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The Laboratory of Tree-Ring Research

A Tradition of Enterprise

&

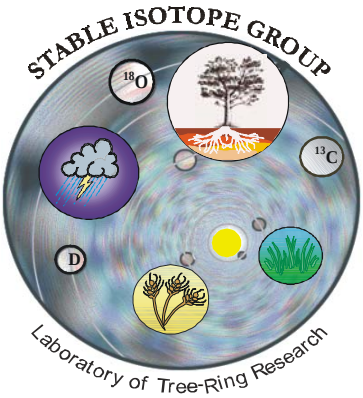
Interdisciplinary Research

Climatology

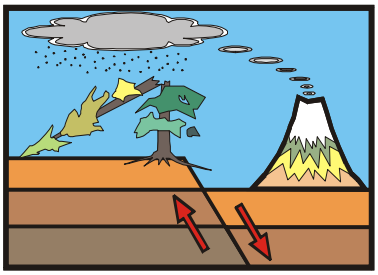
Fire History

Ecology

Archaeology



Stable Isotopes



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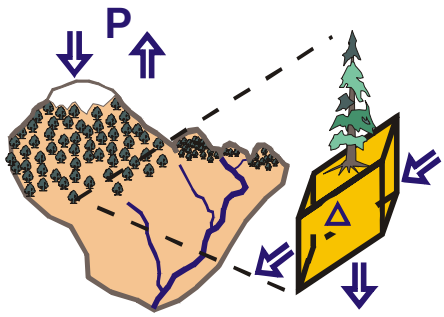
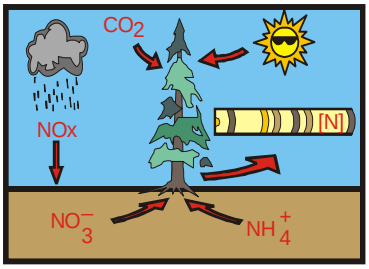


Hydrology



Biogeochemistry

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The Laboratory of Tree-Ring Research (LTRR) at The University of Arizona was established in 1937 by the Arizona Board of Regents to support the work of Andrew E. Douglass, founder of the modern science of dendrochronology. The LTRR is a research unit in the College of Science at the University of Arizona in Tucson, Arizona, USA.

The LTRR is the premier and largest laboratory in the world dedicated to the use of tree rings in environmental and cultural sciences. The field of dendrochronology was essentially "invented" at the LTRR. One of the original contributions (in 1929) by A.E. Douglass was discovering the exact dates of construction of the ancient cliff dwellings of Southwestern peoples, and this finding was one of the earliest world-famous discoveries by a University of Arizona scientist. Since Douglass' time, LTRR has continued to pioneer the applications of tree rings in a broad variety of social, earth, and atmospheric sciences. The continuing high scientific quality and societal significance of our tree-ring discoveries are exemplified in the examples described on the pages that follow.

Our faculty, students, and scientific staff are engaged in a diverse array of research, teaching and outreach programs which include fire history and fire ecology, multi-proxy paleoclimatology, archaeology, biogeography, isotope geochemistry, paleoecology, biogeochemistry, geomorphology, numerical and statistical modeling, and even public health. All of our faculty teach graduate and undergraduate courses, and our outreach program has contact with more than 2,500 K-12 students, undergraduates, graduate students, and community groups each year.

LTRR is housed in the West Stadium (underneath the football bleachers!), and has been located in this building for 70 years! We have been waiting for (and have been promised) more suitable quarters during this whole period. We continue to work toward, and hope for, an improvement in our quarters.

LTRR currently has 7 tenure track and 2 non-tenure track professors, 3 emeritus professors, and 6 adjunct professors. We have 11 office and scientific staff members, 17 graduate students, and 12 undergraduate student assistants. We host visitors from throughout the world, with 4 to 6 visitors typically in residence.

The LTRR also houses and maintains the world's largest collection of ancient timbers (more than 2 million specimens). This is a world-heritage resource that is currently of great value to science, and of inestimable value in the future.

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Tree Rings Used in Water Management

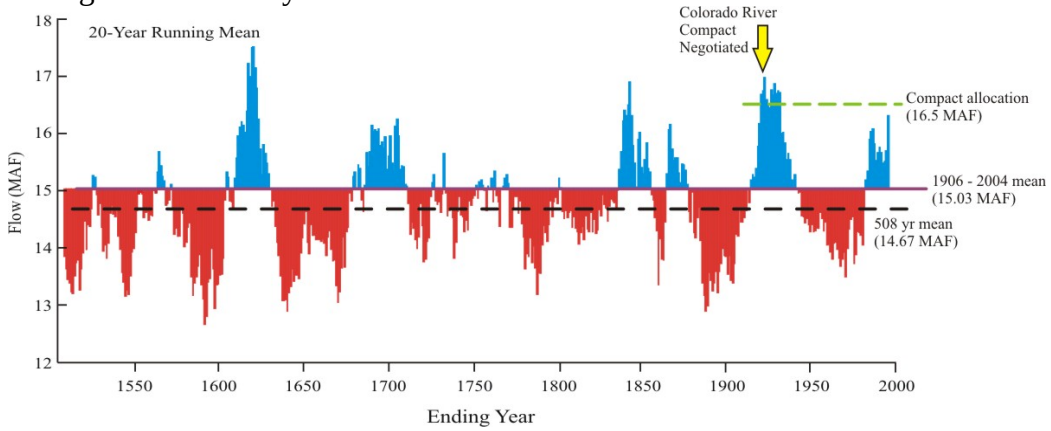
Dr. David Meko, Associate Research Professor, Laboratory of Tree-Ring Research
Dr. Katie Hirschboeck, Associate Professor, Laboratory of Tree-Ring Research

Flow records for rivers in the western United States cover only the 20th century, and may not provide sufficiently long perspectives on the frequency or severity of system-wide drought under 'natural' climatic conditions.

Dr. Meko takes a core sample from an ancient pine.

Drs. Meko and Hirschboeck are providing water managers with augmented time series of reconstructed streamflow to aid in resource management. Three ongoing studies involve close cooperation of tree-ring researchers and water managers.

- A study for the Salt River Project has quantified the long-term probability of drought simultaneously affecting the major runoff-producing regions in Arizona and in the Upper Colorado River Basin. **Results indicate local Arizona water shortages during severe droughts are historically unlikely to be buffered by excess flows on the Colorado.**
- An interdisciplinary study funded by the TRIFF/Water Sustainability Program with contributed funds from the U.S. Bureau of Reclamation is investigating ways in which the Bureau can directly incorporate tree-ring estimates of streamflow in the river management models that guide operation of the reservoirs on the Colorado River. One product of this study is an updated series of reconstructions of Colorado River flow published in May 2006 in *Water Resources Research*. **These long-term records illustrate that the Colorado River is highly sensitive to variations or shifts in climate, and that severe, sustained droughts are a defining feature of the Upper basin over the past five centuries.**
- A third study, funded by the California Department of Water Resources, is aimed at temporal extension of tree-ring information for the Colorado River before A.D. 1300, when tree-rings and other paleoclimatic data hint at multi-decadal droughts of a severity and duration unmatched in more recent centuries.



Tree-ring reconstructed flow of the Colorado River, showing that the flow levels during the period used to establish the Colorado Compact were among the highest in the past 500 years. This resulted in overestimation of available water in the Colorado River.

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Tree Rings Reveal Drought History

Dr. Malcolm Hughes, Professor, Laboratory of Tree-Ring Research
Dr. Ramzi Touchan, Research Associate Professor, Laboratory of Tree-Ring Research

Tree rings provide information about our climate over many centuries. In the Southwest they best record the amount of water that falls as snow and rain in the winter half-year. These records can then be used to place current and recent variability in a longer term context. How does the recent punishing, and perhaps continuing, drought compare with droughts over recent centuries? The answers to such questions can help us assess our exposure to risk of further severe, sustained droughts. With this in mind, Professor Malcolm Hughes and his collaborators developed objective estimates of cool-season precipitation (that is, rain and snow) for every year from AD1988 back to AD1000 for each 'climate division' into which the National Oceanographic and Atmospheric Administration (NOAA) has divided Arizona (see map) and New Mexico.

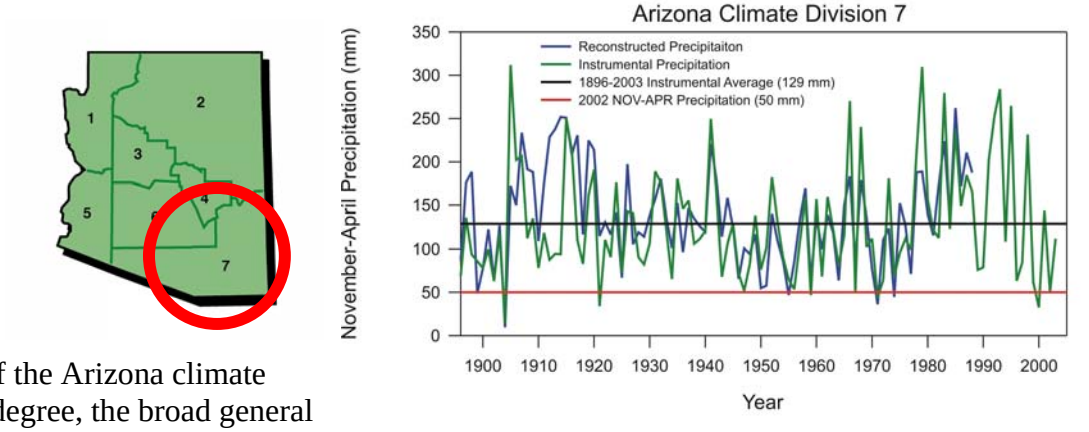

Figure 1: Five-year average of cool-season precipitation recorded by tree rings (blue line) as % of long term mean, compared with value for 5 years 1999-2003 (red line).

Although the precipitation histories of the Arizona climate divisions vary to some degree, the broad general picture corresponds to Figure 1. In essence:

- The present drought is one of a number of sustained droughts in our region since AD 1000, with cool season precipitation totals staying below 80% of long-term average for several years. Multi-year wet periods, more than 20% above the long-term mean, also occurred. We should not be surprised that such "shifts of climate regime" occur.
- Each has its own pattern of development across the region and through the years.
- The question arises: How might the occurrence of such droughts here be changed by ongoing greenhouse warming?

Many more details, including the precipitation history for each division of the two states, may be found at http://www.ispe.arizona.edu/climas/research/paleoclimate/product.html. This work was part of the NOAA – funded CLIMAS project.

Dr. Ramzi Touchan and colleagues are applying similar approaches to the reconstruction of hydroclimatic variables in the Middle East, including Turkey, Jordan, Algeria and Morocco. This pioneering work, supported by the National Science Foundation, is critically important in an arid region where understanding and managing water resources essential for sustaining resources.

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Climate Variability, Climate Change & Tree Rings

Dr. Malcolm Hughes, Professor, Laboratory of Tree-Ring Research
Dr. Michael Evans, Assistant Professor, Laboratory of Tree-Ring Research
Dr. Matt Salzer, Research Associate, Laboratory of Tree-Ring Research

Figure 2. Ancient bristlecone pine at upper tree limit in the White Mountains, California.

The Laboratory of Tree-Ring Research has been at the center of international efforts to build objective, quantitative, detailed histories of climate on continental to global scales for recent centuries and millennia. Year-by-year maps of summer temperature or winter half-year precipitation, for example, are derived from human and natural records. These include tree rings, historical documents, and the annual layers in glacial ice, coral heads, speleothems and marine and freshwater mud. Many of the methods still in use in this field ("high-resolution paleoclimatology") were pioneered here in the 1960s and 1970s, and we are actively involved in developing new methods and collecting new records from around the World. In recent years we have been working in Siberia, the Near East, North Africa, China, India, Canada, as well as in many of the mountain ranges of the western USA. Exploratory work in tropical climates is being conducted in Costa Rica and Peru.

The results of this research inform the scientific study of natural climate variability and the detection of human-caused climate change in recent decades, and, as such, have received a massive amount of attention from both inside and outside the scientific community.

Major findings include:

- At the scale of the Northern Hemisphere, the last three decades have very likely been warmer than any other period of similar length in a thousand years, and the 20th century warming is much more consistent between regions than earlier fluctuations.
- Conditions were cooler over much of the Northern Hemisphere at times in the 17th through 19th centuries ("The Little Ice Age") than in the 20th century;
- There is not a similarly consistent body of evidence for conditions in the late 1st and early 2nd millennia AD (the so-called "Medieval Warm Epoch") being consistently warmer than in the 20th century:
- Tree-ring evidence buttresses the case for shifts in climate "regimes" over huge areas, for example the whole Pacific Basin, having complex, but broadly consistent, local effects in our region and elsewhere throughout the last several centuries:
- Tree-ring growth at the upper tree limit in much of the mountain West has been faster in recent decades than for at least one thousand years, and in some cases, several millennia. Something unusual is most definitely happening.

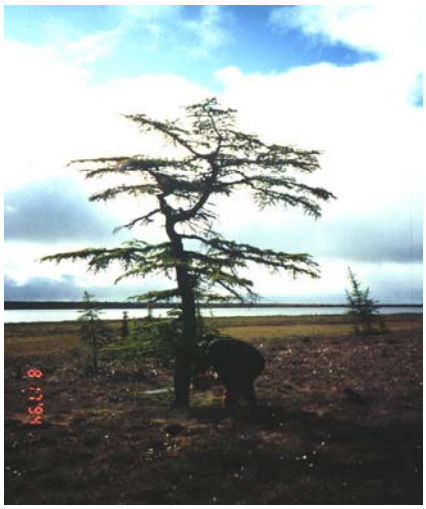

Figure 2. Multi-century larch at 70 degrees north in Siberia.

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Tree Rings Used to Study Forest Fires & Climate

Dr. Thomas W. Swetnam, Professor & Director, Laboratory of Tree-Ring Research

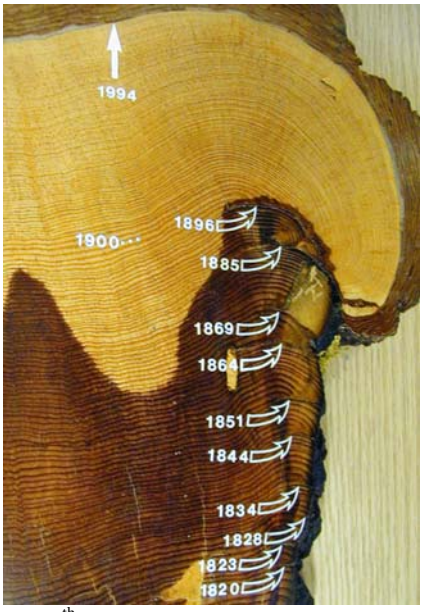
Dr. Donald A. Falk, Adjucnt Associate Professor, Laboratory of Tree-Ring Research

Wildfires have burned over millions of acres of forests and woodlands in recent years, and there is increasing evidence that this trend is partly driven by warming temperatures and earlier occurring springs in the past two decades (see August 18, 2006 issue of Science). Annual costs of suppressing wildfires in the U.S. now exceeds $1 billion annually, and loses of homes, wildlife habitats, and watersheds are many times more costly.

Tree rings have played an important role in the study of climate and wildfires because they provide a very long time perspective that is not captured in documentary records.

Dr. Swetnam (left) and colleague Chris Baisan (right) remove fire-scarred cross sections from the base of a giant sequoia stump at Kings Canyon National Park, California.

Drs. Swetnam and Falk and their students have sampled fire-scarred trees in dozens of forest stands throughout the western U.S. The study of these tree-ring records of fire, in combination with drought and temperature reconstructions from tree-ring widths, has revealed a number of important findings that are useful to forest managers and policy makers:



- Frequent low severity fires occurred in most pine forests for centuries prior to the advent of livestock grazing and fire suppression by government agencies (the “Smokey Bear effect”). The lack of fire has led to fuel accumulation in some areas, and this is one of the causes of increasing fire sizes and severity in recent years. **Mangers use this fire history information from tree rings to justify and guide “forest restoration” treatments and the reintroduction of fire as a “natural” process in wilderness areas and parks.**
- Tree-ring based fire and climate histories show that wet/dry cycles, and large-scale ocean-atmosphere patterns, such as the El Niño-Southern Oscillation, are important to fire activity in the western U.S. **These discoveries by tree-rings have been used to develop fire hazard forecasting models that are now used by federal and state governments to anticipate the likely severity of upcoming seasons, and for strategic planning.**

A fire-scarred ponderosa pine cross-section, showing 10 separate fire events (scars with arrows) during the 19th century, and the long period without low severity fires since 1896.

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Tree Rings Used to Study Possible Environmental Causes of Childhood Leukemia

Dr. Paul R. Sheppard, Assistant Professor, Laboratory of Tree-Ring Research
Dr. Mark Witten, Research Professor, Department of Pediatrics

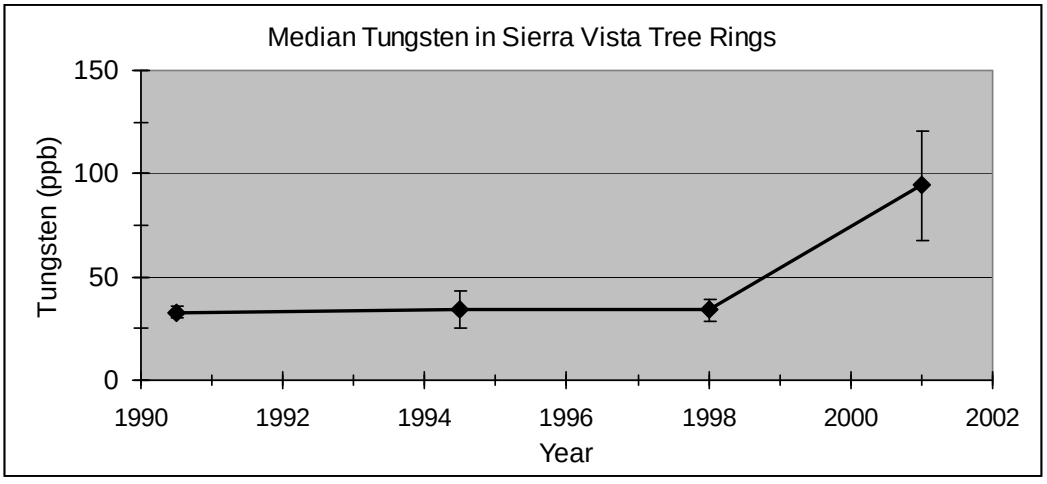
Multiple clusters of childhood leukemia exist concurrently in the West, including Fallon, Nevada, Sierra Vista, Arizona, and Calvine-Florin, California.

Childhood leukemia is a monumental heartbreak for the children involved and their families. The existence of spatial clusters of leukemia indicates the need for research on possible environmental causes: Is there any environmental issue held in common by these different places that might be linkable to leukemia? Finding an answer to this question could save lives in the U.S. and elsewhere in the world.

Dr. Sheppard taking a core sample from a tree.

Drs. Sheppard and Witten have been measuring spatial and temporal monitors of environmental chemistry in these towns. Of particular note, **Fallon is elevated in airborne tungsten and cobalt particles, and tree-rings indicate an increase in these metals during the mid to late 1990s, at about the onset of the leukemia crisis.** A candidate source of tungsten and cobalt particles has been identified in Fallon.

Interestingly, tree rings also indicate an increase in tungsten in Sierra Vista by the late 1990s or early 2000s (see graph below), again at about the onset of the leukemia crisis there. This finding is not yet published and needs more data to be certain, but if it held, it would be an important replicate of the Fallon result. Early tree-ring results form Calvine-Florin also suggested an increase in tungsten (see news coverage by Nature), but those data also need better replication, which we are working on now.



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Tree Rings and Southwestern Archaeology

Dr. Jeffrey S. Dean, Professor, Laboratory of Tree-Ring Research
Dr. Ronald Towner, Associate Research Professor, Laboratory of Tree-Ring Research

The crucial importance to human paleoecology of establishing exact time relationships between past human and natural events drives the archaeological-focused tree-ring research at the UA. A major component of this effort is the analysis of all archaeological tree-ring samples from the Southwest, an endeavor that has enjoyed 23 consecutive years of NSF support (1985-2007). This research has involved intensive dating programs to illuminate social organization, intergroup relationships, and environmental adaptation among the Anasazi of Mesa Verde, Chaco Canyon, and Tsegi Canyon and among the Navajos of northwestern New Mexico.

Dr. Dean's environmental research has emphasized reconstructing past climatic variability across the Southwest, combining dendroclimatic reconstructions with other paleoenvironmental indicators, and assessing the potential effects of environmental change on the human populations of the region. Current research is focused on characterizing the effects of precipitation and temperature variability on the agricultural populations of the Zuni, Tsegi Canyon, Mesa Verde, and Flagstaff areas over the last 2,000 years.

Dr. Towner’s research has focused on the Early Navajo and their adaptation to the fluctuating climate and very unstable social environment of the protohistoric period on the Colorado Plateau. Additionally, Dr. Towner’s has been expanding dendroarchaeology beyond the U.S. Southwest into northern Sonora and Chihuahua, Mexico, coastal Peru, the Texas Hill country, the central Rockies, and northeastern Utah.

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