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Using Ancient Trees to Reconstruct Climate History

Introduction:

Tree rings can tell us how well a tree has grown each year of its life. A cross section of a tree reveals a bull's eye pattern of rings of wood, one ring for each year of growth. If the tree had a good year — usually that means plenty of water — that year's ring will be a thicker layer of wood; if the conditions were poor for the year's growing season, the growth ring will be thinner. Since trees can live for many hundreds of years, we can count back from the present time to see how climate varied from year to year long before there was an instrumental record of weather.

By sampling tree rings from different regions scientists can ask many questions about historical climate patterns: How long did ancient droughts last? How large an area did they cover? How frequent were El Niños in the past? How severe were they? How did they affect global climate? How did ancient droughts affect human history?

Despite a wave of deforestation that accompanied human development, there are still ancient trees living in many parts of the world. They need attention and protection not only because they are part of our natural heritage, but also because they are a unique source of historical information. We spoke with Professor David Stahle about how tree rings have extended our knowledge of climate and climate's effects on human history.

ER: Professor Stahle, what is your training?

DS: I started as an archeologist at the University of Arizona but I became interested in tree rings and moved out of archeology into climatology and geography, and so I've got two degrees, one in archeology and one in geography and climatology. I was trained at the Laboratory of Tree Ring Research in Tucson — dendrochronology in the United States was developed there by A.E. Douglas at the turn of the century — and worked on the Mexican Tree Ring Project..

So I am a dendrochronologist now; that is, I use the annual growth rings in trees to study the history of climate and the environment. My position is professor of geography and geosciences at the University of Arkansas, and I'm the director of the Tree Ring Laboratory here, which I developed. It consists of myself and Dr. Malcolm Cleaveland, who is also a faculty member and a dendrochronologist, and our assistant, Matthew Therrell. We're part of the Department of Geosciences and we offer bachelor's level degrees, master's level degrees, and a doctorate as well. Our principal funding comes from the National Science Foundation Climate Dynamics Program.

ER: Why study tree rings?

DS: Trees are natural libraries of environmental history, and if we can decipher that record, then it is invaluable history of Earth's environment. People are interested in this history because of the potential for human alteration of both the environment and the global climate. So in searching for these natural archives we are hoping to place the twentieth century and even the twenty-first century into the more long-term historical context.

We've been funded by NSF since 1980 to develop a network of climatically sensitive tree ring chronologies,

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in the Southeastern United States at first, but now we're also working in Mexico and in Africa trying to develop tree ring chronologies that might record regional climate variability as well as the world-wide influence of the El Niño Southern Oscillation (ENSO).

So I and colleagues at other institutions are going to those places of the world where El Niño has an effect on the regional climate and where also there might be trees useful for long paleoclimatic studies.

ER: What do you do to a tree to get that information?

DS: Oftentimes people think we've got to destroy the tree to get tree ring data, but we don't. We use a small boring tool that removes a core from the tree approximately the diameter of a pencil, that leaves a wound about one-half inch in diameter through the living layer of the tree. Most species of trees can compartmentalize the wound and show no ill effects, so it is considered a nondestructive sampling technique.

ER: How do you get a history of climate from that?

DS: We would go into an old-growth forest and we would usually sample between twenty and forty trees, two cores per tree. Then we polish the cores and examine the rings under the microscope and date them to the precise calendar year in which the wood formed. We can compare tree growth year by year, which is an average of all the trees at our site. We can then compare this average tree growth for each year with the climate data for the last hundred years and calibrate the relationship between tree growth and, for example, rainfall. We can then use tree growth to estimate how much rain fell in the centuries before instrumental observation began. That's the nitty gritty of dendroclimatic reconstruction.

ER: Don't you also look for dead trees to sample?

DS: Yes, we use living trees, but we also often find old wood, fallen trees and old logs that oftentimes persist for centuries on the forest floor, either in very wet environments or in arid environments. We can use that material to extend the tree-ring record farther into prehistory than would be possible with any of the living trees.

We can plot the ring-width chronology from the old log in a time series, and match that with the chronology of living trees. That point of match might be hundreds of years ago. So suppose we have a 500 year-long chronology from a stand of living trees, and then we find a log that died 300 years ago that also had 500 rings on it. The outer 200 rings of the old log will overlap the earliest portion of our existing chronology. We can match up the growth rings and then extend the chronology back an additional 300 years with the dead wood, ending up with an 800 year-long chronology. So we look for the old living trees, but we also look for these older sources of well preserved wood.

ER: Does data from a tree represent its local environment or a larger area?

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DS: There are many complications that can obscure the climate signal in trees. A bear might come up and scrape the bark off of a tree; elephants in Africa push trees halfway over and eat half the canopy; that is a tremendous insult to the tree, and it is reflected in the tree rings. The naive interpretation would be that elephant damage was a period of prolonged

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