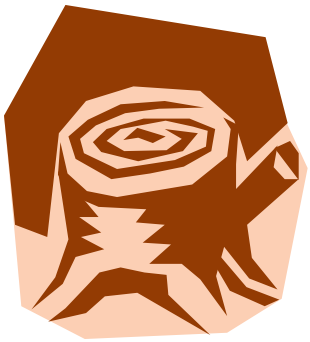
Tree-ring records inform water management decisions

Workshop strives for better integration of past with present



by Dustin Garrick and Kathy Jacobs

Water managers seeking new decision support tools and the scientists developing them congregated May 5 in Tucson to discuss how looking at the past may help inform future water planning efforts.

The workshop brought together key western water managers and paleoclimate researchers—those who use tree rings and other natural records to reconstruct what the climate was like hundreds or even thousands of years ago. Participants were specifically looking at how to incorporate dendrohydrology information into water planning. Dendrohydrology involves using tree ring qualities, typically the width of the annual growth rings, to estimate hydrological values, such as the annual streamflow of a specific river.

Among the outcomes of the meeting were a long list of research and collaborative opportunities, expanded interest in historic flow reconstructions on the part of water managers, and some lessons learned about how to structure meetings to encourage conversations across the perceived gulf between scientists and water managers.

Recent episodes of prolonged drought have functioned as a wake-up call for water supply managers seeking to satisfy demands in the context of water supply uncertainty and variability. Though most of the Southwest has had a wet winter, the severity of recent drought conditions is still fresh in residents' minds, and the low water levels in the Colorado reservoirs are a constant reminder that the drought is likely not over yet.

Meanwhile, conditions in the Pacific Northwest are very dry. The water managers in the room clearly understood the importance of having better climate information, especially in providing context for long-term infrastructure decisions and for drought planning.

The conference reflected the increasing interest in paleoclimate information, such as tree-ring based streamflow reconstructions, for use in water management and reservoir storage operations. Paleoclimate research and hydrologic reconstructions can aid water managers by extending the historical record of streamflow and other key water planning parameters—such as temperature—beyond the instrumental record, which covers approximately the past 100 years.

The lead workshop organizers were Connie Woodhouse of the National Oceanic and Atmospheric Administration (NOAA) Paleoclimatology Program, and Robert S. Webb of NOAA. They were joined by co-organizers from two NOAA-funded projects: the Western Water Assessment and the Climate Assessment for the Southwest (CLIMAS), in conjunction with the University of Arizona's Laboratory of Tree-Ring Research and UA's Water Resources Research Center. CLIMAS hosted the conference with funding from NOAA. The meeting advanced two overarching goals: broadening the use of paleoclimatic data and expanding the application of these data in water management contexts.

Water Management

Water planning needs and priorities took center stage from the outset with presentations by water managers who have incorporated paleoclimatic reconstructions into their planning processes. They recounted experiences integrating paleoclimate research into water resource planning.

Denver Water is working to use tree-ring records in tandem with their water supply simulation model to estimate the occurrence, frequency, and intensity of drought in the Colorado and Platte River basins, according to Steve Schmitzer, the head of water resource analysis. Tree-ring reconstructions have provided the agency with an enhanced understanding of streamflow and water demands during drought periods.

In Arizona, the recent drought coupled with the findings of tree-ring reconstructions have prompted water managers at the Salt River Project to consider long-term drought in planning activities, noted Charlie Ester, manager of the Phoenix-based agency's water resource operations.

SRP has linked with UA researchers from the Laboratory of Tree-Ring Research to investigate simultaneous drought in the Salt River and Colorado River basins. The agency was surprised that preliminary findings show that synchronous drought in their two water supply sources are more common than was previously thought. This is not good news for SRP, and it has motivated development of new strategies to prepare for potential water supply shortfalls caused by broad regional drought events.

Ester concluded that the question, "Is the drought over?" may not be particularly relevant. Even if this drought is over, there will definitely be another one in the future, he pointed out.

"We always get alternating periods of wet and dry years, so we need to start planning for worst-case scenarios now." Ester said.

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Paleo meeting, continued

Ben Harding, principal engineer at Hydrosphere Resource Consultants presented on the potential benefits and lingering challenges of applying tree-ring and other paleoclimate research. He noted that water managers need to make decisions about the future, and paleohydrology information (for example, Figure 1) can help by providing a "surrogate for experience that tends to show you the large-scale structure of wet and dry periods."

However, like others, Harding warned that looking at such records does not allow predictions of specific future conditions, in part because conditions are changing in the context of global warming. Climate change scenarios predict average temperatures in the West will continue to rise in the foreseeable future because of the ongoing input of greenhouse gases from cars, industry, and land use changes. The warming has hydrological impacts, such as a tendency toward earlier melting of the mountain snow that sustains western rivers.

Harding also identified attributes of paleohydrologic data that have prevented wider adoption and application. For example, tree-ring reconstructions are often hard to connect to specific management decisions because the information is not available in locations where it is needed for water management. Often the measured data at key gauges do not have long-term, continuous records. In some cases the records are also less accurate than what is needed for high-quality calibration of the trends. Streamflow gauges may not be located appropriately to correlate to available tree-ring data, Harding noted.

The focus on water resource planning needs continued in a panel discussion involving high-level water managers from five states. The participants spanned the gamut of responsibilities, from reservoir operations at the Bureau of Reclamation to drought planning in New Mexico. The panel was asked how paleoclimate information has been and could be utilized by managers. Though several managers pointed out that they do not currently use tree ring information, all indicated that they were interested in doing so.

One theme that emerged from the panel discussion was the need to manage water resources in the context of uncertainty and to accommodate the role of politics and political pressure in the application of scientific findings.

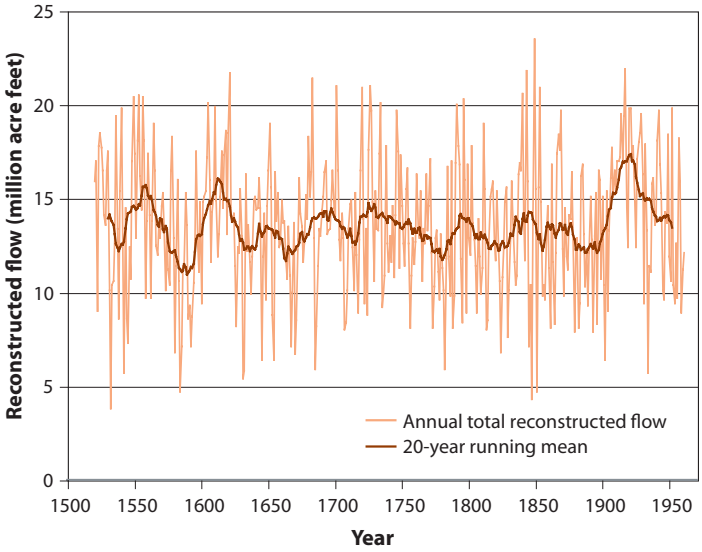

Figure 1. A 442-year record of Colorado River streamflow reconstructed from tree-ring evidence shows that variability is the norm, but high-flow or low-flow years often cluster together to span decades. The values are given in million of acre-feet from 1520 through 1961 and estimate streamflow throughout the Colorado River's 246,000-square-mile basin. Values are derived from tree-ring widths that were calibrated with U.S. Bureau of Reclamation records since 1906 based on gauged flow at Lee's Ferry, Arizona. Some of the scientists at the workshop are preparing an updated version of this record that extends into recent years. Source: Meko et al. 1995. *Water Resources Bulletin,* 31:789–801.

"Every decision is filtered through the political process, and this must be added to the science to come up with the correct method," noted Don Ostler, executive director of the Upper Colorado River Commission.

The notion of triggers—as indicators of drought conditions and water supply variability—also produced a lively discussion between scientists and managers. Water managers expressed the need for triggers that induce specific management procedures and operational measures. This provides a measure of insulation, separating them from the political pressures that are always looming in the water arena.

Paleoclimate Science

The morning concluded with a presentation session by paleoclimate scientists to identify how ongoing research in the Colorado and Platte River basins can support water management decisions.

Many different Colorado River streamflow reconstructions, using varied statistical approaches, show good agreement with regard to the major periods of high and low flow, according to findings presented by David Meko, an associate research professor at the UA Laboratory of Tree-Ring Research. However, a comparison of Colorado River streamflow reconstructions showed significant differences in the precise volume of reconstructed streamflow.

Meko also presented work in progress, which shows that the average volume of flow at Lee's Ferry may actually be higher than the 13.5 million acre-feet that is frequently cited as the long-term average flow based on tree-ring records. However, even this higher long-term average is less than the average used in appropriating Colorado River water. Thus, the most up-to-date science still shows that the Colorado is over-appropriated.

The morning session laid the groundwork for a series of breakout groups in

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Paleo meeting, continued

the afternoon. Scientists and managers convened to identify potential arenas for incorporating tree-ring and other paleoclimate research in water management settings. These breakout groups highlighted the need for enhanced outreach and communication with policymakers to assuage concerns about the level of uncertainty and variation among paleoclimate reconstructions. Water managers also urged further validation of the connections between tree-ring information and streamflow, despite strong concurrence among the scientists that their findings are statistically valid.

Water managers and scientists were eager to exchange ideas in the breakout session. These conversations pointed to relatively easy opportunities to enhance integration of paleoscience into water planning as well as more ambitious proposals for collaborative projects. Scientists and managers realized, for example, that there is a great need to publish findings in publications commonly read by water managers, instead of in scientific journals—the usual practice by paleoscientists. Another idea was to use a National Academy of Sciences panel to develop standardized research methods and criteria that could offer politicians and water managers a seal of approval to help justify the use of paleoclimate information.

The meeting culminated with an overview by co-organizer Kathy Jacobs that synthesized the conference into a set of core messages. Paleoclimate reconstructions have provided a critical long-term frame of possible water supply scenarios that significantly broadens the perspective of water managers, she noted.

Understanding the full range of historic climate conditions allows comparison with conditions experienced during the careers of current water managers, Jacobs surmised. Long-term instrumental records show the period from about the 1970s through the mid-1990s was relatively wet, so our idea of "normal" may be skewed. In spite of the variation among tree-ring reconstructions, the studies do tell consistent stories about the fluctuations from high- to low-flow years, as well as long-term drought.

Jacobs, who is the deputy director for the UA Center for Sustainability of semi-Arid Hydrology and Riparian Areas (SAHRA), also noted that the implications of drought are regionally specific, and paleoclimate information allows us to have a view of the synchroneity of droughts and implications for watersheds at various scales. There is a need to have such information tailored to individual water supply systems.

Managers at the workshop underscored the need for a better understanding of the nature and source of uncertainty, and the need to develop paleoclimate data that can be tailored to specific decisions, such as the Colorado River water supply shortage negotiations. Among specific data needs, water managers seek improved estimation of the "natural" flows—those adjusted for reservoir operations and other depletions—that feed water supply planning and modeling efforts, as well as increased focus on accurate gauging of flows.

Workshop participants also suggested further evaluation of the role of soil moisture in affecting tree ring data, since soil moisture processes may dampen or delay the effect of climate on tree growth. In addition, they noted a need to focus on communication of the findings of paleoclimate research so that it reaches decisionmakers at the right time and in an accessible format. It is particularly important to put the historic information in the context of the growing population in the Southwest and increasing demand for water supplies, since these factors may overwhelm the climate signal in making reservoir operation decisions.

The workshop generated substantial interest in future projects. Two suggestions that workshop organizers are eager to follow through on are the development of an interactive paleohydrology data and analysis web tool, and the development of workshops and training sessions that bring paleohydrology to an audience of water professionals and decision makers.

Working together, participants agreed, scientists and resource managers can use paleohydrological research and analyses to help water resources decisionmakers develop better worst-case scenarios, and to understand the geographic scales of multi-year periods of low-and-high flows. With adequate funding and time, tree-ring scientists should be busy responding to water managers' suggestions for developing reconstructions of flows from unregulated high-elevation stream gauges, Colorado River tributaries, such as the Green River, and examining spring temperature and snowpack—climatic keys to streamflow during the season of high water demand.

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Resources on the Web

- Conference webpage (hosted by CLIMAS)
  http://www.ispe.arizona.edu/climas/conferences/CRBpaleo/index.html
- NOAA Paleoclimatology Program
  http://www.ngdc.noaa.gov/paleo/paleo.html/
- Laboratory of Tree-Ring Research, University of Arizona
  http:// www.ltrr.arizona.edu/