CLIMATE CENTRAL
Why Climate Change Matters

Timelines in Timber: Inside a Tree-Ring Laboratory

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By Michael D. Lemonick

From the outside, the white clapboard structure at Columbia University's Lamont-Doherty Earth Observatory, across the Hudson River and 10 miles north of Columbia's main campus in Manhattan, looks like it could be a suburban dentist's office. It's a modest, two-story, barnlike structure with a white metal awning over the entrance. Only a small, homemade sign beside the door, with the words "Tree Ring Lab" hand-painted on an inch-thick slice of tree trunk, betrays the building's true purpose.

Step inside and you find that the lab doesn't look especially lab-like: there's a single, large room, two stories high, with bookshelves, a display case (more tree slices), and, on a table toward the back, a small stereo microscope. Small offices open off this central room, and at 10 o'clock on a recent weekday morning, just about nobody was home. "That's usually the way it is around here," Kevin Anchukaitis, a young research associate professor at the lab said, emerging to greet a visitor. "People are out in the field as much as possible" — the field meaning Bhutan, China, Turkey, Mongolia, Alaska, Southeast Asia, South America and more — "pretty much anywhere there are trees."

Credit: University of Arizona.

The reason is that tree rings embody a record of climate change going back thousands of years, and they grow on every continent except Antarctica. "They let us reconstruct climate around the world, in both space and time," Neil Pederson, another researcher said, emerging from his office. Climate scientists use all sorts of proxies to study the climate as it was before modern instruments were invented, including ice drilled from Greenland and Antarctica and sediments from lakes and oceans. Tree ring studies, formally known as dendrochronology, are just one more.

Unlike the other proxies, however, tree rings, along with the scientists who use them, have recently come under attack. During the so-called Climategate episode, the phrase "hide the decline," which appeared in an email hacked by person(s) still unknown, became a skeptics' catchphrase. In their interpretation, it suggested that climate scientists were nefariously trying to hide a decline in global temperatures.

In fact, it simply meant that tree rings stop tracking temperature accurately, mostly at high latitudes, starting in about 1960, so that they had to be left out of proxy analyses. "Given that this tree-ring problem has been discussed openly in the scientific literature since 1995," Pederson said, "it's kind of ridiculous for anyone to suggest we've been keeping it a secret."

The basic idea behind tree ring analysis is straightforward enough. Anyone who's looked at the end of a log or the stump of a felled tree knows that the wood is divided into concentric circles. Each ring, generally speaking, represents a single year's growth, so a ring count can tell you how old the tree is (or, if it's cut or fallen, how old it was when it died). The maple tree in your backyard might have scores of rings. A giant sequoia might have upward of 3,000, and a bristlecone pine, found in the White Mountains of California, can approach 5,000 — the most ancient living organism on the planet. "People think, 'my child can count tree rings,'" Pederson said

It isn't nearly as simple as it sounds, however. If you look closely, it's evident that the rings vary in thickness, which is a mark (again, generally speaking), of whether the tree had a good year in terms of favorable temperature and moisture, or a bad one. The wood can vary in density from one year to the next as well, again in response to seasonal changes in weather.

That's why Anchukaitis and his colleagues, both at Lamont and at a handful of other major tree-ring labs in the U.S. and overseas, fan out as often as they can to get more samples: a single proxy, such as an ice core from Antarctica, tells you about what the temperature was locally at some time in the past. If you're interested in global temperature change, however, you need readings from all over the world.

You also need to look at the rings for more than one tree in each location. A single tree, Anchukaitis said, might experience slightly different conditions from a member of the same species a few yards away. Maybe it's more crowded by its neighbors, and doesn't get as much sunlight or water or nutrients. Maybe it's more exposed to the wind. Maybe it's in a depression, where it's protected. "We generally try to sample at least 20 trees at every site," he said.

Credit: University of Arizona.

They also take two or three samples from every tree: most trees are asymmetrical, so their rings can follow one pattern if you bore in from one side of the trunk and another from another angle. The words "bore in" aren't metaphorical. These people care about trees, so there's no way they'd chainsaw their way through a forest to get their information. Instead, they use a sort of auger, which Anchukaitis brandished as he explained how it works. It's a three-piece device: a hollow tube, perhaps three eighths of an inch thick, with sharp, screw-like threads on the outside at one end; a crossbar that attaches at the other end; and a "spoon" that slides in from the crossbar end.

To extract a set of tree rings, the field scientist turns the auger by hand, forcing it to bite deeper and deeper into the tree as a thin, cylindrical sample of wood is forced into the hollow tube. "It's best to do it by hand," Pederson said, because you can feel a change in resistance when you're reaching the center of the tree. "If you used some kind of machine, you'd blow right through it." When the auger reaches the tree's core, the scientist reverses direction, and when it comes out, the researcher uses the spoon to extract a long, cylindrical matchstick of wood.

Back in the lab, those long cylinders are glued into grooves machined into strips of tulip poplar ("beautiful wood," murmured Pederson, a true connoisseur), dried and, finally put under the microscope, where the divisions between rings — just one layer of cells thick in some cases — are easily visible. The goal is to find patterns of wider and narrower rings that appear from one tree to the next, along with patterns of density changes.

"In years when trees are under stress at a given site," Pederson explained, "maybe 15-20 percent of them won't form a distinct ring." The scientists mark the patterns for each sample on long pieces of graph paper in what they call “skeleton plotting”; the paper can then be slid back and forth to correct for those missing rings. If most of the rings line up for most of the trees but a few oddballs don’t, the majority probably reflects a true climate signal. This sort of comparison can also work for dead trees as long as they haven’t rotted, thanks to very dry, cold conditions, like you find in the Alaskan arctic, or from a lack of oxygen at the bottoms of lakes and some rivers. But it only works if scientists can find a ring patterns that overlap with those of living trees.

The rings still can’t say anything meaningful about climate, however, without one more crucial comparison.

“When you see a pattern of wide and narrow rings,” Anchukaitis said, “you know the tree is sensitive to something, but you don’t know if it’s temperature or moisture or both.”

To nail down the answer, you have to look at weather data, ideally gathered by modern instruments. Then, once you know how a particular species in a particular location grows in relatively, wet, dry, hot and cold conditions, you can assume — usually, anyway — that the trees responded similarly in the past.

And then, since sugar maples don’t grow in Southeast Asia, and the Tasmanian huon pine doesn’t grow in Alabama, and California redwoods don’t grow in Africa, you have to do these calibrations over and over again. “If you want to move into new areas,” said Pederson, who was leaving for the forests of eastern Turkey that evening, “you need new species.” Anchukaitis, meanwhile, will be heading for the Himalayan nation of Bhutan later this year.

Researchers extract increment cores from a teak tree in Indonesia. Credit: Tree-Ring Laboratory Lamont-Doherty Earth Observatory.

The idea isn’t just to understand global climate change, but also to understand regional climate variations. In 2004, for example, the Tree Ring Lab published its North American Drought Atlas, which showed evidence of several megadroughts that parched the continent over the past millennium.

> “We’re talking about droughts that make the Dust Bowl look like nothing,” Anchukaitis said.

In the Northeast, people still remember the extended drought of the 1960’s, which lasted five or six years, as a big deal. But tree rings tell the tale of a more severe megadrought that lasted about 22 years. Pederson, meanwhile, recently published a paper showing that the 20th century was unusually wet in the Southeastern U.S. “We’re living in good times in terms of water supply,” he said, “but we can’t count on it continuing.”

The same is true for other parts of the world where extensive tree-ring studies have been done. “We’re continually learning,” Anchukaitis said, “that you don’t have to go back all that far to find megadroughts in lots of places. Along with several colleagues, he also contributed to a major study of the Asian Monsoon, which suggests (among many other things) that the fall of Angkor, in what is now Cambodia, came partly as a result of megadroughts in that part of the world. The lab is now at work on an Old World drought atlas for Europe.

If crushing droughts were surprisingly common at a time when humans weren’t causing climate change, the threat is even more ominous now that we are. Climate scientists project that the rising temperatures resulting from greenhouse-gas emissions will raise the risk of drought in areas that are already prone to it.

The global tree-ring record, meanwhile, tells scientists whether the current global temperature is consistent with normal variations over the past couple of thousand years. According to the much-discussed "hockey stick" graph, it isn't: the planet's thermometer has spiked to an unprecedented level. Skeptics have tried to discredit the graph, along with Penn State climatologist Michael Mann, who created it, citing the "hidden" truth about northern-latitude tree rings. Several investigations have cleared Mann, however — and it turns out that if you abandon tree rings entirely and use other temperature proxies, the graph shows essentially the same form.

But there's no reason to abandon tree rings as gauges of past climate. "Until the 60's," Anchukaitis said, "the relationship between tree rings and temperatures matched the instrumental record. And the relationship between wood density and temperature is still valid."

So what's going on? "We don't know," Anchukaitis said. It may be that the temperature, which is rising more quickly in the Arctic than anywhere else, is now so high that it can't push the trees to grow any faster. "We haven't seen this in lower latitudes yet," Pederson said, "or in trees that respond strongly to changes in moisture."

They're still trying to figure it out, and in the meantime, they're being very careful about using recent ring measurements from those high-latitude trees.

In short, they're acting like scientists. "We challenge each others' results all the time," Anchukaitis said, "and we do it publicly."

It's not always good for the ego. But it guarantees that the results coming out of tree ring-labs all over the world are as solid as they can possibly be.

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