

Dendrochronology



Teacher Reference Unit

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



THE UNIVERSITY
OF ARIZONA

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

Arin C. Haverland

Arin C. Haverland, Ph.D.
Outreach & Research Assistant
arin@email.arizona.edu



THE UNIVERSITY
OF ARIZONA

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.



THE UNIVERSITY
OF ARIZONA

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.



THE UNIVERSITY
OF ARIZONA

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!



THE UNIVERSITY
OF ARIZONA

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



THE UNIVERSITY
OF ARIZONA

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)



The Laboratory of Tree-Ring Research

The University of Arizona

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	Fire Regime	Phenology
Anthropogenic	Fire Scar	Phloem
Bark	Fire Severity	Photosynthesis
Branch	Fire Triangle	Precipitation
Cambium	Geography	Proxy
Carbon Cycle	Geology	Ray
Cell	Hardwood	Resin Duct
Cellulose	Increment Borer	Sapwood
Climate	Insect	Signal
Core	Instrumentation	Skeleton Plotting
Cross Dating	Interdisciplinary	Standardization
Cross Section	Latewood	Tree-Cookie
Dendrochronology	Limiting Factor	Topography
Disturbance	Master Chronology	Variability
Drought	Nutrients	Vessel
Earlywood	Palmer Drought Severity	Wildland Urban Interface
Evapotranspiration	Index (PDSI)	Xylem



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 T. 520.248.9933

Arin C. Haverland, Ph.D. – Outreach, Research, and Education
arin@email.arizona.edu T. 520.248.0714

Randall Smith – Retired Educator and Docent rsmars@aol.com

Will Smalzer - Retired Educator and Docent wsmalzer@yahoo.com

Janice Gallagher - Retired Educator and Docent 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.



THE UNIVERSITY
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 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.



THE UNIVERSITY
OF ARIZONA

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.

