Reconstructing Streamflow in the Salt River Using Tree Rings: An Error Analysis

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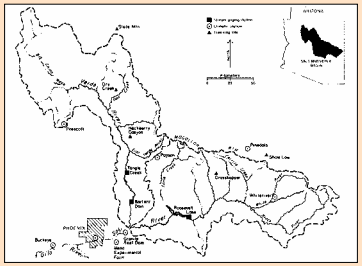
Abstract:

The Hohokam built the largest canal network known in prehistoric North America. Understanding the relationship between these people and the river that supported them is a key challenge for archaeologists. Using tree ring data collected on the Mogollon Rim, archaeologists have reconstructed annual stream flow conditions for the past 1,400 years. These data have also been used to infer presence and absence of flooding. Through this project I analyze calculations and assumptions previously made and show that while tree ring data are useful, they have limited application in retrodicting precise annual stream flow, and by themselves do not indicate presence or absence of flood events.



Salt River Watershed. From Graybill 1989.

Background

Tree ring chronologies developed for the Salt River watershed have been used to support specific statements concerning flood events in the Salt River (Nials et al. 1989, Gregory 1991).

Abbott (2001, p. 33) provides an example of such a statement:

> Based on Graybill's (1989) reconstruction, we know that a disastrous discharge from the Salt River in AD 1356 followed by 33 years of low flow. Continued research also tells us that the Classic period residents were hit with even larger floods in AD 1380.

These statements provide the basis for many authors' reconstructions of Hohokam environments. Understanding these environments, especially the timing and magnitude of flood events, is critical in interpreting environmental influences on cultural changes apparent in the archeological record.

Research Question:
Can tree ring records be used to retrodict paleofloods?

Methods and Results:

I. Error Analysis.

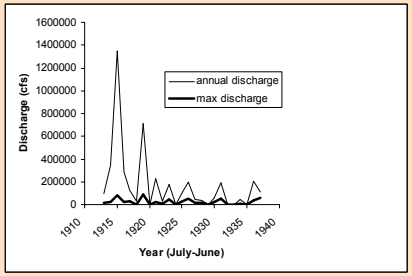
Greybill's function defines annual streamflow (SL10) as a function of tree-ring width (AZNOF), and predicts an annual flow of 2,599,794 acre-feet for the year 899AD (the highest volume reflected in the tree ring record).

SL10=2.69665 + 0.54190 AZNOF r^2**=. 53, p<.00**

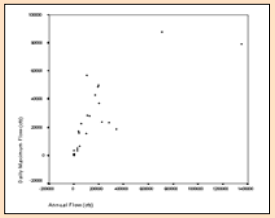
Using the standard error (0.21), I backcalculated the error envelope to determine that the actual volume lies between 1,585,000 and 4,169,000 acre-feet, a range that is larger than the predicted volume.

II. Determining the relationship between annual flows and peak flows

Intuitively, years of high streamflow would seem to be likely to have large floods, but this is not necessarily the case. A year with high streamflow may see flow evenly distributed with no outstanding floods, while a year with little annual streamflow could receive that flow in one storm. To determine the nature of the relationship between annual streamflow and peak streamflow, I examined historical data from Granite Reef Dam.



Relationship between annual flow and daily maximum flow



Daily maximum flow (cfs) = 13,368 + (0.65 x annual flow (cfs)) ± 3770
R^2=0.59, p<0.0

Conclusions:

1. Because the relationship between tree ring data and annual stream flow is weak, retrodicted annual stream flows should be characterized in terms of ranges. Single values imply false precision.

2. The relationship between annual discharge and maximum mean daily flow is weak but significant. This relationship suggests that high annual flows may, but not necessarily, indicate large flood events. Conversely, in years of low annual discharge, the Salt River may experience significant flooding.

Tree ring records reflect annual conditions and should not, by themselves, be used to infer flood events or subsequent geomorphic change. Their usefulness lies in retrodicting ranges of annual conditions.

References

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