/08/23/159373691/how-the-smokey-bear-effect-led-to-raging-wildfires>

### **Summary of Content and Methodology**



**Earth Friendly Tips:** Ask students to bring in realia for you to save on gas and carbon emissions, print double sided handouts without color, have students view handouts on computers, or laminate handouts to reuse with other classes and give students dry erase markers which can be wiped off after each use, or reuse old magazines and scratch paper. For this lesson, consider using earth friendly rechargeable batteries and make sure to turn off lights when you leave the classroom to go outside and don't forget to power off the cameras, phones and video recorders when not in use.

**Summary (Teacher):** The teacher will ask questions to help the students summarize the lesson. Are fires harmful or beneficial or both? Why? What else might we need to consider in examining such complex relationships?

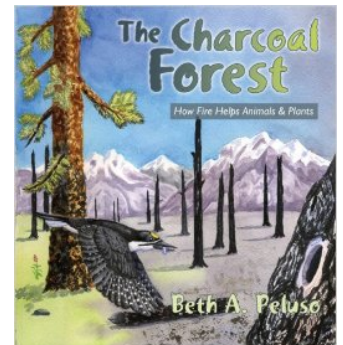


**Conclusion (Student): Little Professor Moment: This moment encourages learners to teach other learners.** The students will turn in a summary of how droughts and fires are linked and share with another student.



**Go with the flow moment: This moment help learners to organize information using shapes, images, and directional arrows.** Ask students to create a flowchart of their interpretation of the relationships between human activities, natural disturbances and the forest ecosystem.(Note that Ticket Out handouts are in your memory drive in the Lesson 3 folder).

**Extended Classroom Activity:** Have students research interactions between drought, tree-disease, insects and fire and present to the class what they find. Have students research the fire history of Smokey the Bear. Use actual series of temperature and precipitation records and ask students to reconstruct those data points by drawing a series of tree-rings that reflect the wet and dry years – the end result will be a tree-ring cross-section that they draw based on the data that you provide. Have students examine additional fire scarred samples by borrowing a fire kit from the lab or invite a docent to come to your classroom to do a hands on activity with your students. Or even visit our lab!



Have students read the Bear Essential news on Dendroecology that is in your Lesson 3 Folder and in your readings folder. There is also a great book titled "The Charcoal Forest" that may be read in class.  
<http://www.amazon.com/The-Charcoal-Forest-Animals-Plants/dp/0878425322>

**Evaluation:** Students will be evaluated by short activities, periodic quizzes or exams based on grade level and classroom needs.



**The Laboratory of Tree-Ring Research**  
**The University of Arizona**  
**1215 E. Lowell Street**  
**Tucson, AZ 85721**  
<http://ltrr.arizona.edu/>

## **Lesson 4 Title: The Tales Trees Tell**

### **Examining the human connection to trees**

**Area:** \*This section related to ADE standards is to be completed by the K-12 educator. The study of tree-rings fits in to every strand/concept and can be connected to any subject area from Art History to Zoology! Need materials? Contact us at [outreach@ltrr.arizona.edu](mailto:outreach@ltrr.arizona.edu)

ACADEMIC STANDARDS:			
<b>Unit (ADE Standard):</b>	R__	M__	SC__
INDICATORS:			
<b>Lesson Title (ADE Measurement Strand/Concept Criteria):</b>	S_C_	S_C_	S_C_
<b>Objectives:</b>	PO:	PO:	PO:
<ol style="list-style-type: none"> <li>1. <b>Describe</b> how humans have used/interacted with trees throughout human history</li> <li>2. <b>List</b> descriptive words and emotions that are related to trees</li> <li>3. <b>Demonstrate</b> a connection between art and science by creating artwork/skit that analyzes and interprets one or more aspects of tree-rings</li> </ol>			

**Need:** This lesson explores the human connection to trees and the many ways we use trees in our daily lives. This lesson is a creative challenge that summarizes fundamental aspects of tree rings, emphasizes the events shared by humans and trees, and provides a synthesis covering the many ways we have connected to trees and tree-rings over time.

**Time:** 60 min (may be divided by 2 600 minute sessions depending on the set up, performance needs, and class size: 1 review and create session and 1 prep and perform session)

#### **Realia (Tools, Equipment, and Supplies):**

- Tales Trees Tell Lesson 4 Presentation
- List of Tree-Ring Vocabulary Terms for each team
- Review sheet listing parts of the tree for each team
- Review list of processes that enable tree growth such as photosynthesis

- art supplies
- poster board
- magazines/recyclables with imagery related to trees
- fun/random/imaginative props that students can use to enhance their presentation and challenge them to connect unlikely shapes and props to tree-rings to demonstrate higher cognitive processes.
- timer
- rubrics for each group, for each evaluator/student
- You tube videos of Public Service Announcement or the More You Know Campaign videos (optional)
- Any inspiring readings or tidbits that provide inspiration and imagery!

**Key Terms:** (This is a comprehensive list of the vocabulary that may be helpful to review or introduce for this lesson and you may choose the terms that make sense for your grade level and classroom needs from this list for this lesson.) application of tree-ring science, annual ring formation, connection, dendrochronology, emotion, evaluation, indigenous, inspiration, interaction, interpretation, presentation, prop, public service announcement, rubric, tree growth processes, tree-ring vocabulary, visualization.

Prep: Print handouts, props, rubrics set out and have art supplies and a timer ready! You may want to arrange the desks so that there is room to observe as an audience and room to perform as actors!

**Bellwork Option 1:** Ask students to answer: How have humans used or interacted with trees over time? (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 4 folder on your memory drive).

**Bellwork Option 2:** Ask students to answer: How might a researcher use data from tree-rings? (Note: A bellwork handout has been made for you and is included with this lesson plan in your Lesson 4 folder on your memory drive).

### Interest Approach:

Ask: How many human connections to trees can you think of in one minute?

List the student answers on the board.

Ask: how have humans used or interacted with trees over time?

List the student answers on the board.

State: Wonderful – it is nice to hear all of these great connections!

State: Humans have always had a strong connection. Here we see images of many uses of wood over time and around the world.

Ask: What special uses have you seen in Arizona? Other places?

Show images from lesson 4 presentation.

State: Indigenous people had an awareness of tree rings however it was an astronomer by the name of Andrew E. Douglass that formalized the study of tree-rings.

Ask: Does anyone remember what the study of tree-rings is called? Dendrochronology

State: Today we are going to talk about connection to trees. So I want you all to close your eyes and visualize your favorite tree and think about the events it may have experienced. If you are 5000 years old you have probably experienced many events. If you are 4 years old you are just starting to explore your environment. I will give you 2 minutes of silence to visualize your tree.

Wait 2 minutes and ask the class to refocus and open their eyes.

State: Now that you have your trees in mind, I know you are ready to tell everyone about tree-rings!



**Activity: Dickens Moment – this moment provides opportunities for learners to work in small groups to create and perform/present scenes to an audience to reinforce concepts.**

**State:** Your task is to create a 2 minute skit in the form of a Public Service announcement that reminds people of the importance of trees and emphasizes the applications of tree-ring data. You will perform the skit and must include the following items:

3+ Tree-ring vocabulary terms

1+ reason for studying tree-rings

2+ applications of tree-ring records

A connection to tree-rings through your visual aid made with the art supplies

Your secret prop!

**State:** You will be evaluated using the following system (explain rubric with Lesson 4) Note that you can tailor this to fit your classroom needs as it is a great way to work in active listening and critical thinking and writing skills.

**State:** Be ready to share your announcement for the group! Plan on 2 minute limit

**State:** You will have \_\_\_\_ time to prepare your skit and visual aid, Remember you must use your special prop as well! I am excited to see what you all create!

Have students prep their visual aids and skit. As one group performs their skit the rest will use the rubric to evaluate as well so be sure to **restate:** that when you aren't presenting you are evaluating!

Enjoy the presentations and feel free to have our docents join your class on the day of your presentations or if you like, bring your class to the lab and perform in our lobby for a special event.


### **Summary of Content and Methodology**




**Earth Friendly Tips:** Ask students to bring in realia for you to save on gas and carbon emissions, print double sided handouts without color, have students view handouts on computers, or laminate handouts to reuse with other classes and give students dry

erase markers which can be wiped off after each use, reuse the backs of old posters and scratch paper for this lesson. Check out books from the lab or the library and share the love of trees!

**Summary (Teacher):** The teacher will use the rubric to evaluate presentations to help the students summarize the lesson.

 **Conclusion (Student): Ticket Out Option 1: Hole in One Moment: This moment guides learners to visualize each step of a concept, imagine the end result and demonstrate their thoughts through a drawing. Ticket Out Option 2: Einstein Moment: This moment guides learners to create a mathematical equation to express a concept such as  $A+B = C$  or  $D=M/V$ . (Note: A Ticket Out handout has been made for you and is included with this lesson plan in your Lesson 4 folder on your memory drive).**

**Application:** Students may now teach others about tree-rings using their newly acquired knowledge and their wonderful presentations!

 **Extended Classroom Activity: Cartographer Moment. This moment inspires learners to use or create maps to research concepts and express ideas.** Have students create a map of the trees in their own yards and explore what types of data they may be able to collect about those trees. **Hieroglyphics Moment. This moment inspires learners to create their own symbols to express an idea.** Have students create a legend for their tree map using symbols they assign to specific trees in their yard.

**Evaluation:** Students will be evaluated by a rubric which guides the use of tree-ring related vocabulary, processes and concepts related to the study of trees and tree-rings, and connections to tree-ring research through a short small group presentation by the students. Students will present in small groups while the audience practices active listening and writing skills by completing the rubric as well.



# UA Laboratory of Tree-Ring Research Contacts

The following is a list of individuals that are available to assist you and your students.

LTRR Main Website: <http://ltrr.arizona.edu/>

LTRR Outreach Website: <http://ltrr.arizona.edu/outreach>

LTRR Public Calendar of Events: <http://ltrr.arizona.edu/calendar/month>

LTRR Facebook Page <http://goo.gl/2qRGqS>

Pamela Pelletier, M.S. – Director of Outreach, Sky Island Science Investigators Program  
[pamela@email.arizona.edu](mailto:pamela@email.arizona.edu) T. 520.248.9933

Arin C. Haverland, Ph.D. – Outreach, Research, and Education  
[arin@email.arizona.edu](mailto:arin@email.arizona.edu) T. 520.248.0714

Randall Smith – Retired Educator and Docent [rsmars@aol.com](mailto:rsmars@aol.com)

Will Smalzer - Retired Educator and Docent [wsmalzer@yahoo.com](mailto:wsmalzer@yahoo.com)

Janice Gallagher - Retired Educator and Docent [jregallagher@hotmail.com](mailto:jregallagher@hotmail.com)



# Suggested Readings

The following is a list of books that are suitable for many audiences and are related to trees and tree-rings. This list of books was composed by our lead docent Randall Smith.



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OF ARIZONA

# Additional Tree-Ring Related Resources

The following is a collection of various activities and readings that you may use for educational purposes.

1. <http://ltrr.arizona.edu/outreach/sky-island-science-investigators>  
LTRR info on 4-8th grade field classes
2. <http://ltrr.arizona.edu/outreach/become-docent> LTRR Activities
3. <http://ltrr.arizona.edu/outreach/tree-ring-open-house-tucson-festival-book> LTRR Event Info
4. <http://ltrr.arizona.edu/content/art-bryant-bannister-tree-ring-building> LTRR News Story
5. <http://video.pbs.org/video/2330301577/> LTRR News Story
6. [http://www.nytimes.com/2015/04/14/science/californias-history-of-drought-repeats.html?smid=fb-share&\\_r=0](http://www.nytimes.com/2015/04/14/science/californias-history-of-drought-repeats.html?smid=fb-share&_r=0) NYT News Story
7. <http://uanews.org/story/the-art-and-science-of-the-environment> UA News Story
8. <https://goo.gl/21vkYx> UA News Story
9. <http://uanews.org/story/the-lord-of-the-tree-rings>  
UA News Story
10. UA News Story
11. <http://www.bbc.com/news/science-environment-31588671> BBC News Story
12. <http://goo.gl/QeIT1x> video
13. <http://video.pbs.org/video/2330301577/> video
14. <http://www.npr.org/2012/08/23/159373691/how-the-smokey-bear-effect-led-to-raging-wildfires>  
NPR video
15. <http://www.12news.com/story/weather/talking-weather/2015/11/15/treering-time-travel/75837144/>  
LTRR on ABC News Phoenix
16. <https://www.youtube.com/watch?v=GvuLjhdEBoo> Dedroclimatology video



# Workshop Kit Materials

After successful completion of the “Branching Out” Dendrochronology STEMAZing Workshop, you will receive an educator’s kit with materials that will assist you in bringing the study of tree-rings in to your classroom. The Introductory Dendrochronology Kit includes:

- Workshop Notebook with lessons and supplementary materials
- A memory drive with lesson plans and supplementary materials
- Tree-Ring Cross-Sections and Cores from various tree-species
- Re-useable Dry Erase Laminates
- Macrolenses (for use with a cell phone camera for magnification)
- Magnifying Glasses

The Laboratory of Tree-Ring Research also has portable dendrochronology kits and other teacher materials available for loan to educators, as well as guest speakers that will visit your classroom ad bring samples for students of all ages. For information on lab tour, classroom visits, field classes and materials for loan please contact our Outreach Team at [outreach@ltrr.arizona.edu](mailto:outreach@ltrr.arizona.edu).



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