Tree-Ring Times

Newsletter of the Laboratory of Tree-Ring Research
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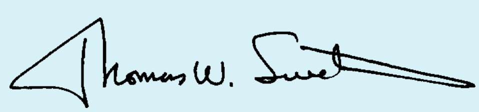
The University of Arizona®

Director's Note

We are pleased to bring to you this fourth issue of the Tree-Ring Times. This issue highlights Dr. Katie Hirschboeck's research in "synoptic dendroclimatology," and a new Tree-Ring Lab archive. Katie's research reflects her commitment to improving knowledge and understanding of broad-scale climate mechanisms. Katie's focus on fundamentals and mechanisms is also characteristic of her teaching. She has become a renowned teacher on campus, particularly in her leadership in implementing and improving the undergraduate General Education Program. Katie teaches a freshman course for non-science majors called "Introduction to Global Change," where she uses state-of-the-art classroom technologies and hands-on, group exercises to inspire learning.

Our new archive in a building we are calling "Tree-Ring West" has stimulated our thinking about the future of our entire, priceless collection of tree-ring specimens. We expect to occupy a larger space, including room for the rest of our collections, in a new building to be constructed on campus in 2004 and 2005. The article on page 4 highlights some of the values of our enormous tree-ring collection, and our need for support to develop the potential of this unique archive of environmental and cultural history.

Here's wishing you all Happy Holidays and a productive New Ring (Year)!



COVER: *Bristlecone pine trees, such as the one on the cover growing in the White Mountains of California, can live more than 4,000 years. Thousands of samples from these trees have been used in dendroclimatic studies, and they helped fill the Tree-Ring Lab's archive.*
Photo by Thomas P. Harlan

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Hirschboeck

• *By Melanie Lenart*

While most dendrochronologists keep their feet on the ground, matching records of surface temperature, rainfall and snowpack to variations in tree-ring widths, Laboratory of Tree-Ring Research Associate Professor Katherine Hirschboeck has her head in the clouds.

She and some of her students at the University of Arizona consider air pressure between roughly 8,000 and 10,000 feet and other lofty variables when seeking to explain fluctuations in tree-ring records. This allows them to consider the overarching weather and climatic processes that influence regional temperature and precipitation patterns along with the growth of annual tree rings.

"We're so married to temperature and precipitation because they've been so consistently collected," Dr. Hirschboeck said. "Yet there are all kinds of other weather-related variables that trees may be responding to that haven't traditionally been looked at in a systematic way."

Hirschboeck calls this branch of study "synoptic dendroclimatology," with "synoptic" alluding to the use of information from weather balloons sent out simultaneously around the globe (see sidebar on page 6 for more details) and "dendroclimatology" referring to using tree-ring patterns over time to infer climatic conditions.

The concepts behind synoptic dendroclimatology have been developing since at least the 1970s publications by LTRR Professor Emeritus Harold Fritts and others connecting spatial patterns of tree growth to seasonal pressure fields, Hirschboeck said.

Other researchers have considered the influence on tree rings of both sea-level and

Focuses On Synoptic Dendroclimatology

upper-level atmospheric circulation, including linkages to circulation patterns associated with the El Niño phenomenon, Hirschboeck noted in a 1996 paper introducing "synoptic dendroclimatology" as a useful name for the budding specialty. The paper, written with co-authors Fenbiao Ni, Michelle Wood and Connie Woodhouse for the Radiocarbon publication "Tree Rings, Environment and Humanity," reviews important contributions to this new field and proposes that standard dendrochronological reconstructions could also benefit from looking at the bigger picture.

The dozens of variables she and her team examine include: the 700-millibar height, which is the height at which the atmospheric pressure is about 70% of sea level pressure; relative humidity at this height; and the number of days the system can be described as being in a "ridge" or "trough" as the 700-millibar height respectively towers above or plunges below its average height.

"Sometimes the 700-millibar circulation level is actually at or below the ground level, where you've got tall mountains, hence it's a good indicator of the environment at those high elevations," she noted.

As it happens, tall mountains tend to favor long-lived trees, such as bristlecone pine, which eke out a living for millennium living at high altitudes and low pressure. Because one tree can produce 4,000 annual rings or more during its lifetime, bristlecone are the source of some of the longest tree-ring-based climatic reconstructions.

In some situations, the regional patterns captured by the 700-millibar height can reflect a tree's reality more than the nearest weather station, which may be 100 miles away as the crow flies and, perhaps worse, a mile down as the stone drops. Temperature rises on average by more than 3 degrees Fahrenheit for every 1,000 vertical feet down a mountain, while precipitation tends to decrease.

Also, surface rainfall may be spotty, with thunderstorms inundating the weather station or the forest, but not necessarily both. In contrast, atmospheric circulation conditions tend to be regionally consistent at the 700-millibar height.

As an example of how fluctuations at the 700-millibar height can affect tree growth, Hirschboeck displayed some results linking trees at Keen Camp Summit with conditions above San Diego, the nearest weather balloon site. During 1961, a year of slow growth as evidenced by a narrow annual ring, upper-level ridges dominated throughout the growing season window, she pointed out.

"And this was a wet year," she said of 1973, a year of abundant growth with a wide ring to prove it. She indicated a graphic showing the abundance of troughs passing overhead during the growing season.

"Now we're linking the wide ring to the dynamics of what's delivering temperature

CONTINUES ON PAGE 6

LTRR Associate Professor Katherine Hirschboeck, above, matches tree-ring widths with upper-level atmospheric conditions, as described in the poster behind her.

syn·op·tic den·dro·cli·ma·tol·o·gy

synoptic *relating to or displaying conditions (as of the atmosphere or weather) as they exist simultaneously over a broad area*

dendroclimatology *referring to using tree ring patterns to infer climatic conditions over time*

Archive Space Expanding for ‘National Treasure’

• *By Melanie Lenart*

Like the feet of a child forced to wear the same shoes year after year, the Laboratory of Tree-Ring Research’s archive collection has long been stuffed into a space far too small for its growth.

Finally, the new school year started with a change in size. This fall, LTRR staff began transferring a portion of the many thousands of tree-ring samples collected over the past 90 years into a new archive area, located in the basement of University of Arizona’s Building 45. Known to others on campus as Math East, the facility has been dubbed “Tree-Ring West” by local dendrochronologists.

The old storeroom in the LTRR’s main facility in the football stadium, above, is filled with specimens collected over the past 90 years from sites all over the world.
Photo by Thomas W. Swetnam

In addition to archival space, Tree-Ring West now contains the equipment for measuring tree rings down to a tenth of a millimeter, a multi-purpose room for seminars, and areas for processing wood. Construction of a new building called Environment and Natural Resources II (ENR II) is slated to begin in 2004, and will house new offices and labs for LTRR, as well as a much larger archive for the rest of LTRR’s collections.

“Our storeroom in the West Stadium was overflowing,” noted LTRR Director Thomas Swetnam. “There’s no place else in the world that has a larger or more valuable collection of tree-ring materials.”

The importance of LTRR’s collection was noted by a seven-member committee, including top scientists from other universities, that conducted an Academic Program Review of the LTRR in 1999. As one of its chief recommendations, the committee urged re-housing the archive.

“Given the unique nature of this collection, arguably a ‘national treasure,’ it seems to the committee that a strong case could be made for federal and/or foundation support to catalogue and maintain it,” the committee stated in its report.

LTRR researchers are currently seeking support from both federal agencies and private donors.

“It would be great if we could find a donor to help us really expand the concept of a working archive to go into our new building. This, of course, could be a match or partial match for our existing $1 million gift from Agnese Haury,” Dr. Swetnam said.

> *“There’s no place else in the world that has a larger or more valuable collection of tree-ring materials.”*
> – Thomas Swetnam
> *LTRR Director*

For instance, the director would like to see part of the archive in the new ENR II building double as a museum that members of the public could tour. Swetnam envisions interpretive displays of some of the more spectacular samples, computer stations where people could try their hand at cross-dating tree-ring samples, and other educational features.

“One of the great things about tree rings is that they’re very tangible,” he said. “We find that students relate to specimens, like a tree with bullets embedded in it from somebody doing target practice – little kids just love that – or where a tree has grown around old barbed wire.”

Cross-sections from giant sequoias also tend to be crowd-pleasers. Fire history work, Swetnam’s specialty and one that has attracted dozens of graduate students to the lab over the years, generally requires cross-sections or at least wedges of trees. In the past 15 years Swetnam and his colleagues have collected cross-sections from the stumps of majestic California sequoias. Some of these stumps measure 30 feet across.

“Part of our problem with space has been precipitated by the fire history work, in particular, giant sequoia,” he admitted. “I always joke with people, it’s sort of like I work on dinosaurs, so my fossils are these gigantic fossils. And all my colleagues work on small mammals or insects.”

The “insects” of tree-ring collections are pencil-sized cores from living trees, or penny-wide cores from archeological beams. Although the individual samples don’t take up much space, consider that LTRR researchers over the years have collected more than 2 million specimens.

Subfossil wood, especially long-dead remnants of long-lived bristlecone trees, is another category that requires space. Although bristlecone pines can fit 3,000 or 4,000 years of tree rings in a section of wood the length of a cat, these pieces add up. LTRR researchers began collecting bristlecone cores and subfossil wood half a century ago, and researcher Thomas P. Harlan and others continue the effort today. (For more on the history of LTRR’s

Senior Research Assistants Rex Adams, left, and Christopher Baisan fit a sequoia wedge into the new archive in "Tree-Ring West." Photo by Melanie Lenart

bristlecone collection efforts, see *http://www.ltrr.arizona.edu/trt/20011221.pdf* .)

Tree-ring researchers still find value in the older collections. For instance, LTRR Research Associate Matthew Salzer, whose proposal with Professor Malcolm Hughes just received three years of National Science Foundation funding, is sifting through some of the bristlecone samples collected from California's White Mountains by the late Valmore LaMarche back in the 1970s.

By combining information from Professor LaMarche's samples with his own from the Whites, Dr. Salzer can expand the sample size and strengthen the climate analyses without spending extra money.

"Going off to remote places and collecting tree rings is generally the most expensive part of a tree-ring research venture," Salzer noted. "If we've got these archives well-organized and available, we can do important research without having to cover the expense of going to these remote places."

Swetnam also emphasized the importance of the archives for ongoing research.

"The value is it's really something like a library of environmental information," he said. "These volumes of information that we've collected, we've read parts of them but there are unread chapters. I'm sure with new technologies, and new kinds of indicators we will discover that are present in the tree rings, that we'll be going back to this wood to learn new things."

Salzer noted that since LaMarche's time, computerized statistical and graphical tools have come into practice that facilitate crossdating remnant tree-ring samples. This is particularly true with bristlecone pine, where dendrochronologists must search for the best dating match of unknown time sequences that might be a few hundred years long, in comparison with existing chronologies that are up to 9,000 years long. These new tools enable Salzer to establish dates for previously collected wood that had previously gone undated.

In another example of researchers exposing old wood to new technology, a team that includes LTRR Professor Jeffrey Dean has used strontium isotope ratios in construction-beam samples to illuminate wood resource use between 850 and 1150 by the Anasazi occupants of Chaco Canyon, New Mexico.

Earlier tree-ring analyses had established that these ancestors of the modern Pueblo had abandoned their complex structures in the late 12th Century. The strontium research expanded the story by pinpointing the source of the timbers used in construction to two of three mountain ranges in the area. (The bristlecone link at the top of the page to the Winter 2001 issue of the Tree-Ring Times includes a page 4 story on this strontium research.)

Swetnam expects that scientists will continue to find innovative ways to extract more knowledge from the LTRR's archives. For now, the priority is to put information on the samples in one large, online database so researchers will not have to depend on numerous paper files to access these resources.

Several LTRR faculty members working with Dr. Sudha Ram, a renowned professor of the UA Management Information Systems, have requested NSF funds to catalogue the archives and digitize the information associated with certain specimens. With enough funding, Swetnam envisions that the project could even include photographing and scanning some samples so tree-ring researchers around the world could access "virtual" specimens via the web.

"This is just the beginning," Swetnam said. "I have a sense that some time from now, maybe it'll be a century or more, the value of this wood will be much increased over what it is now. Because as time goes on, wood is disappearing, ancient forests are being cut down or are dying for various reasons. There's loss of material. What we have here is an archive that is non-renewable. It's a legacy of the Tree-Ring Laboratory."

Synoptic Dendroclimatology

Continued from page 3

and precipitation," Hirschboeck said. LTRR Principal Research Specialist David Meko also contributed to the project, as did several graduate students, including Fenbiao Ni, Gregg Garfin and Matthew Salzer, all of whom have since completed their Ph.D. requirements and taken positions at the University of Arizona.

The research team followed similar procedures for six other sites throughout the western United States, selected because preliminary analyses indicated they might reflect different regional responses to upper-level circulation patterns.

Using a statistical program refined by Dr. Meko, the researchers first pinpointed the specific months that influence tree-ring widths for each site. Then they considered atmospheric circulation patterns during the crucial growing season windows for the past 40 years or so of the chronologies. From there, they created spatial correlation fields for each site, and compared them with composite maps showing the typical atmospheric circulation pattern for years in which tree rings were narrow, wide or average.

"Basically, the same precipitation-related circulation patterns are showing up at each site but they sometimes operate in different seasons," Hirschboeck said. "Luckily we found things were geographically consistent and you could explain them meteorologically. Even the patterns for average years made meteorological sense. I didn't know if they would."

The success of the project has made her eager to examine other tree-ring data sets with an eye to linking the climatic responses to atmospheric circulation. So there's a good chance Dr. Hirschboeck will be looking skyward for the answers for many years to come as she explores her LTRR niche more thoroughly.

WEATHER BALLOONS AND TREE RINGS

• *By Melanie Lenart*

The opportunity to use upper-level atmospheric circulation patterns to consider their influence on tree-ring growth goes back only to the 1940s, when meteorologists around the world agreed upon a system for collecting the necessary information.

Basically, they agreed to send up weather balloons twice a day at exactly the same moment from hundreds of stations all over the world. The balloons go up every 12 hours, sending down details on air pressure, moisture and temperature as they ascend into the clouds.

From these thousands of snapshots of the atmosphere, meteorologists can piece together a moving picture of global circulation patterns. In Arizona, weather balloons arising from only two locations, Tucson and Flagstaff, can capture fluctuations occurring across the state in combination with neighboring stations.

Forecasters rely on this "synoptic weather mapping," as it is known, to predict movement of cold and warm fronts and the probability of seeing rain or snow in specific locations.

This technique works because air is a fluid that moves in waves. Air molecules go with the flow, riding the crests and troughs like surfers. Or perhaps they are like skiers rushing downslope into the troughs of low-pressure systems, such as in areas where the 700-millibar height – the height where atmospheric pressure is about 70% of sea level pressure – may be 1,000 feet lower than the 700-millibar height of the closest high-pressure system.

From a ground-based point of view, the low pressure can allow a hovering air mass to rise high enough in the atmosphere to become a storm cloud, with its water vapor condensing into droplets only if it reaches the cooler regions high above the Earth's relatively warm surface.

While low-pressure systems tend to promote precipitation, high-pressure systems tend to prevent it, creating deserts when they consistently linger over an area as they do in the Southwest.

The proportion of time a piece of ground spends under troughs vs. ridges during the growing season affects the productivity of the trees on the landscape, as described in the main story. This translates into measurable differences in tree-ring widths because of the precipitation and temperature patterns that are associated with the ridges and troughs.

Fire & Bugs

• *By Ellis Margolis*
Graduate student

My research at the Laboratory of Tree-Ring Research is focusing on disturbance ecology of the upper elevation forests of the southwestern United States. More specifically, I am researching the two most important disturbance events affecting high elevation southwestern forests: crown fires and insect outbreaks.

My master's degree research involves reconstructing stand-clearing crown fires within a roughly 40,000-square-mile study area in the Upper Rio Grande basin of New Mexico and Colorado. This collaborative effort, with LTRR Director Thomas Swetnam and U.S. Geological Survey ecologist Craig Allen, has revealed that crown fires in the past were climate-driven events occurring primarily during years of extensive, extreme drought and widespread surface fires at lower elevations.

Our research is the first to produce a regional crown fire data set, which can now be used to examine the potential predictability of these catastrophic events based on climate relationships.

Another research interest of mine involves insect outbreaks. I have studied tent caterpillar outbreaks in the quaking aspen stands of the Jemez Mountains of New Mexico. Outbreaks in the recent past have defoliated more than 100,000 acres of quaking aspen at a time, with squished caterpillars causing travel by road and railroad to cease. If that wasn't bad enough, tent caterpillar outbreaks leave piles of caterpillars three to four feet tall in the streams that contaminate the vital, local water resources.

In collaboration with Dr. Swetnam and Christopher Baisan of the LTRR and Dr. Ann Lynch of the Rocky Mountain Research Station, I investigated the potential for reconstructing tent caterpillar outbreaks using tree rings. The long-term goal of this research was to determine if there was a climate relationship or cyclical pattern in the defoliation events that could be used to predict and prepare for future outbreaks. In the course of the study we sampled aspen that were greater than 250 years old, which approaches the oldest documented age for aspen stems.

The results of our pilot study show growth suppression at approximately 20-year intervals. Further statistical analyses are underway to determine if this is the signature of periodic tent caterpillar outbreaks, perhaps related to the insect's life cycle, virus lifecycles, or climate. Thus, there is potential to study tent caterpillar outbreaks using annual growth patterns in aspen tree rings. There may be periodicity in these insect outbreaks, but a few "bugs" need to be worked out!

Summer School

The Laboratory of Tree-Ring Research will offer two intensive summer school courses for those interested in applying dendrochronology (the study of tree rings) to archaeological or climate research.

The courses, designed for professionals, graduate students or upper-level undergraduates, will run from May 19 through June 7 at the LTRR in Tucson, Arizona.

The participants in the Dendroarchaeology course and the Practical Dendroclimatology course will meet together for the first week as they learn the fundamentals of dendrochronology. Lectures will be supplemented by a one-day field trip and laboratory work involving preparation of tree-ring samples, crossdating samples to account for potential missing and/or false rings, and constructing composite chronologies from samples for use in dating other wood specimens or interpreting climate fluctuations.

For the rest of the Dendroarchaeology course, LTRR Adjunct Assistant Professor Ronald Towner will focus on the chronological, behavioral and environmental interpretation of archaeological tree-ring samples. Some of the instruction will be given during a field trip to well-known southwestern archaeological sites, including New Mexico's Chaco Canyon and the Navajo Pueblitos.

For the remaining two weeks of the Dendroclimatology course, LTRR Professor Malcolm Hughes and guest lecturers will instruct students in interpreting tree rings as natural archives of climate fluctuation on a variety of time scales, from annual to millennial. Senior Research Specialist Ramzi Touchan will assist in the practical exercises to help students develop climate reconstructions from tree rings.

Tuition is approximately $410 for the three-credit courses. Each course is limited to 15 participants each. For more information on the course of interest, contact the appropriate instructor: Dr. Towner at **rtowner@ltrr.arizona.edu** or Dr. Hughes at **mhughes@ltrr.arizona.edu**. Details may be found at **http://www.ltrr.arizona.edu/summerschool**.

BEHIND THE WOODSHED

An irreverent microanatomical view of life at the LTRR

By Steve Leavitt

Skeletons In Our Closets

Although we know who we are, the worldwide dendrochronology community knows who we are, and a surprising number of civilians everywhere seem to know about the "Arizona Tree-Ring Laboratory," we commonly encounter people unaware of us, sometimes even people from Tucson or among the University of Arizona community.

When I meet someone who asks about my UA departmental affiliation, I say "the Tree-Ring Lab" while trying to annunciate slowly and particularly clearly, to avoid conveying the idea of a "three-ring" something or other. After I get the seemingly obligatory puzzled look, similar to that of the bewildered gaze of the attendant at a fleamarket Ask-an-Expert booth, I commonly follow it up with a "you know … growth rings of trees." A range of responses follows, typically related to their effort to deduce my "real" department such as forestry, or perhaps biology.

At this point I usually put on my educator's hat, and with the swagger and puffery of the headmaster at a fleamarket canine obedience school, I explain we are indeed our own independent department (for now). In fact, we are one of a dozen or so departments, co-equal in some respects, within the College of Science. The impromptu discourse ends with a review of all of the applications of tree rings, from archaeology to climatology, hydrology, ecology, and beyond.

Unfortunately, every now and again one of these clever novice inquisitors stumbles on to one of the more sinister aspects of what we do. They start to put tree and tree together, and come to a macabre realization, even more frightening than the back-hair clumps on the floor of a fleamarket hair removal booth – namely, our supreme role in killing the world's trees.

There are 2 million specimens estimated to be in our storage collections. Most are cores, but if 1% are disks from trees, that would be 20,000 slaughtered trees. We cannot take credit for killing all of them. Some of the disks are from archaeological wood cut long ago by paleo-peoples in the Southwest and elsewhere, cross-sections archived from the timber industry, slices of logs from geological deposits, and in the case of fire ecology, re-sampled stumps of trees that were cut for lumber decades ago.

Assuming that half of the disks were actually living trees euphemistically "harvested" by us, the number would be horrific even to a hardened old hand like me, who normally doesn't faint for more than 20 minutes at the sight of hypodermic needles. Naturally, you don't have to look far in the Tree-Ring Lab to find the tools of this carnage, the omnipresent axes and chainsaws. We could certainly be characterized as the ultimate anti-"tree-huggers."

Those 10,000 trees cut over 100 years compute to about 100 per year! Look out Georgia-Pacific, and look out Weyerhaeuser – we might have cut enough board feet to stock a fleamarket crate boutique, or enough pulpwood to build all the cardboard furniture in a fleamarket antique emporium!

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