

Climate Science and Decision-Making: The Case of Water Managers and Tree- Ring Data in the Western United States

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Context of Water Management in the Western U.S.

Growing populations, limited resources, and sustained drought have placed increased pressure on already over-allocated water resources throughout the Western United States



<http://www.daylife.com/photo/03XXg4671Bb07>



<http://www.msnbc.msn.com/id/23130256/>

Context of Water Management in the Western U.S.

Gaged streamflow records have been used as the basis for water resource management in the US.

BUT current drought conditions raise new questions:

- Are gage records representative of the range of long-term streamflow variations?
- What about the frequency and severity of drought conditions that have occurred before observed records exist?
- Not to mention climate change!



Context of Water Management in the Western U.S.

- Some water managers are seeking out new forms of climate information (beyond the instrumental record) that may be used in water management
 - paleoclimate data and information
- Beginning in 2000, scientists from the Western Water Assessment (WWA) began collaborating with Colorado Front Range water providers to investigate the ways that tree-ring data, primarily streamflow reconstructions, could be incorporated into water resource management
 - WWA is a NOAA funded climate research center at the University of Colorado, whose mission is to connect relevant climate information to regional decision-makers (RISA- Regional Integrated Sciences & Assessments program).

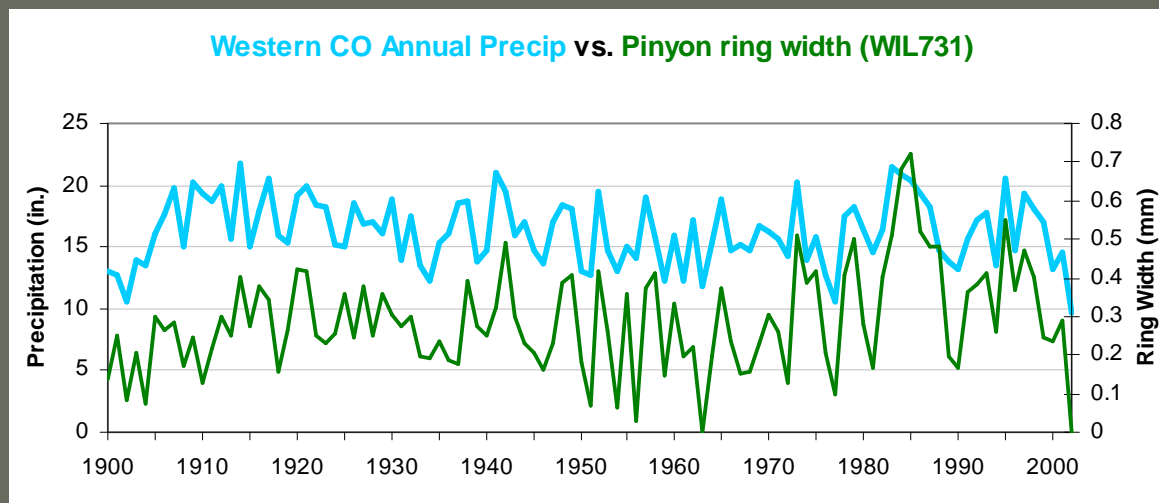
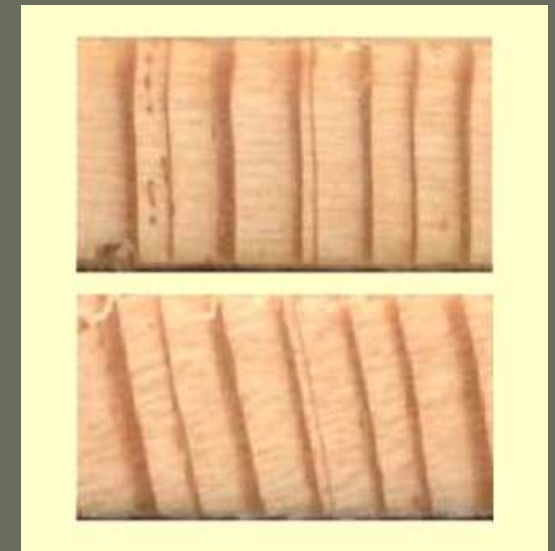
Research Questions

We conducted an assessment of these collaborations to determine what aspects of these activities have been more or less successful, and how tree-ring based reconstructions of hydrology can be made relevant and applicable to water resource planning.

1. What motivates the acceptance and use of scientific information for planning in water resource management? (relevance for managers?)
2. What is the relationship between institutional characteristics of water supply organizations and the use of tree-ring data in water resource management? (barriers to use, conditions that facilitate use?)
3. How have tree-ring data been used by water managers, and has this influenced organizational procedures or plans related to climate variability and uncertainty? (produce actual changes in plans/procedures?)

Using Tree-Ring Data to Extend Records of Streamflow

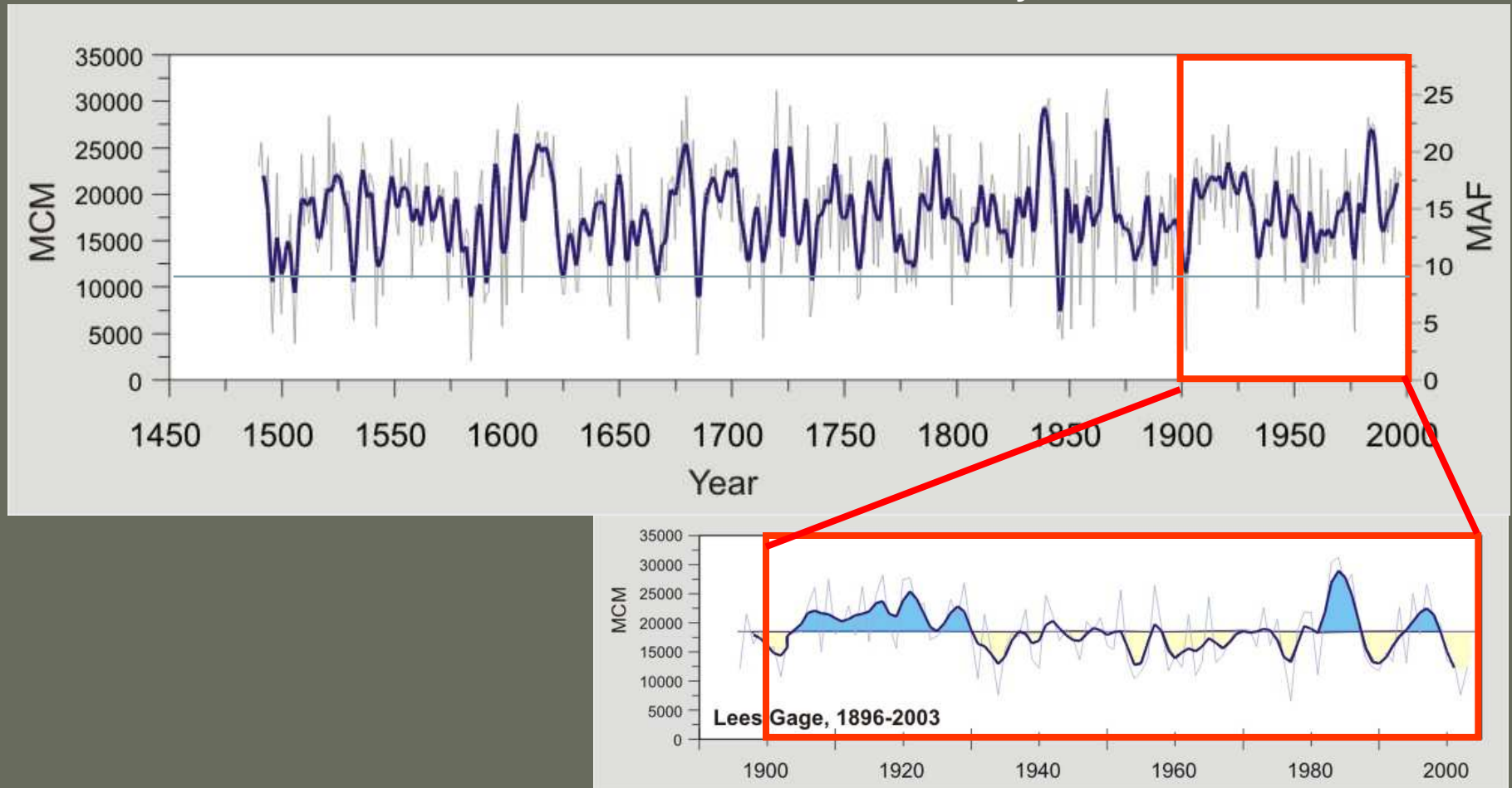
- Moisture-stressed trees closely track variations in precipitation, drought, and streamflow
- In these trees, tree rings are wide in wet years and narrow in dry years
- Because of this, records of ring widths can be used to extend instrumental climate record back in time centuries to millennia.



Ring widths from a single tree near Grand Junction are plotted with annual precipitation in the Colorado River basin. ($r = 0.69$). Samples from many trees and sites are incorporated into a single reconstruction of streamflow.

Tree-ring based reconstructions of streamflow allow the shorter gage records to be assessed in a centuries-long context.

Reconstruction of Colorado River at Lees Ferry, 1490-1997



Interactions Between Scientists and Water Managers in the Study

Two forms of science-policy engagements occurred:

1) WWA dendrochronologists ('tree-ringers') provided specific reconstructions for three water utilities in Colorado from 2000 to 2006.

2) In 2006, WWA researchers began to share the results of this work with the larger management community through a series of small, technical workshops.



Methodology

- *Phase One:* Semi-structured interviews were conducted with a total of nine individuals associated with three different water utilities in Colorado during January 2008.
- *Phase Two:* An online survey was distributed to all workshop participants (n=71) during March 2008.
 - Response rate was 39.4% (n=28)
 - Much more diverse population with respect to occupation and location

Description of Water Utilities that Collaborated with WWA scientists

Representatives of these organizations were interviewed in Phase One

Water Provider	Comments
Organization A	Private water utility serving a large urban area.
Organization B	City-owned water utility serving a mid-sized urban area.
Organization C	Publically owned water conservation district. A water board determines how much of each contractee's water quota will be delivered each year based on snow pack, runoff, and estimated diversions.

More information on Survey Respondents

Survey Responses to the Question "In What Area(s) do you Work?"
(Respondents could select more than one answer)

Planning	56 %
Operations	41 %
Research	26 %
Water Conservation District	15 %
Water Conservancy District	0 %
Private Consulting	26 %
City Government	26 %
County/State Government	15 %
Federal Government	16 %

Results (1): Use of Tree Ring Data

- *Why do Water Managers Seek out Tree-Ring Data?*
 - The most prominent motivating factor that emerged was the occurrence and persistence of an extreme event—drought.
 - Survey responses varied more, but drought, variability, & water reliability were still prominent

Results (1) cont: Use of Tree Ring Data

- EXAMPLE: An engineer from Organization C stated, “We hadn’t seen anything like that [2002 drought]... So we were contemplating a 30% quota, which was just unheard of and a lot of us here were really pretty worried about 30% of a full allotment... We were water-supply-limited for the first time”
(January 16, 2008, Personal Communication).

Results (1) cont: Use of Tree Ring Data

- *How do Water Managers Use Tree-Ring Data?*
 - Quantitative *and* Qualitative uses



Quantitative Uses of Tree-Ring Data

Survey Responses to the Question **“How Have Tree-Ring Data Been Used by You, Your Organization, or Organizations that you Consult for?”**
(Respondents could select more than one answer)

To Broaden Understanding of Hydrologic Variability	75%
To Educate Users/Public	46%
To Educate Board and Other Decision-Makers	50%
As Input into a Water System Model or Other Model	25%
For Quantitative Analysis, but not in a Modeling Environment	14%
To Inform Planning and Decision-Making	54%
I have not Used Tree-Rings in my Organization	18%

Quantitative Uses Tree Rings (Cont.)

- Additionally, all three water utilities have incorporated streamflow reconstructions into their water systems models.
- Overwhelmingly, these assessments have shown that the worst drought of the instrumental record (1950s) was not the worst drought of the paleo record (1840s), prompting them to re-assess their drought plans.

Quantitative Uses of Tree-Rings (Cont.)

- EXAMPLE: Water managers at Organization C have used data from a tree-ring reconstruction to quantitatively assess what water quotas the organization would have set over the entire paleo streamflow record, under their current quota-setting guidelines.
 - “So, I did this little study... [I] ran through our project under some different quota setting methodologies, and I guess the result out of that study is that the 30% quotas really aren't that unusual when you have a longer time period to look at... We had a few public meetings just to knock on people's doors and say, *'oh, by the way, you know that 50% you thought you might get, it's going to be 30%!'*”
(January 16, 2008, Personal Communication)

Qualitative Uses of Tree-Ring Data, Cont.

Survey Responses to the Question **“How Have Tree-Ring Data Been Used by You, Your Organization, or Organizations that you Consult for?”**
(Respondents could select more than one answer)

To Broaden Understanding of Hydrologic Variability	75%
To Educate Users/Public	46%
To Educate Board and Other Decision-Makers	50%
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I have not Used Tree-Rings in my Organization	18%

Using Tree-Rings to Educate Water Boards about Streamflow Variability

A representative from Organization A said:

“So we took them [the board] through part of the planning process to re-educate or educate them on what our planning approach was—the 1950s drought, without restrictions, [and] what we learned from using the tree-rings... We got a really positive favorable response that made them feel a lot better to see a longer hydrological period”

(January 14, 2008, Personal Communication).

Results (2): Importance of Institutional Context and User Constituencies

- **Institutional context and water users do influence how climate data is incorporated into water management.**
 - Some utilities have been able to aggressively pursue integration of climate information into resource planning, while others have concerns regarding the perceptions of other decision-makers or water users.

Results (2).: Importance of Institutional Context and User Constituencies

Table 6: Survey Responses to the Question “Do you or individuals in your organization have any of the Following Concerns that Might Limit the use of Tree-Ring Data?” (Respondents could select more than one answer)

Tree-ring data are too uncertain/not credible	22%
Stakeholders/public may not accept/understand use of tree-ring data	37%
Observed/gaged record is sufficient for our planning needs	15%
It is difficult to use tree-ring data in qualitative or quantitative assessments with gage data	22%
It is difficult to incorporate information related to tree-ring data into decision-making	30%
None of the Above	37%

Results (2) Cont.: Importance of Institutional Context and User Constituencies

- **EXAMPLE:** Organization C is careful of how it presents tree-ring data (and other data related to climate change) to its water users.
 - This is primarily due to the concern that water users—who currently buy and sell shares of delivery rights in an open market—would “hoard” water if supplies are shown to be less reliable or plentiful than previously thought.

Results (3): Data Challenges and Considerations

- **Even with increased understanding of the applications of tree-ring information, technical and social challenges still exist in using the data.**
 - These include spatial and temporal disaggregation (from yearly paleo records to daily model inputs) and difficulty explaining the use of tree-ring data during public review procedures.

Example: Data Difficulties

A representative from Organization A stated:

“So there’s like 450 nodes [in our water system model] that we have daily data for, so, using the tree-ring data unfortunately you have to make giant leaps...absolutely giant leaps...so ...we just went back and found the closest year in the '47 to '91 data that we had, so the year 1680 might have been closest to 1950. And so we used the daily data for 1950 for all the east slope nodes. So, it’s a huge leap” (January 14, 2008, Personal Communication)

Theoretical Framework for Understanding Results

How can we understand the engagements
between scientists and decision-makers?

- What do we learn from this evaluation of
science-policy engagements?

Theoretical Framework for Understanding Results

- We advocate the *Co-production of science and policy* approach
 - Lemos & Morehouse 2005, Tribbia & Moser 2008 , Vogel et al. 2007
 - Recognizes that science and policy are not separate spheres of 'producer' and 'user' groups, often they are co-produced as scientists and decision-makers work to collectively define problems and useful information to address those problems.
 - Encourage collaborative processes that engage scientists, decision-makers, and publics to interactively and iteratively seek solutions to complex environmental problems
 - 'Better' science does not always lead to 'better' management

Summary of Results

- Climate researchers and water utilities in the Western U.S. have created effective and productive partnerships for integrating tree-ring data into water management efforts. Deliberate and reflexive interactions between scientists and resource managers can improve the accessibility, understanding, and utilization of climate data in water management.
- These partnerships do change the practice of water management. Almost all water managers state that they have a better understanding of the range of hydrological variability they may reasonably expect. This knowledge has been integrated into water models, drought planning efforts, and educational outreach.
- Through these partnerships, research scientists are afforded the opportunity to help with policy challenges, while resource managers can help define and create scientific research agendas

- Thank you!

We would also like to say a special thanks to all of the interview and survey participants

Thanks also to the Western Water Assessment, including Jeffry Lukas, for their assistance in facilitating this project

Please look for our paper later this year in the Journal of the American Water Resources Association

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