Researchers at the University of Arizona's Laboratory of Tree-Ring Research are using dendrochronology to learn about the history of the Southwest.

The Truth In The Tree Rings

By Jasmine Demers

The noted businessman, mathematician, and astronomer Percival Lawrence Lowell was obsessed with Mars. To study the distant planet, he founded an eponymous observatory in Flagstaff, in what was then the territory of Arizona, in 1894. Lowell hired another astronomer, A. E. Douglass, to design the telescope and observatory. Douglass, however, was preoccupied with solar variability rather than Mars, and he began studying trees to see if there was a correlation between tree-ring widths and sunspot cycles, which he believed affected the Earth's climate. And so it was, curiously enough, that an astronomer founded the University of Arizona's Laboratory of Tree Ring Research (LTRR) in 1937.

The LTRR is the world's premier laboratory devoted to dendrochronology—the study of tree ring dating. By the time the LTRR opened, Douglass had already been analyzing tree rings for over thirty years, fathering the science of dendrochronology in the process. Dendrochronology operates on the principle that in temperate climates like the Southwestern United States trees grow one ring every year. In the best of circumstances, researchers can count each of these rings to find out how old a tree was when it was cut down. But dendrochronology, particularly as it is applied to archaeological samples, is considerably more complicated than simply counting rings. "The essence of tree-ring dating is matching the sequence of narrow and wide rings from one tree with those of other trees to establish a pattern of ring-width variability common to all trees in the group," said Jeff Dean, professor emeritus at the LTRR. "The matching process is called crossdating and is the foundation of dendrochronology."

The width of each ring is based on the amount of water a tree absorbs in a given year. Wet years are marked by wide rings, and dry years by narrow ones. Trees develop the same pattern of rings across the same region and climate. So, for example, if a particular forest gets a lot of rain in a given year, then all of the trees in that forest will grow a wide ring that year. Because of this, dendrochronologists can compare the tree-ring patterns of one tree to other trees in the same area. "We use hundreds of trees for several reasons. First, we strive to capture the pattern common to large numbers of trees in order to minimize the idiosyncratic effects of differences between trees," says Dean. Second, we attempt to capture localized variations by studying separate chronologies for different localities and species. These local chronologies are necessary because climate and tree-ring growth can vary from place to place within a given region.

To identify these patterns, they sand a crosssection of the wood's surface so they can see each ring. Researchers take core samples from living trees in order to study their ring patterns. Then, using a pencil, a microscope, and a graph paper, they plot each ring from the inside to the outside of the wood's surface. Because trees from the same climate or region share ring growth patterns, dendrochronologists are able to compare numerous tree samples. "One tree may have aberrant growth patterns for a variety of reasons," said Ron Towner, a researcher and professor in archaeological dendrochronology at the University of Arizona. "These growth patterns are a function of the environment, and the more we know about the environment, the more we can learn about the tree."

The Laboratory of Tree-Ring Research's archaeological samples include this cross section of a Douglas fir root that supported the roof of a pit house in Broken Plate Cave in northeastern Arizona. Its center ring dates to A.D. 522, and it was cut down in 623. The small cross section in the upper left is that of a branch that was part of this tree.
trees that extended to the late A.D. 1300s, and its inner rings matched the outer rings of samples Douglass had obtained from archaeological sites older than 1300. Thus HH-39 bridged the gap between the chronologies of living trees and ancient samples, resulting in the beginning of tree-ring dating of archaeological sites.

Douglass and his team were able to assign definitive dates to some prehistoric Southwesterner ruins for the first time. For example, Towner said there had been various theories about how old the cliff dwellings in Mesa Verde National Park were, but no one actually knew. Using dendrochronology, Douglass found that various cliff dwellings dated to the late-twelfth and early-thirteenth centuries. “He was able to absolutely date, to the year, when archaeological sites were built or occupied,” said Towner. “It was the first time in the world that anyone was able to do that with prehistoric archaeological sites.”

In an article in National Geographic in December 1929, Douglass wrote: “The successful dating of the many ruins of the pueblo area that this research has made possible enables us now to correlate the increases of rainfall that permitted these villages to expand and the drought years that placed upon them the heavy hand of starvation. With careful archaeological study we shall perhaps be able to trace the movements of clans and test tribal traditions which have been so often quoted as the early history of these people. In the combination of climatic conditions with tribal activities we have a rich field for studying the influence of climate on human history.”

Since its establishment, the LTRR has continued Douglass’ efforts to make significant contributions to archaeological studies. Of the lab’s several million tree-ring samples, approximately 400,000 are archaeological samples from the Southwest. The LTRR’s master chronology of modern and archaeological samples from the Southwest extends back to 322 B.C., and its researchers have assigned more than 60,000 dates to samples from over 5,000 sites. When an archaeologist finds a piece of wood, dendrochronologists prepare a cross section and then match the pattern of the growth rings of the wood to those in the already-established chronology to determine the year the tree was cut down. “If we have enough trees and samples from a specific area, we can match those patterns up,” Towner said. “That allows us to move beyond just living trees.”

The tree-ring samples also provide paleoclimate data. “Especially in the Southwest, because the trees are limited by water, we’re able to then use those rings to...”

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Archeologist Pete Davis takes a core sample from a beam of a cliff dwelling at the Crum. On Your Belly site in southeast Utah.

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The problem with applying tree-ring dating to archeology was that dendrochronology was hard to date a site. However, after reading Douglass’ research on tree growth and rainfall patterns, an archeologist named Clark Wissler wrote to him asking if it was possible to apply dated samples from living trees with wood from ancient ruins by correlating their ring patterns. “Douglass was trying to reconstruct the climate with tree rings, and living trees only go back so far,” said Dean. Wissler got the idea that you could extend that sequence back farther and farther using samples from archaeological sites.” In 1917, Douglass began developing chronologies for wood recovered from colonial Spanish churches and Ancestral Puebloan buildup. Twelve years later, he made a discovery that would have a significant impact on archaeological dating. A beam labeled HH-39 was recovered from a site in Snow Low, Arizona. The outer rings of HH-39 matched the inner rings of the dated chronology of living...
reconstruct precipitation patterns," Towne said. "We're able to see droughts, wet periods, and then compare that to the archaeology work that we do. "The samples can also reveal information about temperature: brief periods of extremely cold weather are manifested in frost-damaged rings. This information, in turn, informs our study of ancient human behavior. "It's absolutely critical in terms of understanding how people adapted as societies to major environmental and social changes," Towne said. "A lot of times it was migration. Other times it was changing their subsistence patterns." He noted that tree-ring data from eastern Utah, when correlated with other archaeological information, shows that during times of adequate precipitation, people often farmed. But during droughts they resorted to hunting and gathering.

"The archaeological samples also reveal how people viewed wood as a resource and how they exploited forests. Since starting his career at the lab in the 1960s, Dean has become a pioneer in gaining insights into human behavior through analysis of the samples. "You can," he said, "understand how people used logs and turned them into beams, what tools they used, what species they used for different purposes. And it varies from group to group."

In his current project, Dean is working to extract additional information from archaeological sites on Black Mesa on the Navajo Nation in northern Arizona that were excavated by Prescott College and Southern Illinois University researchers in the 1960s, 70s, and 80s. "There's more information that we can get other than dating, such as tool marks," he said. In his lab Dean has dozens of tree-ring samples from this site covering the surface of his desk. "Some of the samples have small, precise chips in their edges, indicating a metal axe was used. Others show more uneven chopping marks that were likely made by a stone axe. By knowing what types of tools were used, archaeologists can study how ancient humans made things, which contributes to their understanding of how these people lived and evolved over time.

In another project, Towne is using tree-ring data to analyze the use of cambium-peeled trees in the Zuni Mountains of New Mexico. The cambium layer, which is a layer of plant tissue between the tree's bark and wood, helps the trunk, branches, and roots grow. Historically, people have peeled and used this layer, but the reason for this is still being debated. "There's been a controversy for a long time about what people used these layers for," he said. "Was that starvation food? Was it medicine? Some people say it was a sweet delicacy. Evidence of drought could suggest people consumed cambium to stave off starvation, but Towne has found dozens of these trees, which are still standing, dated to various times in the late 19th, 'none of which were particularly stressful climatic years,' he said. This evidence seems to weaken the starvation food theory.

Winders said tree-ring data provides invaluable information. "It works mostly in southern New Mexico, southeastern Utah, and southwestern Colorado, and he has used the LTRR for several decades. Windes began working on the National Park Service's Chaco Project, a major investigation of Chaco Canyon, in 1972. "...and that's when I got interested in wood, particularly all the structural wood that was still left in the Great Houses that nobody had ever documented or sampled," he said. "It took me ten years with a volunteer crew and we documented every visible piece of wood in Chaco's Great Houses," which amounted to about 10,000 pieces.

Winders now has a volunteer crew that comes from all over the country to help him survey sites and preserve details of the architecture. "We're interested in trying to get samples from the structure before it is displaced by looting, rots away, gets burned in a forest fire, or just disappears," he said. "In a lot of the historic sites, like mission churches that are being remodeled, nobody is recording what's happening to the wood, which can be reused elsewhere, tossed if it has partially rotted, or ritually deposed if it has sacred value." After collecting samples and sending them off to the LTRR, Windes receives an analysis from the lab that can provide a range of information such as dates, tree species, ring growth condition, frost-damaged rings, missing ring years, fire scars, and growth patterns of the forest from which the wood came.

"The work is particularly important not just for understanding when these structures were built, but also because they provide such good environmental information that tells us what was going on at that time in the local area," he said. Windes also compares the analysis of the samples with written and oral histories. "We've heard in some cases that logs were dragged down from the mountain by oxen, but we didn't often see that pattern on the wood. Part of the wood would be sorted of ripped or scraped off if that were the case," he said. "You have to double check your historic records and compare them to what you're finding. The tree-ring analysis can also help verify written and oral histories by providing exact dates.

"Wood is an artifact," Windes said. "There's nothing in archaeology, in my opinion, that provides greater potential for understanding things than a piece of wood."

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