Tree-Ring Monsoon Workshop

November 1, 2011
Salt River Project,
Phoenix AZ

Welcome

- introductions – who we are, who you are

- purpose of workshop
  - provide a brief overview of tree-ring methods
  - show you new results for reconstructions of the North American Monsoon and cool season precipitation for southeastern AZ
  - discuss how this information might be useful to you

North American Monsoon Project

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- National Science Foundation
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- Climate Assessment for the Southwest (CLIMAS)
- Salt River Project – workshop host

THE UNIVERSITY OF ARIZONA. LTRR Laboratory of Tree-Ring Research University of Arizona CLIMAS Climate Assessment for the Southwest NSF EPA

Today's Agenda

- Monsoon project background
- Tree Rings 101 in brief: using tree rings to reconstruct past climate
- Reconstructing monsoon precipitation with latewood widths
- What do the monsoon and cool season reconstructions tell us about past rainfall variability in this region?

- ***Break for working lunch***

- Discussion
- Wrap-up and next steps

Tree Rings and the North American Monsoon

Project Goals

- Develop the first monsoon-sensitive chronology network in the SW U.S.
- Investigate long term monsoon season drought variability in SW U.S.
- Compare cool-season and monsoon-season precipitation in the paleo records
- Assess relationship between monsoon and large scale circulation (i.e., El Niño)
- Provide useful information to stakeholders

http://monsoon.ltrr.arizona.edu

NSF

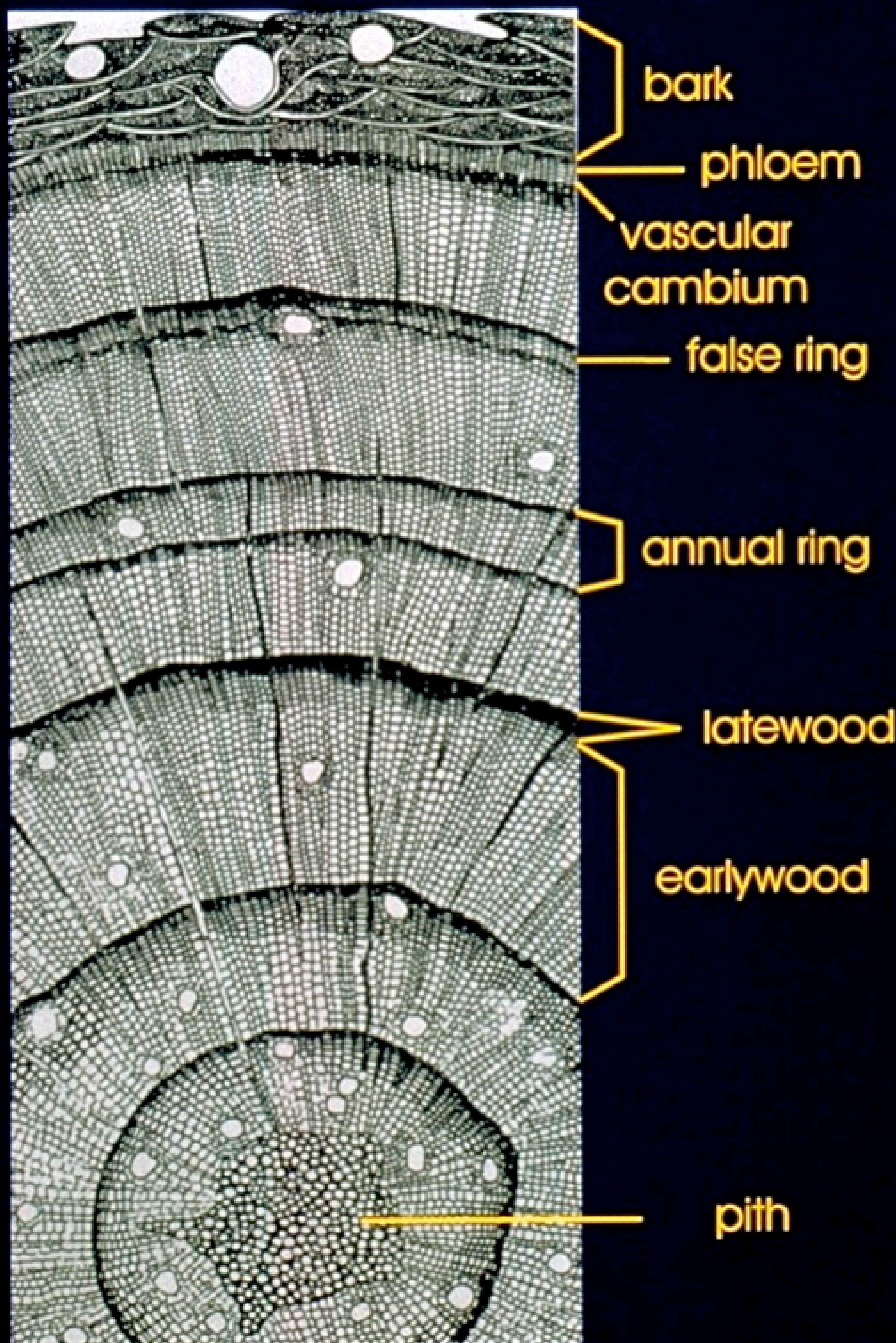
EPA

Part 1.

Overview of Tree Rings and Climate Reconstruction

- how trees record climate
- how climate reconstructions are developed
- uncertainty in reconstructions
- kinds of information from reconstructions

How tree rings record climate information



- New wood forms in the vascular cambium, underneath the bark
- Earlywood + latewood = growth ring
- In temperate climates, growth ring = *annual ring*
- Ring width vary according the factor which is most limiting to growth, typically climate in the southwestern U.S.

What trees are the best recorders of precipitation?

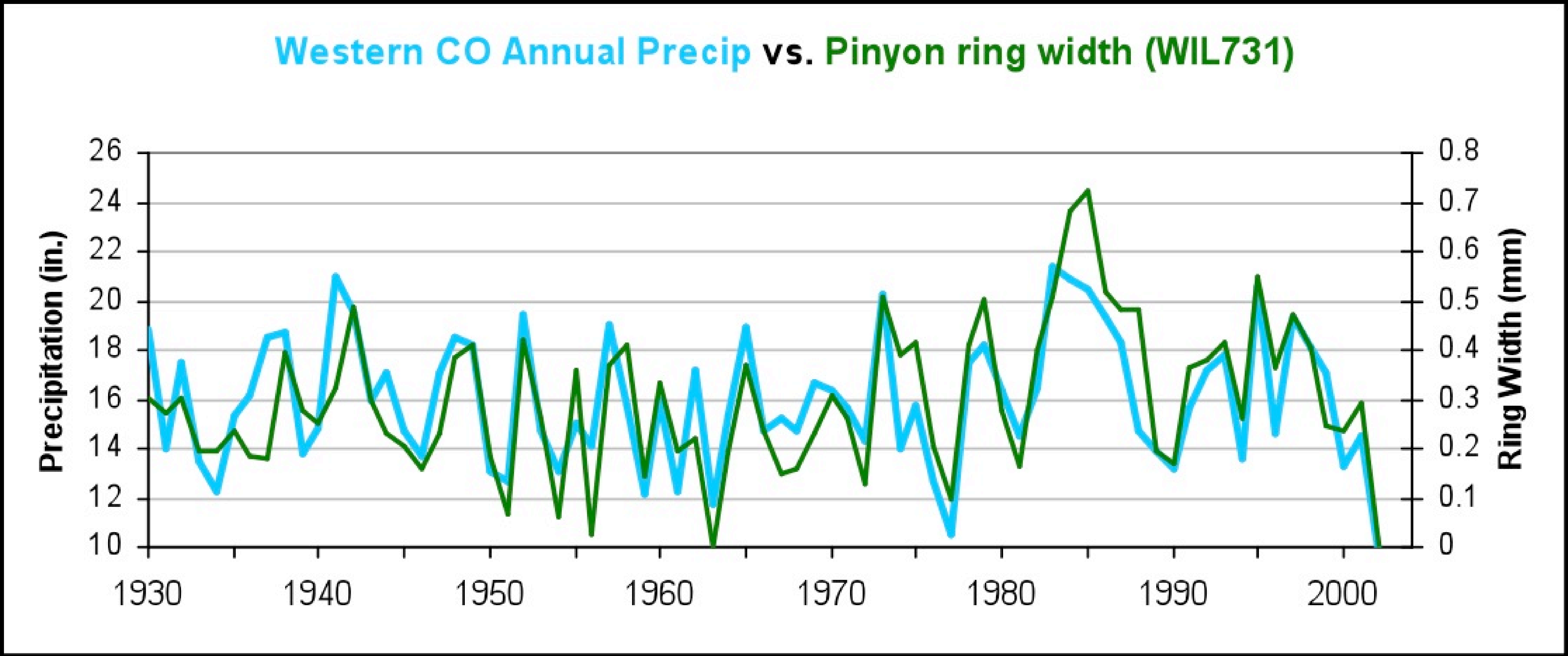
Trees that are limited by moisture, growing on open, well-drained sites, with thin soils

Douglas-fir

Pinyon pine

Ponderosa pine

The moisture signal recorded by trees in the Southwest is particularly strong

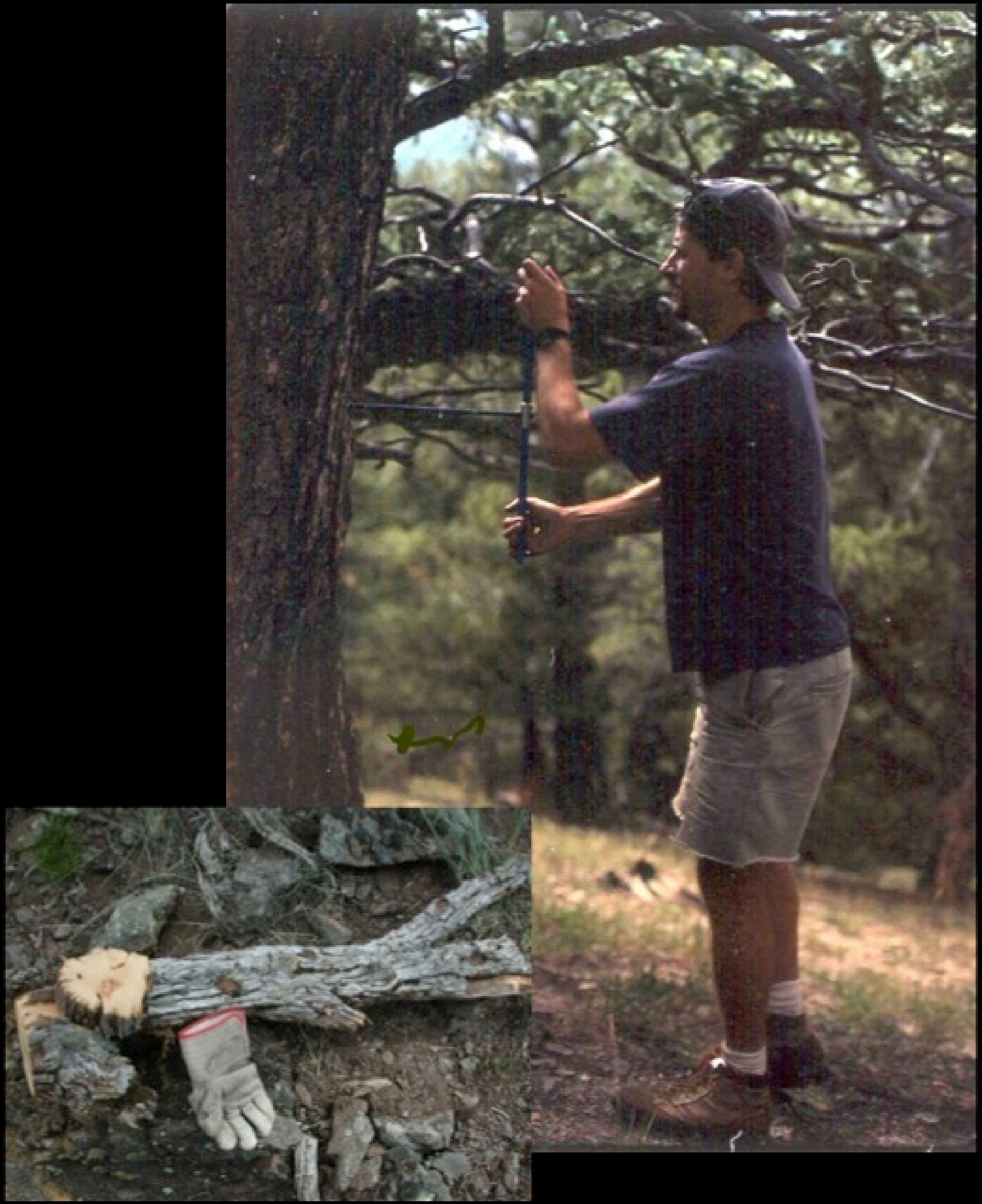


Here, the ring widths from *one* tree are closely correlated to the western Colorado precipitation ($r = 0.78$) from 1930-2002

How climate reconstructions are developed : field work to statistical model

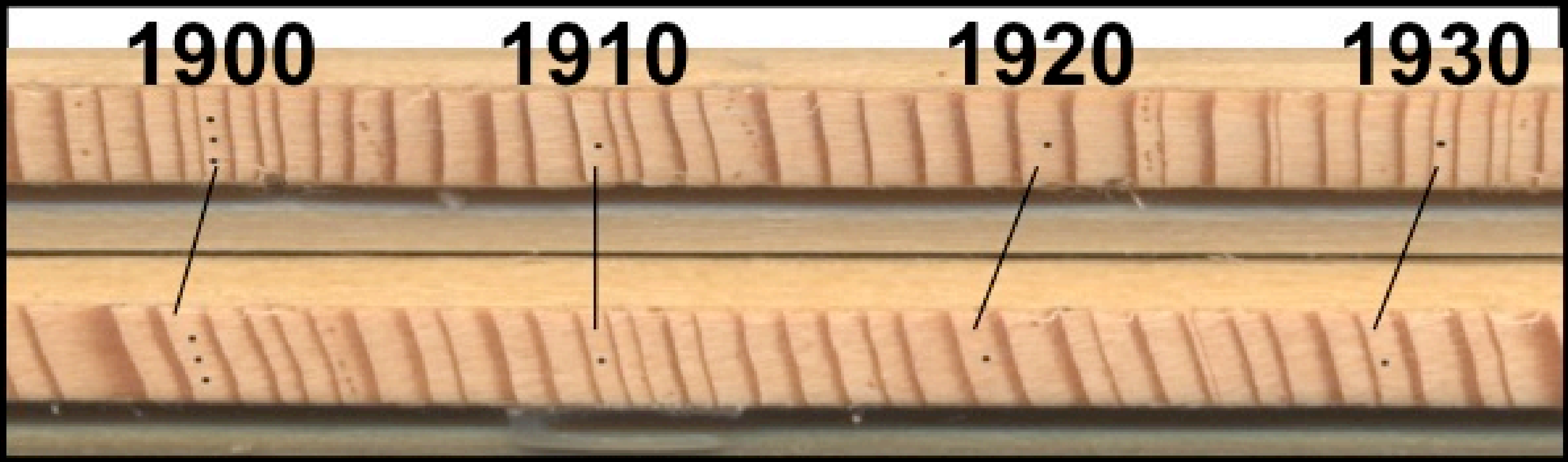
1. Field Collections

An increment borer is used to sample cores from about 20 trees at a site

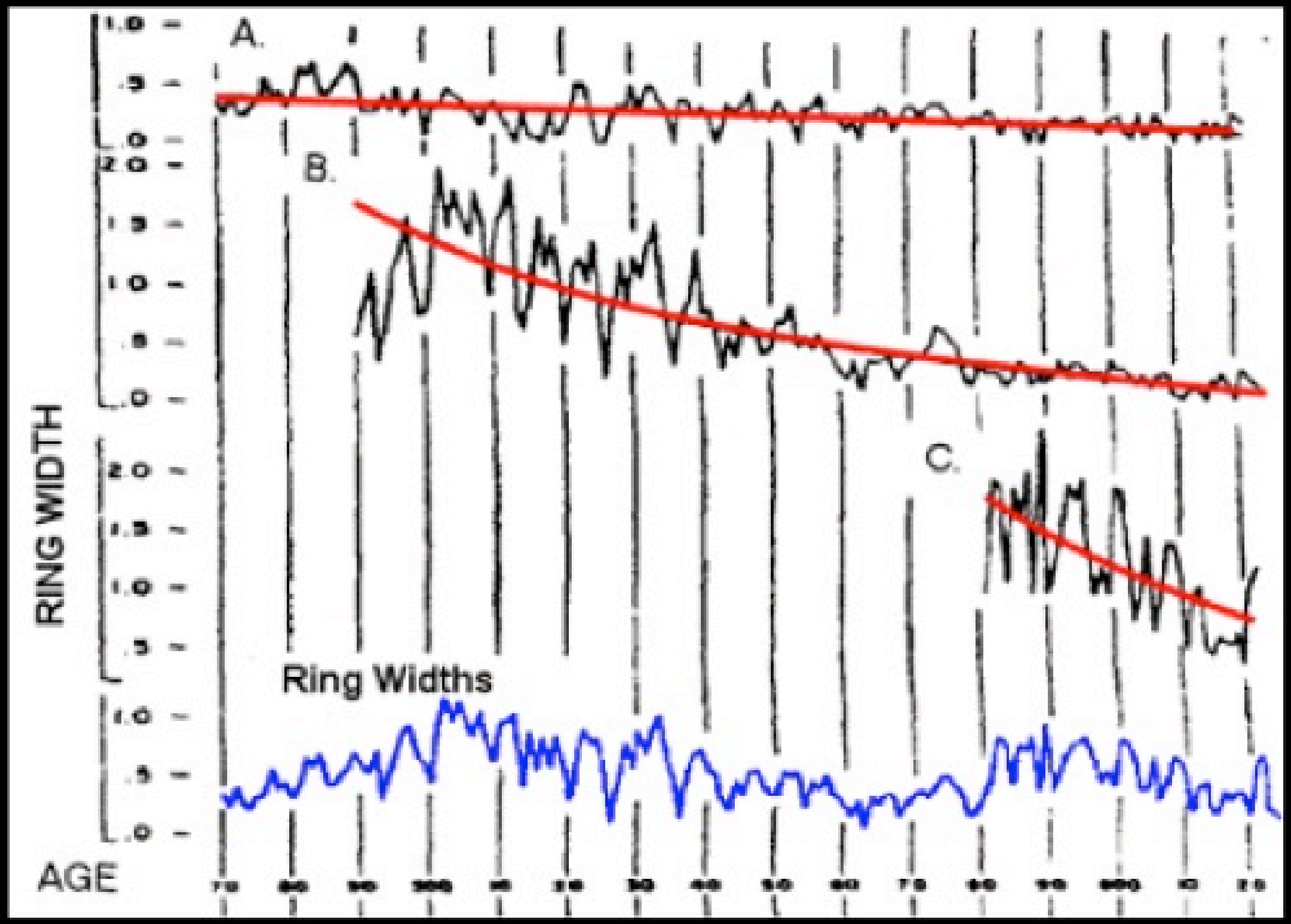


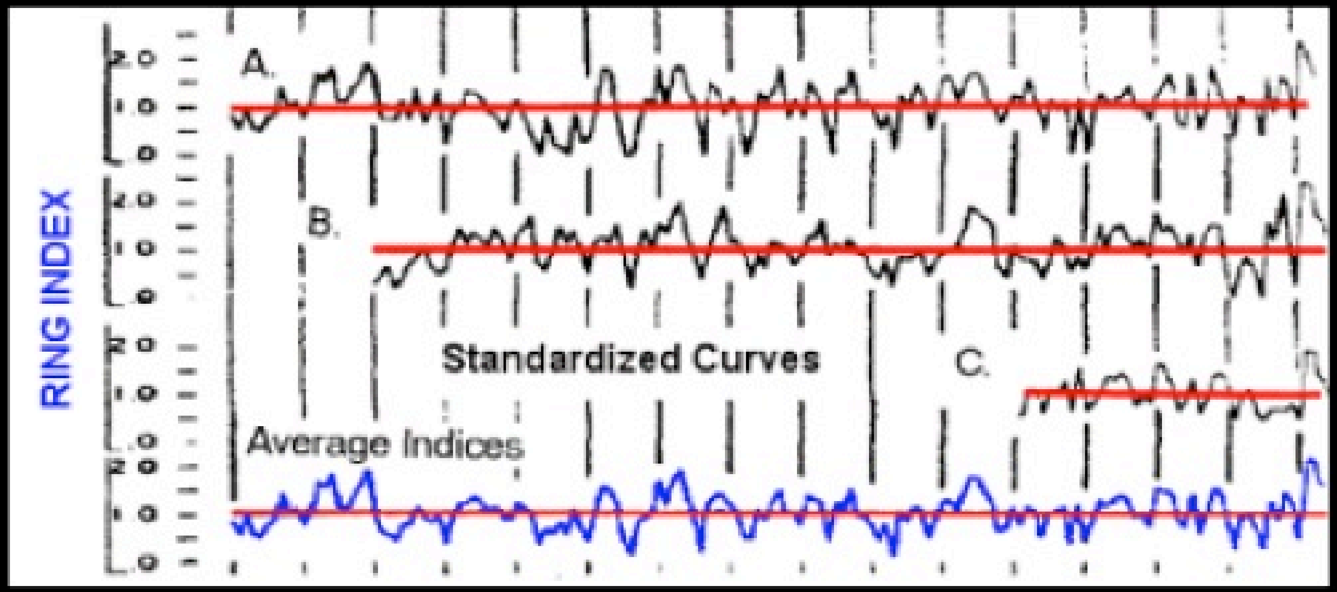
2. Sample Preparation

Cores are mounted and sanded, then dated, and measured



3. Detrending the measured series



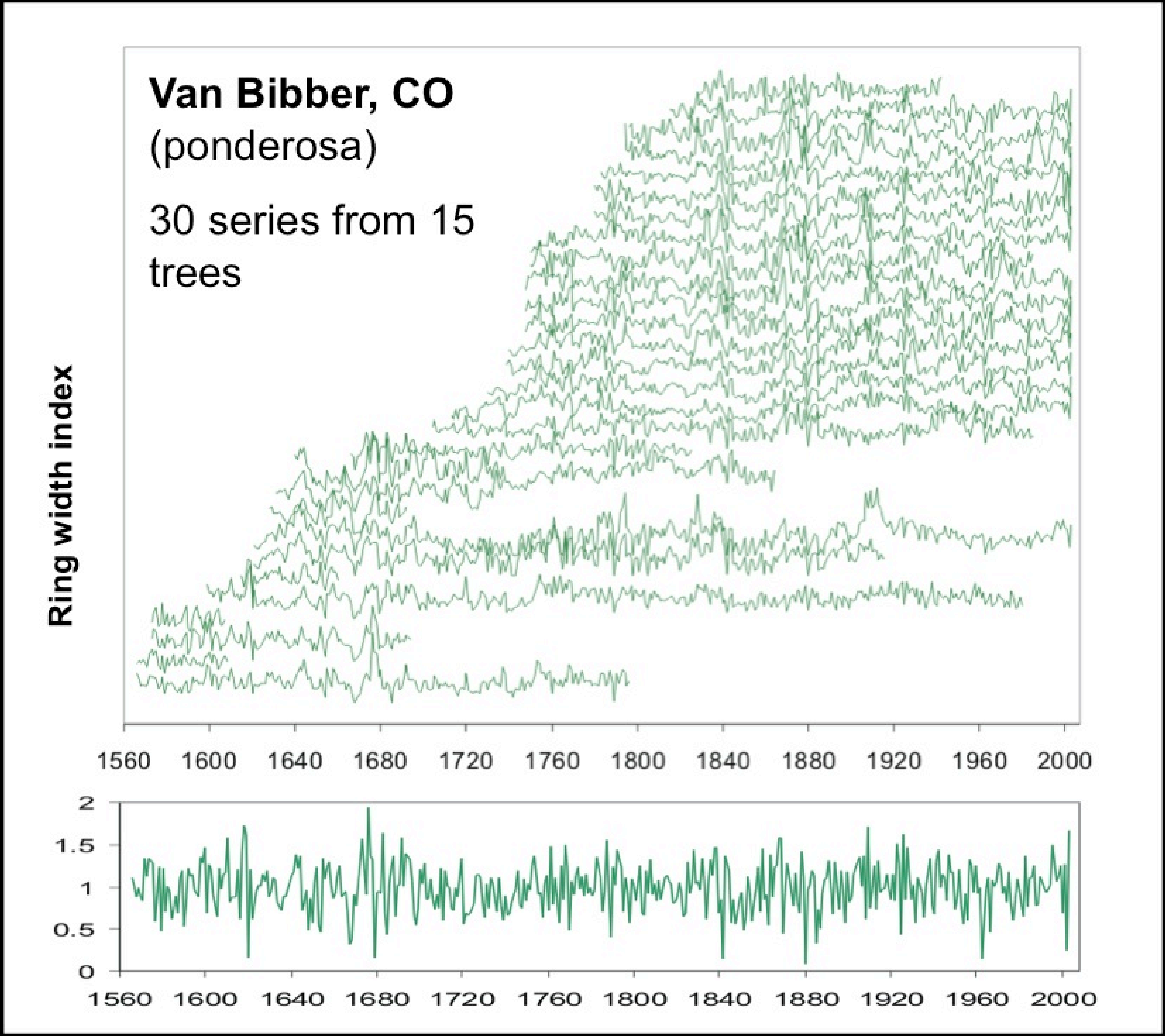


- Ring-width series typically have a declining trend with time because of tree geometry
- These biological trends are not related to climate so are removed

- Raw ring series are detrended with straight line, exponential curve, or spline

- These *standardized* series are compiled into the site chronology

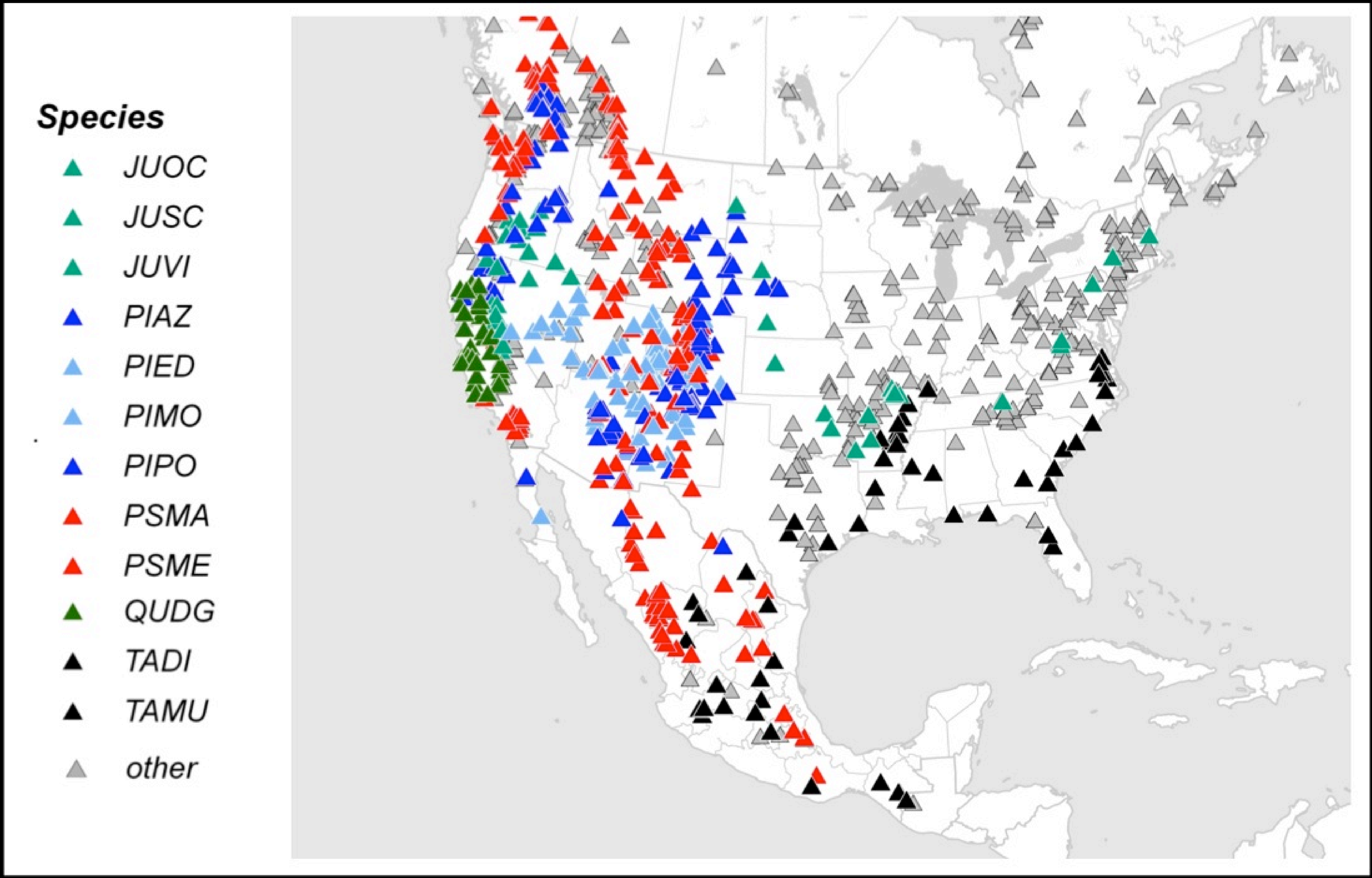
4. Compiling the Tree-Ring Chronology from the measurements from many trees



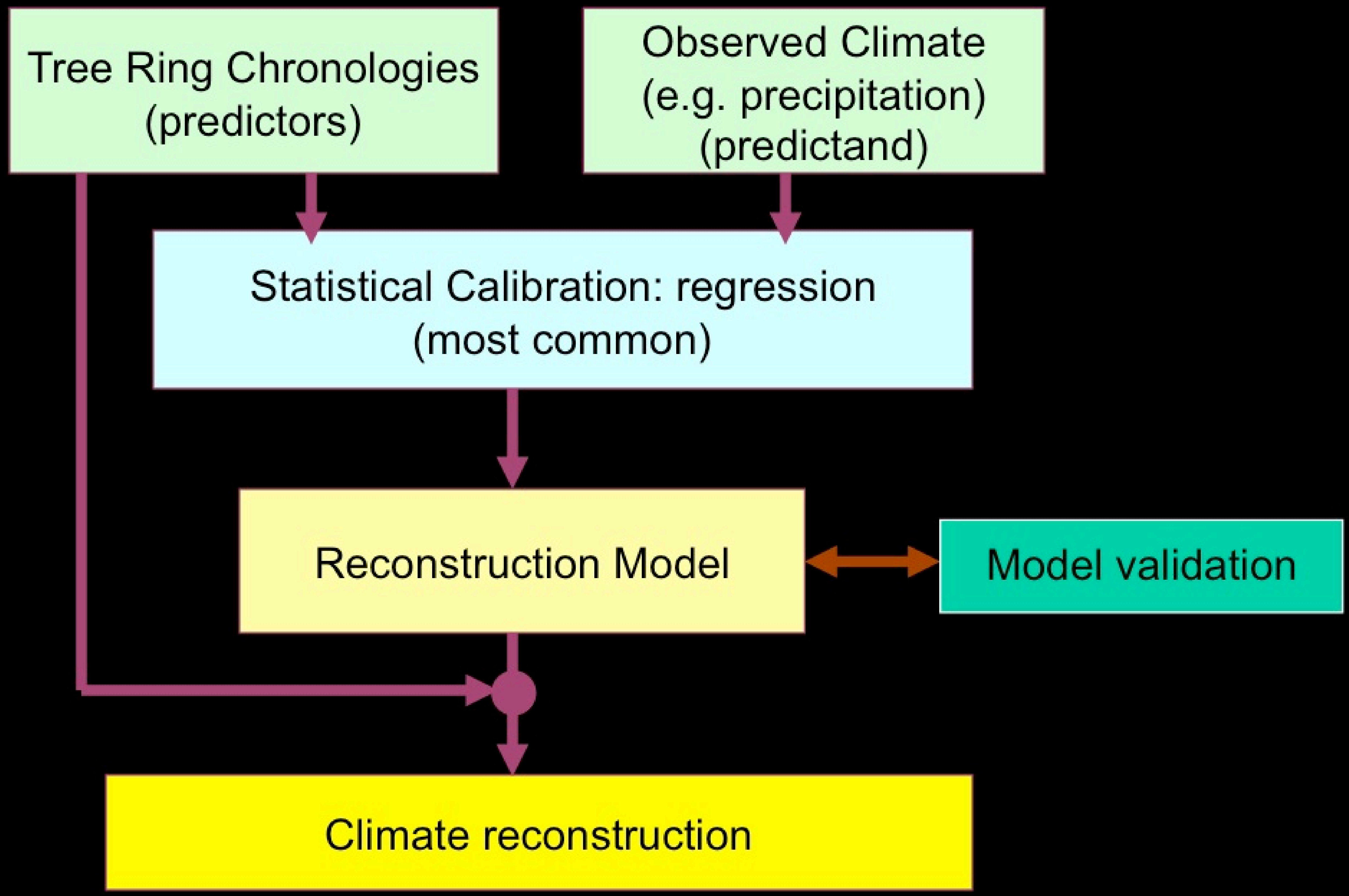
Chronology = basic unit of tree-ring data, "building block" for the flow reconstruction

Tree-ring chronologies in North America > 200 years

Colored triangle are moisture sensitive chronologies



5. Generating the climate reconstruction



based on Meko (2005)

Requirements for observed climate record

- **Length** – minimum 40 years for robust calibration with tree-ring data
- **Quality –** screened for station moves, changes in instrumentation.
- Increasingly, we are using **gridded climate data** (4 km)
  - Pluses –1) takes advantage of all sources of climate data for an area; 2) quality control has been performed; 3) common length of record
  - Minuses – 1) although data are available for all grid points going back to 1895, less accuracy for earlier years, 2) spatial representation dependent on reliability of algorithm for estimating values in regions with no climate data

Requirements for tree-ring chronologies

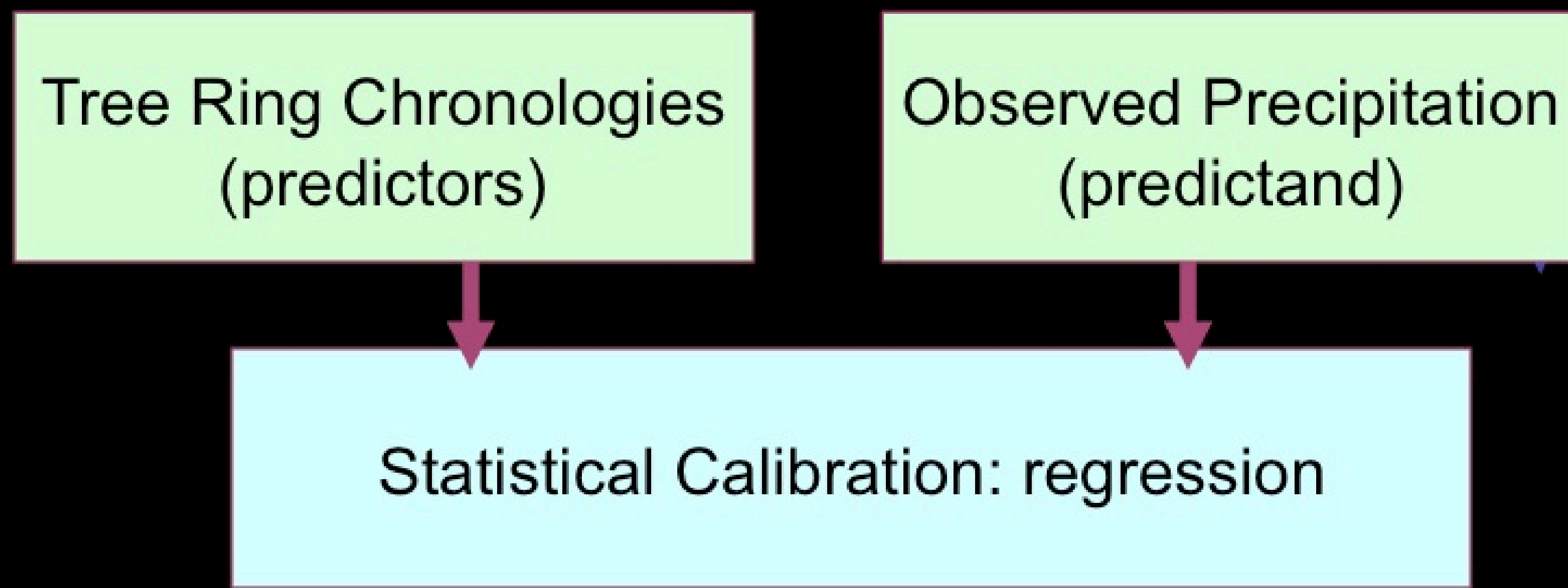
- **Moisture sensitive species** – primarily Douglas-fir, ponderosa pine, pinyon pine
- **Location** – from a region that is climatically linked to the region of interest
- Length tradeoff: fewer chronologies available further back in time, and in recent years, to some extent

Douglas-fir

Pinyon pine

Ponderosa pine

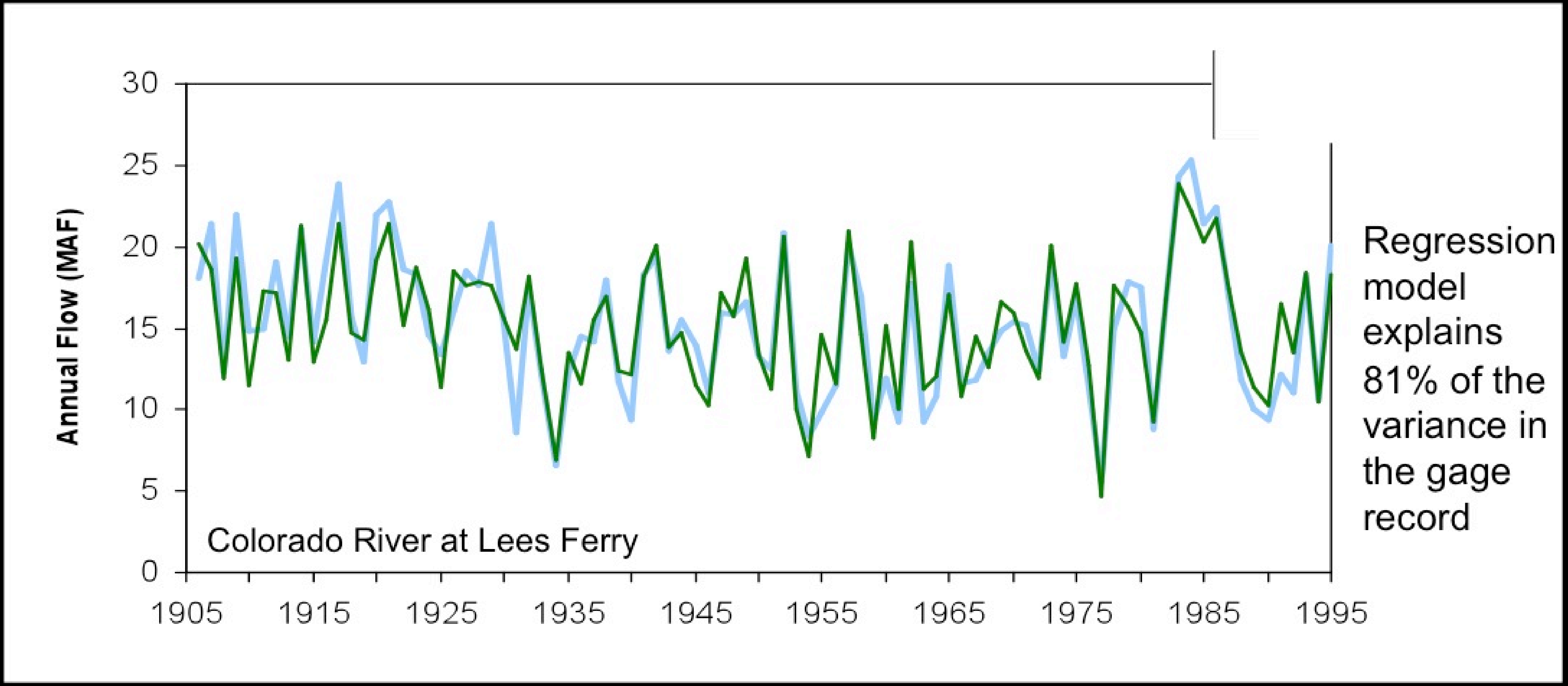
Reconstruction modeling strategies



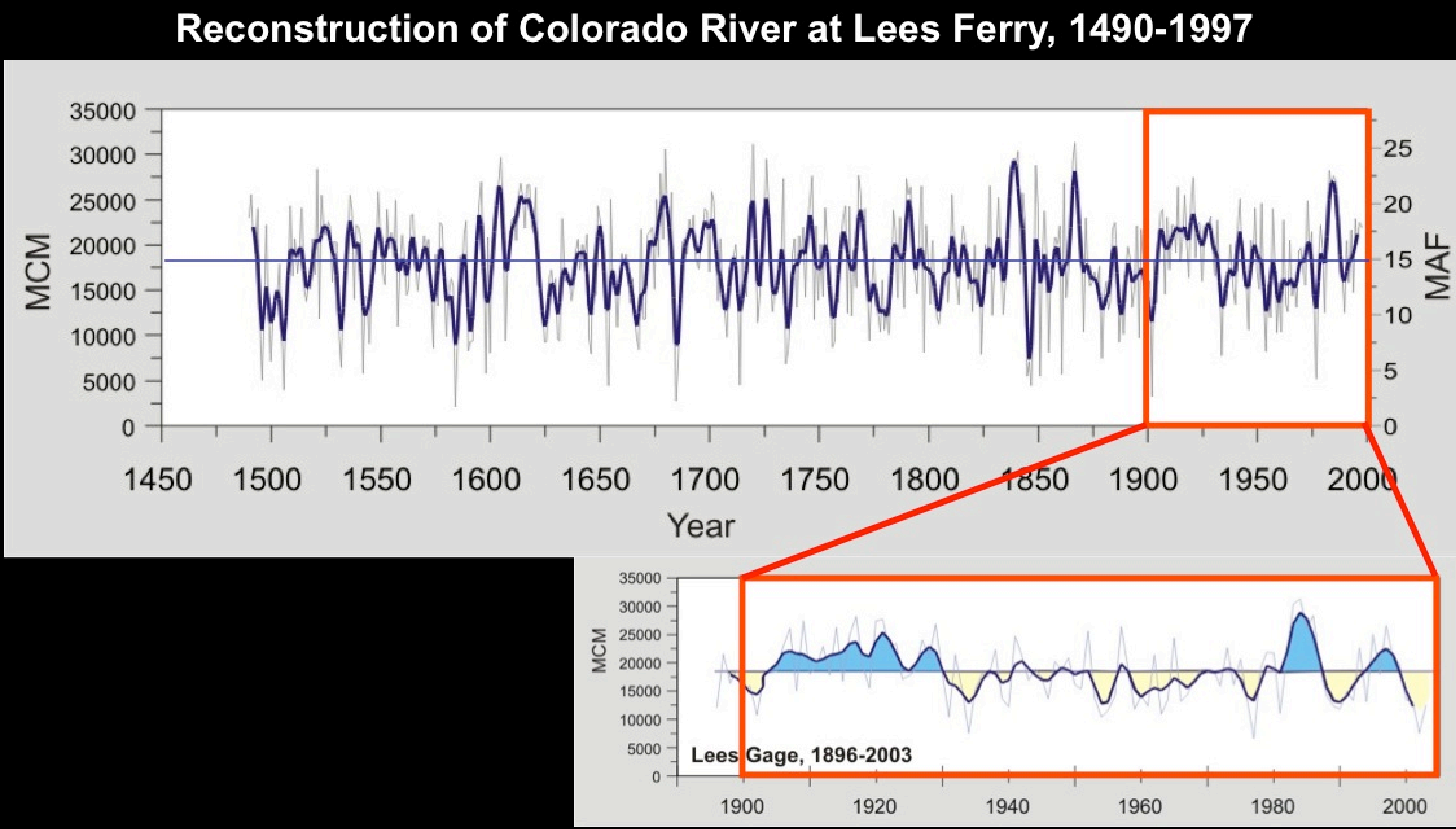
- Linear or multiple linear regression are most common
  - one common version of linear regression is principle components regression
- Other approaches are possible (e.g., quantile regression, neural networks, non-parametric methods)

6. Model validation and skill assessment

- Are regression assumptions satisfied?
- How does the model validate on data not used to calibrate the model?
- How does the reconstruction compare to the gage record?



7. The model is then applied to the full-length chronologies to produce a record of past climate variability



Woodhouse et al. 2006

Sources of Uncertainty in Climate Reconstructions

- Trees are imperfect recorders of climate.

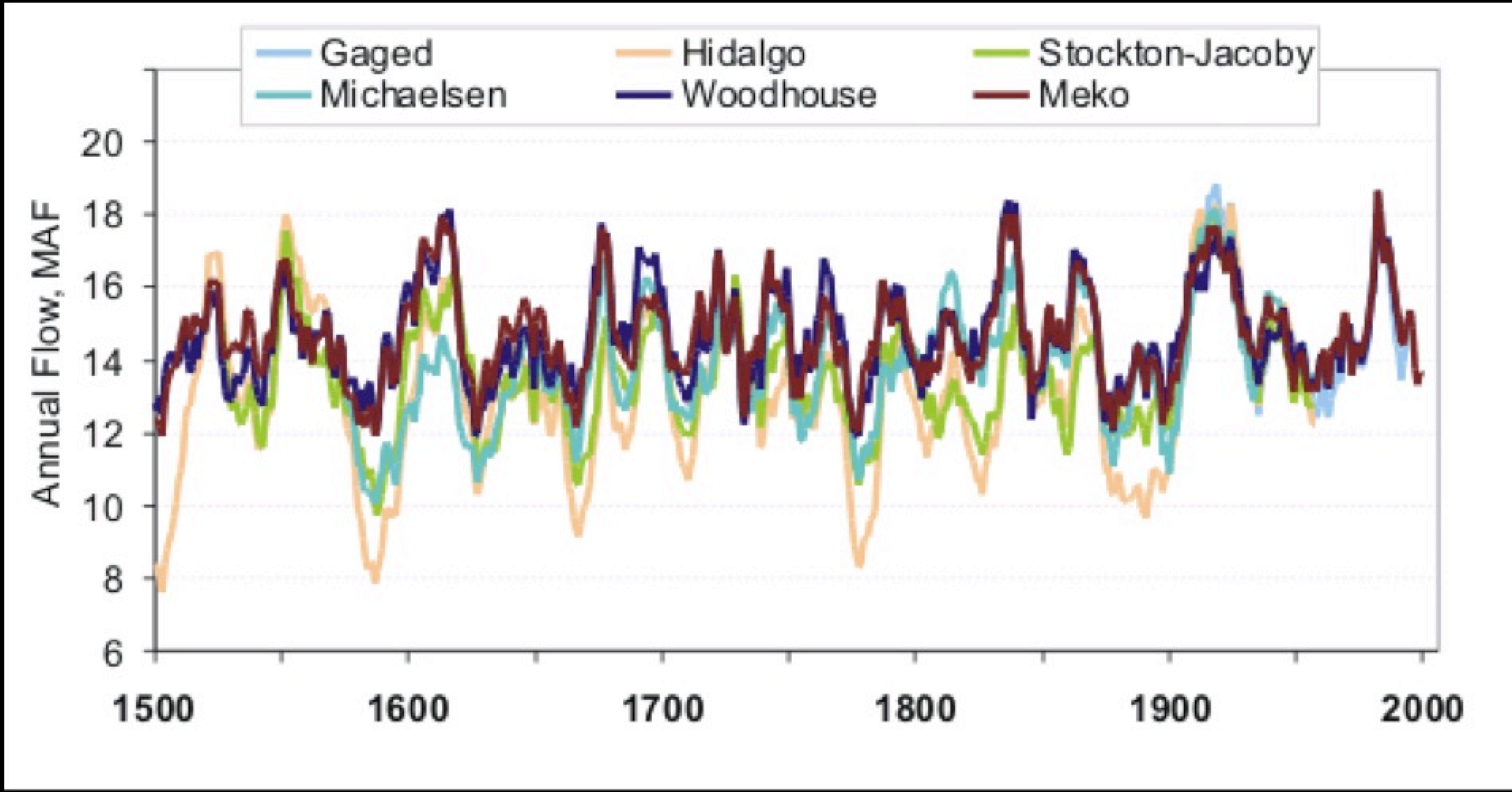
- The reconstruction model never explains 100% of the variance in the observed record.

- Climate data may contain errors.

- A variety of decisions are made in the reconstruction process, all of which can have an effect on the final reconstruction.

- A reconstruction is a *best estimate* of past climate, and each annual point represents the central tendency of a range of plausible values, given the uncertainty

An Example: Colorado River at Lees Ferry Streamflow Reconstructions, 1977-2007



Differences are due to a variety of factors:

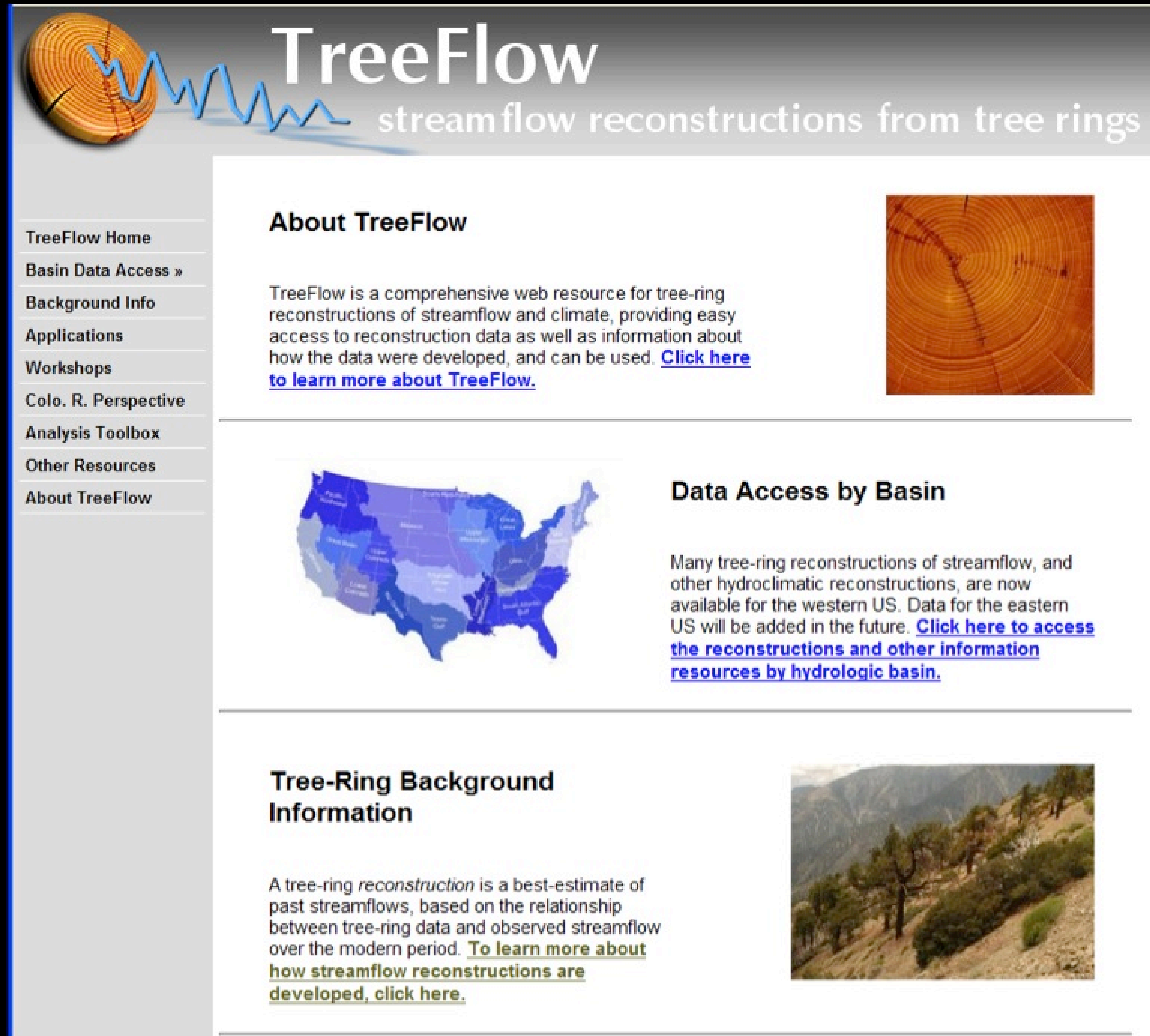
- calibration data used
- selection of tree-ring data
- treatment of tree-ring data (detrending)
- statistical methods for model calibration

What tree-ring reconstructions provide:

- context for assessing instrumental climate record over a longer time frame
- a way to evaluate recent drought events in terms of natural variability over past centuries
- a framework for understanding the range of drought characteristics (intensity, duration, magnitude) that has occurred
- insights on low-frequency (scale of decades to half century) variability
- an understanding of the rich sequences of wet and dry years that have occurred over past centuries

TreeFlow web pages: A resource for water managers

- tree-ring basics
- reconstruction and gage data
- workshop presentations
- applications examples
- references
- NEW: tools for analysis



http://treeflow.info/