Dendrochronology: A sampling of the study of tree ring dating

Amanda Sesler

Geology of the Sierra Nevada, 2009

Abstract:

Dendrochronology is a complicated science that has gained credibility over the last 100 years. Dendrochronology is the study of tree rings and how their annual growth aids in dating. Methods such as cross dating and radiocarbon dating are used to determine the chronology of tree rings from several different tree populations. Exploration of tree ring dating in equatorial regions is occurring. It is also used as a tool in the science of geology to determine the relative age of landforms

Table of Contents

1. Introduction/Background

Dendrochronology is the study of tree rings. This study has allowed accurate records of time to be created and managed. This study is a very important tool in other sciences, including archaeology and geology. The words of researcher Kevin Smith describe dendrochronology as “a tool to better understand the web of earth, ocean, atmosphere, life, and human society” (Smith, 2008). This statement sets the tone for the work that dendrochronologists do.

Andrew E. Douglass and Bruno Huber worked in the first part of the twentieth century to develop dendrochronology. Their work caused dendrochronology to be observed as an acknowledged science. (Eckstein and Schweingruber, 2009). Their work inspired other dendrochronologists to expand explore the world of tree ring dating. Technology continued and intensified the work that Douglass and Bruno started. Computers increased the accuracy of counting and compiling tree rings information.

Trees are temperamental organisms that are great indicators of climate and weather, so archaeologists use dendrochronology to study why peoples may have migrated. Geologists use dendrochronology to get relative ages of landforms that are formed, such as fissures, domes and volcanoes.

2. Up and Out: How tree growth helps with dating

Trees are organisms that are formed through mitosis. Trees grow through extension growth. Extension up allows the tree to be more competitive for energy. Extension allows for healthy competition for minerals and water in the soil. Many saplings and weaker trees die. This runs synonymously with the theory of natural selection. The best design for a tree is to distribute the stress equally to avoid overbuilding, which allows the tree to use the energy saved more

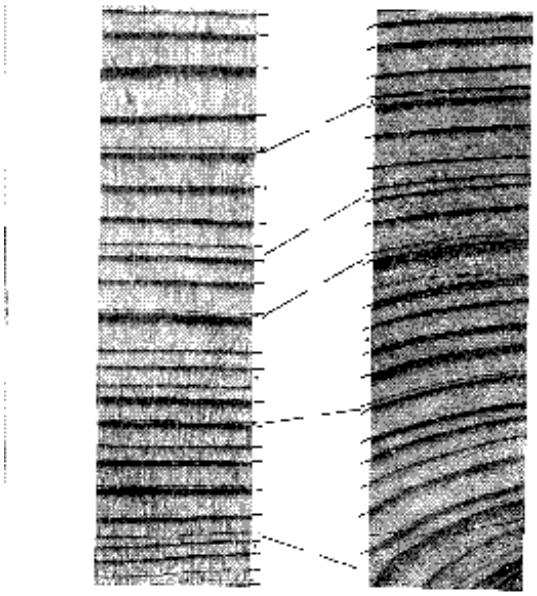
efficiently. Blips in tree rings can be found in places where a tree had to concentrate more of its energy to supporting the weight at that part of the tree. Tree rings are mainly a phenotypic way to observe the wood.

Tree rings typically form in annual pattern. This annual growth pattern is what makes trees a reliable way to date and configure data. Most of the studies that have occurred have happened in more temperate climates. In extreme climates where the annual growth is not apparent, the chemical signatures within the wood are used to determine ring boundaries, which tend to coincide with the rainfall patterns in the environment of the trees (Poussart, et.al 2006 from Smith, 2008).

Long tree-ring series stem from long-lived trees and the absence of decay and natural disasters (Smith, 2008). Trees such as the bristlecone pines are perfect examples of a long tree-ring series. They are further discussed in section 6 of this paper.

3. Importance of cross dating

"Baille (1995, pg 20) described cross-dating as the 'art of dendrochronology'" (Wills et. al, 2007). This is an accurate way to describe cross dating, because it allows scientists to see patterns in rings for larger areas of land. These patterns can be used to determine climate and weather patterns that occur over macroclimate sites, such as the Olympic Peninsula or the Saharan desert



This picture is an example of how different trees' rings are compared using cross dating. This picture can be found at the website below (www.ltrr.arizona.edu/lorim/basic.html)

(Stokes and Smiley, 1968). Macroclimate sites are regions that have been labeled as having similar weather patterns. These labels are determined by the similar patterns that are found in the tree ring record. Climate, precipitation, and density of the population are factors that affect tree ring growth. The differences and similarities created by these factors are what makes cross dating possible.

The trial and error method of meticulously matching rings together is somewhat reminiscent of the hermeneutic circle (Wils et.al)[1]. This method occurs between individual ring-width series and the ring width series as a whole. To determine the chronology of a group of trees the rings from the individual trees must be counted and the age of each of the individual specimens determined. Once that occurs cross dating begins. The cores are matched up by thickness of the rings and each ring's color. The different colors and widths of the rings can help determine the amount of rain received during the year of growth because on a wet year the thickness of the ring will be greater and the color lighter. A dendrochronologist must also find the average, or typical growth, of the tree by looking at the rings and measuring the typical width. The tricky part about this guess work is that all trees have a different rate of growth. They must find the average growth of each tree and then match it to the patterns of width in other tees. This guesswork is where the hermeneutic method comes in. They determine the individual rings, and then determine how in the individual growth cycles relate to each other through cross dating. They may not match up exactly, but there is enough of a pattern within the individual ring patterns, that a pretty accurate form of dating can be determined by a skilled dendrochronologist.

[1] The hermeneutic circle is a circular movement of thought between and individual part and the whole in order to deepen the understanding.

Cross dating is also a useful tool that allows for the comparison of weather patterns across several regions. If the patterns coincide with each other the size of the weather system can be inferred. Figure 1 on the previous page displays the uses of cross dating in collaboration with radiocarbon dating. The tree ring chronology is able to use samples from Seattle to Belfast to create a more detailed and accurate chronology.

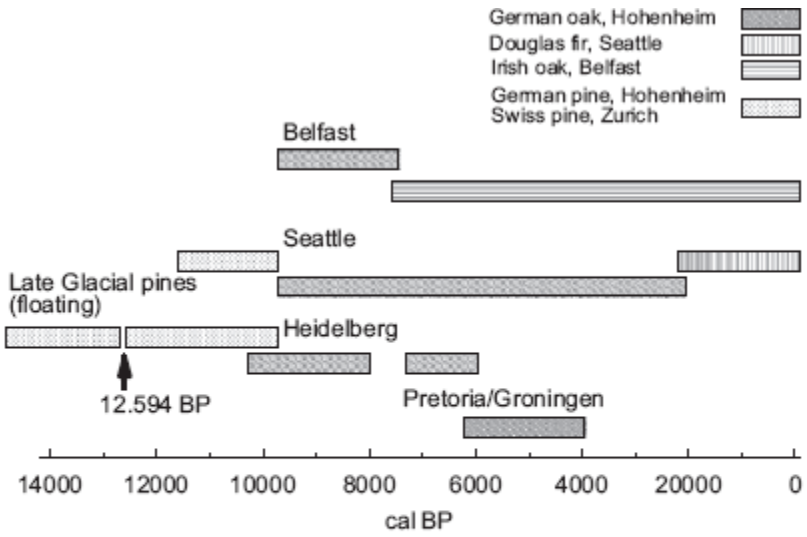


Fig. 1. Tree-ring-based ^{14}C data series obtained from three tree-ring chronologies. The names of the ^{14}C labs are given above the bars. The species and the tree-ring laboratories are shown in the legend.

4. Radiocarbon Dating

Radiocarbon dating is a reliable dating method that would be much less accurate without the tree ring record. Trees are sturdy, yet temperamental organisms. They are affected by changes in temperature, weather, climate, and the atmosphere. The most reliable indicator of how much 14c is found in the atmosphere at a certain time is tree ring cellulose because directly reflects the makeup of the atmosphere in which in which it was formed (Kromer, 2009). Samples of very well preserved and useful tree rings are found mostly in alluvial sediments and arid conditions respectively. Living trees with a long history are typically found in arid conditions, where as alluvial sediments preserve dead trees in such a way that they are still used for research. These arid and anoxic conditions preserve the trees and make them wonderful specimens, free of rot or other decay that would affect the ability to take a useful sample.

The tree ring chronology would not be as long as it is without the technology of radiocarbon dating. This is true because there is a period of 'floating tree ring sections'. These sections are lengths of time, where the ring record seems to disappear. There were about 500 years missing in the bristlecone forest. Radiocarbon dating can be used to assign floating tree ring sections to within a few decades using 'wiggles'[2] (Kromer 2009). Wiggle dating is a method of cross dating that uses radiocarbon dating to accurately place tree rings into the holes that are found in the tree ring record. The more trees that are sampled the more accurate the radiocarbon data can be. It is just like any other experiment in the data collection stage. The larger the number of samples you have, the more accurate your results will be. The use of cross-dating and wiggle dating of the wood in Marmotta, Lazio, Italy allowed researchers to calibrate the floating sequence to 22 years rather than 110 that a single sample would use. (Kromer, 2009). The 14c wiggle matching is found in the figure above.

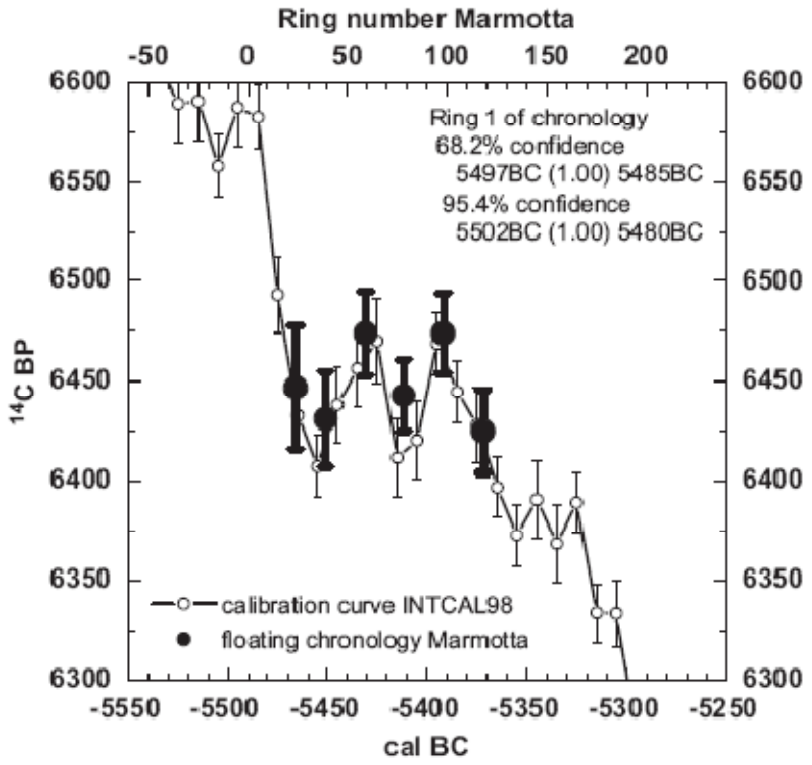


Fig. 3. ^{14}C wiggle-matching of the floating oak chronology Marmotta. The calibrated position of the first ring of the sequence is given in the inset text.

[2] Wiggles are fluctuations of 14c in the wood.

5. Equatorial tree ring dating

There are two methods of sample collection for tree: coring and cross-sections. Coring is done with a tool that bores a hole into the side of the tree and removes that gives a small core to get a sampling of the rings. Cross sections are taken from a highpoint on the tree and tend to effect the growth of the tree, but for trees found in equatorial regions this method is preferred. This preference is due to the fact that trees that grow in the equatorial region do not have an annual ring cycle. They put on rings that pertain to the wet and dry seasons. This poses a problem when an area doesn't have a typical pattern to its wet and dry seasons. Some areas have two wet and two dry seasons. Some areas have one short rainy season. It just depends on the area.

This makes the typical dating method of annual tree ring dating a difficult task. The long and steady process of determining where the rings begin and end starts with figuring out what type of cells were formed when it was wet and when it was dry. Once this process is completed radiocarbon dating can be used to gage the amount of 14c in the atmosphere at the time that tree added a certain ring. This in turn can expand the accuracy of the ring record. Radiocarbon dating and dendrochronology work hand in hand with each other to create an accurate record.

The figure below shows an example of how scientists go about determining which rings are annual, and which are seasonal. If you remember the diagram of rings from the section on cross dating you will see that the rings of tropical trees are much more indistinct compared to those found in temperate climates.

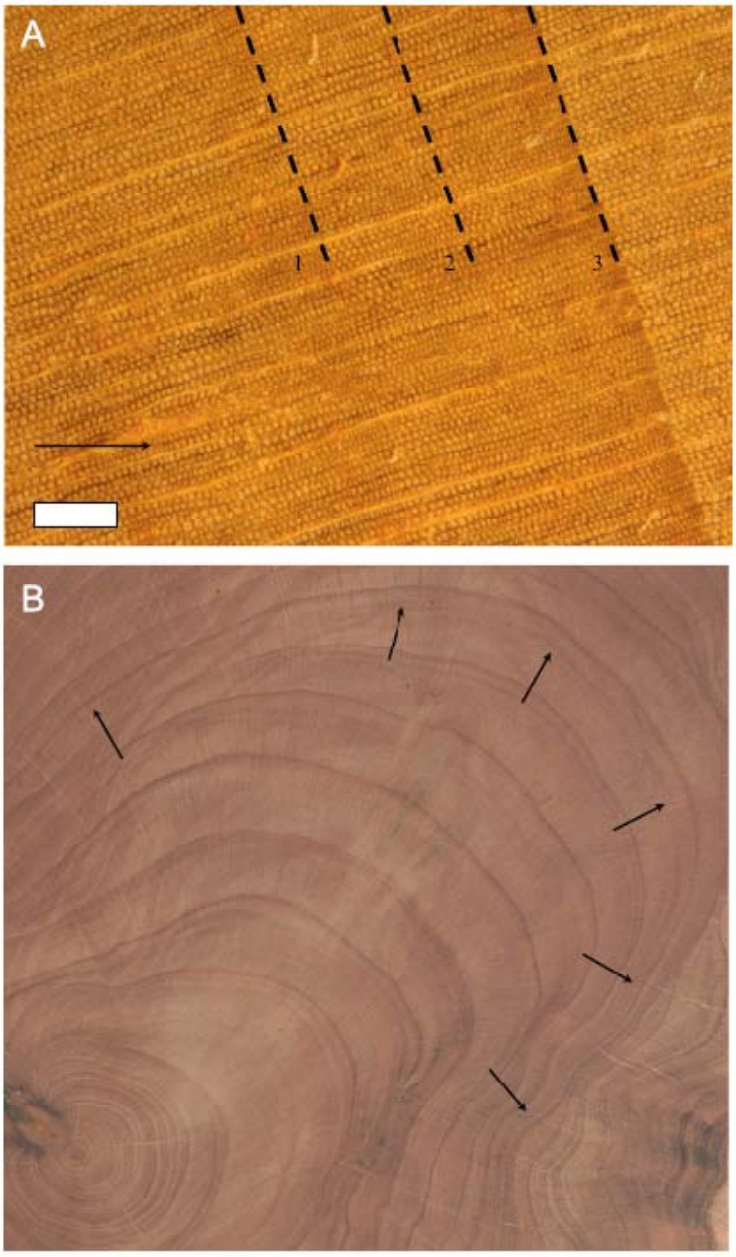


Fig. 3. Ring distinctness in *Juniperus procera*. (A) Growth-ring 7–9 in tree 2. Growth is from left to right (marked by an arrow) and measured ring boundaries are indicated. Boundary 3 is clear and continuous, whereas boundaries 1 and 2 are weaker and partial. During crossdating boundary 2 was discarded. Magnification is 4 × and scale bar is 500 μm. (B) Partially indistinct growth ring in tree 8, indicated by arrows. The ring boundary changes from distinct (bottom right) to less distinct (top right), to indistinct (top left).

6. Importance of the Bristlecone Pine (*Pinus Longaeva*) to future research

Bristlecone Pines (*Pinus Longaeva*) are an amazing species of tree that grows on the rocky outcrops of the White Mountains and around California and Colorado. The Bristlecone pine trees contain a constant tree ring sequence back to 6700 BC. The arid climate of the mountain deserts that they live in are responsible for the wonderful preservation of the trees (alive and dead).

The focus of the research occurring at the White Mountain bristlecone stand is a climatic series or a recreation of past climate activity (Ferguson and Graybill, 1983). Through this research the focus on dendroclimatology has increased. The bristlecones have two different 'treelines', so the difference in the two line are what is being studied as well as the affects that the rising temperatures in higher altitudes are having on the trees.

7. Dendrochronology as a geologic research tool

Dendrochronology is a very important research tool that many geologists use. Dendrochronology can be a useful tool to judge the age of geologic features. For example, at the distant observation of two volcanic domes, it could be understood that the dome with more vegetation is older. This is probably a safe assumption, but with the tools that dendrochronology provides create more accurate data about each feature that the trees are found on. The age of a crevice can be determined by the trees that grow inside of it. A geologist would infer that the crevice or fissure believe is at least older than the trees that grow inside of it. Dendrochronology can also be used to solidify the years in which massive volcanic eruptions occur. Massive stands of growth with trees all about the same age lead the observer to believe that some type of

massive die out occurred before the trees began to grow. If trees in a certain area are all about the same age as an eruption trees can be used to measure the distance of the explosion.

8. Conclusion

Tree growth is effected by many different environmental factors that allow trees to be an important tool for dating. The Carbon 14 level in tree rings makes them a reliable way to solidify the tree-ring record. Radiocarbon dating would not be reliable without the aid of dendrochronology, but dendrochronology would not be as accurate with radiocarbon dating and the use of wiggle dating. Wiggle dating is a method that is used in radiocarbon dating and cross-dating to find the most accurate time table of tree rings in many different regions. Cross-dating allows dendrochronologists to look at bigger picture of widespread effects of climate on a large population of trees. It also allows scientists to compare trees from different countries and different areas. This ability lengthens the record from the lifetime of one stand to the lifetime of every tree on the planet. Equatorial trees are not the most ideal for samples for dating that we have available to us, but the research that is happening today is moving toward a reliable way to date equatorial plants. These methods will help us in the future to understand the affects of climate and environmental changes on trees in the long term. Dendrochronology is a helpful tool that allows more absolute dates to be given to abrupt changes in climate and the environment. Geologists use dendrochronology to expand their knowledge of the timeline of the planet by using the trees to infer when the most recent activity occurred.

Bibliography

1. Eckstein and Schweingruber (2009). Dendrochronologia—a mirror for 25 years of tree-ring research and a sensor for promising topics. *Dendrochronologia, Vol 27.*
2. Ferguson and Graybill (1983). Dendrochronology of the Bristlecone pine: A progress report. (Electronic format). *Radiocarbon, Vol 25.*
3. H.G. Wils, et.al (2009). Periodicity of growth rings in *Juniperus procera* from Ethiopia inferred from cross dating and radiocarbon dating, *Dendrochronologia, Vol 27*
4. Kromer (2009). Radiocarbon and dendrochronology, *Dendrochronologia, Vol 27*
5. Smith (2009). An organismal view of dendrochronology, *Dendrochronologia, Vol 27*
6. Stokes and Smiley (1968). *An Introduction of Tree-Ring Dating*. Chicago: University of Chicago Press.