Prehistoric streamflow and demography in the lower Salt River Basin of central Arizona

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Research question

What is the relationship between Lower Salt River discharge variation and population growth and decline among the Hohokam in Canal System 2 from A.D. 775 to 1450?

Problem

Floods and droughts and their effects on Hohokam irrigation systems have played a prominent role in many cultural-historical interpretations of the Hohokam trajectory in the lower Salt River Basin (cf. Graybill et al. 1989, 2005; Gregory 2001; Nials et al. 1989).

However, not all researchers agree on the effects or importance of streamflow variation on conditions for irrigation agriculture and the Hohokam trajectory (cf. Dean 1988; Fish 1989; Waters and Ravesloot 2001)

This study systematically examines the relationship between streamflow and demography over 675 years of Hohokam prehistory.

Data and Methods

Streamflow

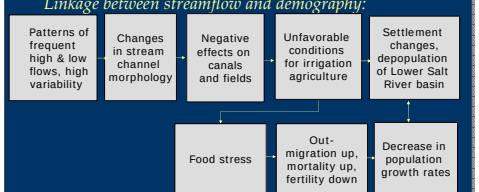
1. Annual streamflow discharge variation has been retrodicted from tree-rings from A.D. 572 to 1988 (in million acre feet/year) by Graybill et al. (1989, 2005).

2. I grouped annual discharges by Hohokam temporal/cultural phases (100 to 150 years) and statistically characterized streamflow within each phase by an index of flood and drought frequency and clustering, variability, and streamflow patterns likely to have affected stream channel morphology. Note: floods and droughts are inferred from high (upper quartile) and low (lower quartile) annual discharges.

Demography

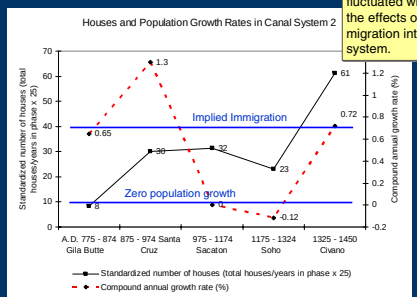
Population growth rates are inferred from 851 Hohokam houses excavated during 12 archaeological projects conducted along Canal System 2.

Linkage between streamflow and demography:

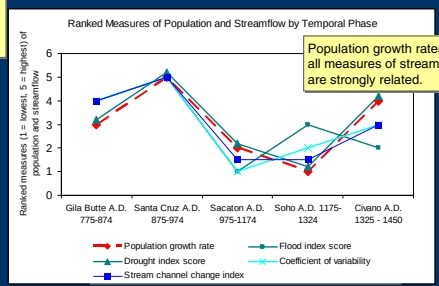


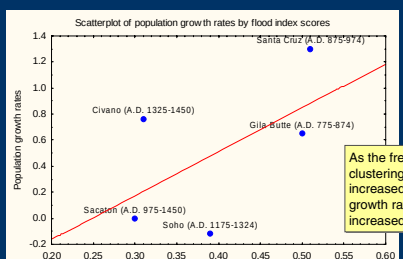
Results

Population growth rates fluctuated widely indicating the effects of in and out migration into the canal system.



Population growth rates and all measures of streamflow are strongly related.

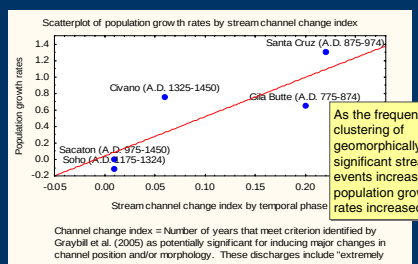




As the frequency and clustering of flooding increased, population growth rates increased.

Flood index = (total number of annual streamflow discharge years in the upper quartile of discharges from A.D. 572 - 1450) + (total number of these years in each temporal phase that occur consecutively).

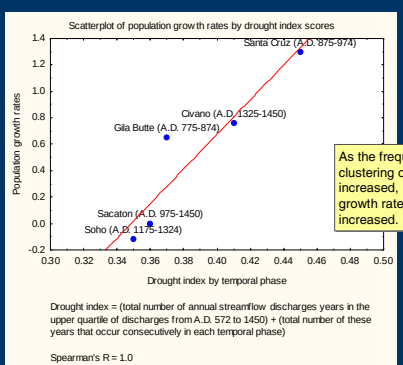
Spearman's R = 0.5



As the frequency and clustering of geomorphically significant streamflow events increased, population growth rates increased.

Channel change index = Number of years that meet criterion identified by Graybill et al. (2005) as potentially significant for inducing major changes in channel position and/or morphology. These discharges include "extremely high annual flows that may have included 'catastrophic' flood events, 2) closely spaced clusters of high-magnitude annual flows; 3) larger annual flows or clusters of them preceded by prolonged periods of drought in headwater areas; and 4) prolonged periods of pronounced variability." Note: periods of high variability are assessed with the coefficient of variation elsewhere.

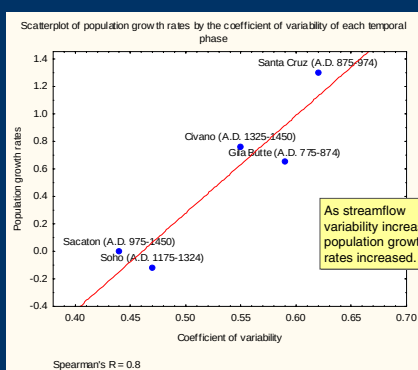
Spearman's R = 0.87



As the frequency and clustering of droughts increased, population growth rates increased.

Drought index = (total number of annual streamflow discharges years in the upper quartile of discharges from A.D. 572 to 1450) + (total number of these years that occur consecutively in each temporal phase)

Spearman's R = 1.0



As streamflow variability increased, population growth rates increased.

Spearman's R = 0.8

Summary of Results

Population levels generally increased as the frequency and clustering of high and low magnitude discharges and variability increased.

Conclusions

The results of this analysis contradict commonly held assumptions regarding the negative effects of floods, droughts, and high variability on prehistoric irrigation agriculture and settlement in the lower Salt River Basin.

Long-term agricultural and ecological benefits of flooding, drought, and high variability could have been essential to maintain agricultural productivity. Flooding likely recharged soil nutrients and flushed salts from fields. Droughts could have forced fallow field time.

Population growth rates in Canal System 2 are strongly affected by in and out migration of both non-canal and canal irrigators.

The strong relationships between streamflow patterns and population growth rates suggests streamflow patterns were influencing demography.

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