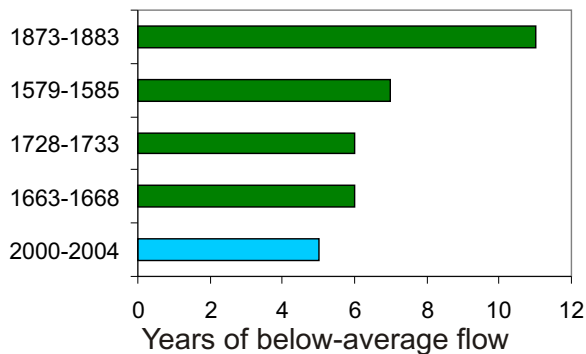
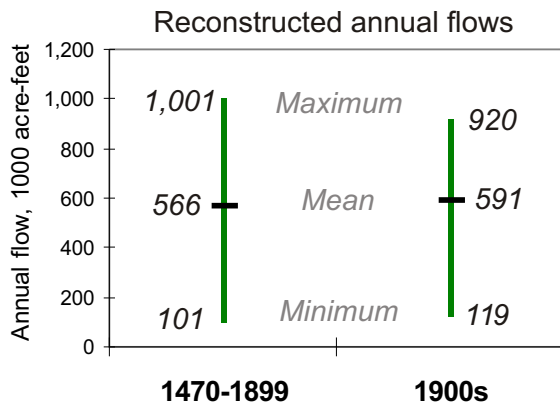


What are the implications for water resource management?

The range of variability of Animas flow over the four centuries prior to 1900 was broader than what was seen in the past century, and flows were lower on average before 1900 (*figure below*). In addition to more extreme flows, the record of past flows included several droughts longer than 2000-2004 (*bottom figure*).



While the conditions of the past will not be exactly repeated in the future, they can provide a guide to the full range of conditions that might be expected--including droughts longer and more severe than 2000-2004.



For more information:

TreeFlow - Tree-ring reconstructions of streamflow for the West

<http://wwa.colorado.edu/treeflow/>

- Access to Animas flow reconstruction:

<http://wwa.colorado.edu/treeflow/durango2008.html>

Western Water Assessment

<http://wwa.colorado.edu/>

Mountain Studies Institute

<http://www.mountainstudies.org>

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Tree rings and drought in the Animas basin



The 2000-04 drought in the Animas River basin was, by most measures, the worst since records began around 1900. But have droughts this severe occurred before then? If so, how often? Have there been even worse droughts?

What can tree-rings tell us about drought?

Tree growth in dry climates is limited by water availability. So trees growing at lower elevations in Colorado (pinyon pine, ponderosa pine, and Douglas-fir) faithfully record the changes in precipitation from year to year (*image below*).



1977

1983

Annual growth rings from a Douglas-fir in the South San Juan Mts. include a drought year (1977) and a very wet year (1983).



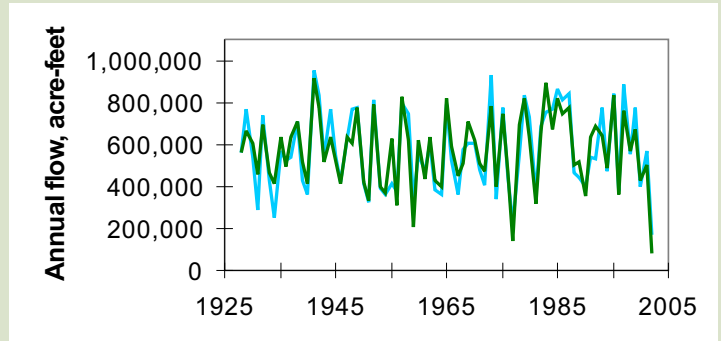
How are tree rings used to extend streamflow records?

Since annual streamflow, like annual tree growth, is driven by cumulative precipitation over the course of the year, tree ring-widths track the variation in streamflow. Because of this, tree rings can be used as a proxy for past streamflow, extending back hundreds of years.

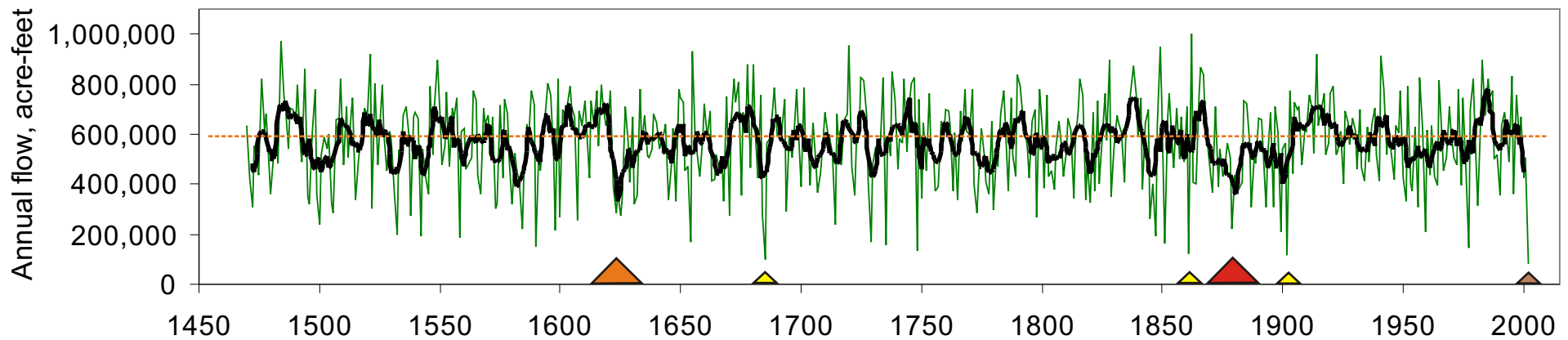
A record of tree growth for one site, called a tree-ring chronology is compiled from about 20 trees at a site. Old trees on dry, rocky sites are cored (*photo, left*), the rings are *crossdated* to the correct year, then the ring widths are measured. The measurements for each core are averaged to create a site *chronology*.

An increment borer is used to collect a core from an old pinyon pine in western Colorado.

To extend, or "reconstruct", a gaged streamflow record, several tree-ring chronologies are calibrated with a gage record to create a statistical model (*figure, below*) that describes the relationship between flow and tree growth. The model is then applied to the full length of the chronologies to reconstruct streamflow back in time, typically 400 to 800 years.



Animas R. at Durango tree-ring modeled annual flows (green) and gaged annual flows (blue), 1928-2002



What the Animas streamflow reconstruction shows

The graph above shows Animas River at Durango reconstructed annual flows from 1470-2002 (green line), with a 5-year running average (black line) to highlight multi-year droughts. The orange line is the average gaged flow (595,000 acre-feet). The reconstruction shows several multi-year droughts more severe than any in the gaged record. The 11-year drought from 1873-1883 (red arrow) was the longest drought in the reconstruction, while the 5-year drought from 1622-1626 (orange arrow) had the lowest 5-year average flow (332,000 acre-feet, 56% of normal). The reconstructed annual flow for 2002 (brown arrow) was the lowest in the entire 533-year record--indicating what a truly extreme year it was, although three other years (yellow arrows) had reconstructed flow similar to 2002.