Path Dependence: Water Allocation, Settlement Patterns and Urban Trajectories in the Salt River Valley, 1914-1979

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Arizona State University/NASA Space Grant Program

Research Question

Do patterns of water allocation in the early Salt River Valley Water Users Association (SRVWUA) affect the growth of Salt River Valley such that their influence on stages of settlement, reclamation, cultivation, and urbanization may, in turn, reveal a classic case of path dependency and spatial organization of cities?

Growth Stage	Settlement	Reclamation	Cultivation	Urbanization
Adjustments	Settlement north and south of Salt River bank, excavation of Hohokam Canal system.	Construction of Roosevelt Dam, formation of SRVWUA. Unified sourcing of canal systems.	Depression-era CCC improvements of canals, added water supply and power generation capacity from Verde River.	Domestic water delivery contracts with SRP→canal piping; increased coal power generation established outside SRV, major urban boundary expansion for rapid residential & industrial development.
Consequences of "lock-in"	Scattered canal systems, climatic fluctuations, unstable water supply.	Canal extension, wider cultivation of desert , emergence of peripheral settlements along Arizona, Grand, and Crosscut Canals.	Power revenues maintain cheap water costs. Popular opinion by SRVWUA and local govts. toward population expansion as benefactor of economic growth.	Compromised decision-making by rural landholders, strengthening of urban disamenity zones, new ecological system shocks.

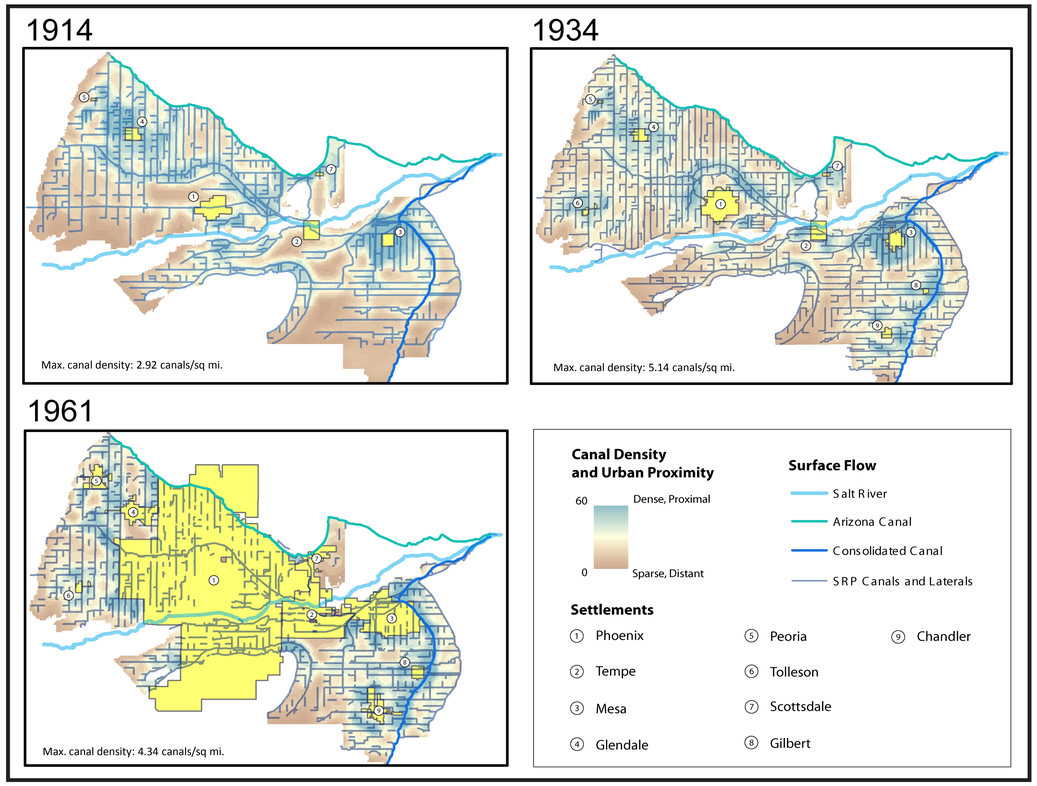
Methodology

Indexes:

- Time-series of the SRV canal system from historical SRP Maps (1914, 34, 51, 61, & 79).
- Using present-day satellite imagery, traced canals (in use) and estimated beginning and ending points for canals based on the street grid and changes in zoning/land partitions.
- Isolated cities contained by SRP boundary (Phoenix, Tempe, Mesa, Scottsdale, Gilbert, Chandler, Glendale, Peoria, & Tolleson) from a time series of Arizona city boundaries (polygon shapefiles), and created mile buffers for each city (estimating growth, in any direction, of an additional Township and Range section past a given city's existing boundaries, as well as each city's rural "fringe").
- Determined the length of each canal shapefile and the areas of each city boundary and buffer zone; and calculated a series indexes based on these attributes. (Made some corrections for boundary mismatch with the SRP boundary shapefile).

Visualization:

- Created a distance buffer (resolution 50) for city boundaries using SRP boundary shapefile.
- Reclassified the raster using a Natural Breaks classification with 6 breaks, one of them an additional break inserted at each city's 1 mi. (1609.344m) buffer boundary.
- Created a kernel density raster of the canal system for each year and reclassified it using Natural Breaks with 10 breaks.
- Multiplied the two rasters to create the final raster. Symbolized with a Natural Breaks classification with 5 breaks (0 values excluded).



Measurements (calculated in ArcGIS)

Canal Length, City (Miles) C_X

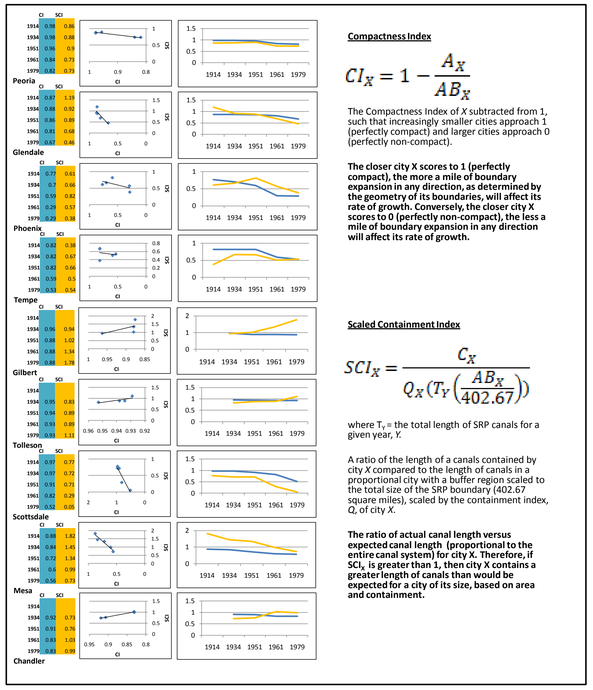
Canal Length, Buffer (Miles) Total length of canals contained by the mile buffer of a city, *X*. B_X

City Area (Square Miles) A_X

Buffer Area (Square Miles) Total area of city *X*'s mile buffer, including the area of *X*. AB_X

Containment Index: The ratio of the total length of canals contained by a city, *X*, compared to the total length of canals contained by *X* and its mile buffer. $Q_X = \frac{C_X}{B_X + C_X}$

Buffer Containment Index: ratio of the total length of canals contained by the mile buffer of a city, *X*, compared to the total length of canals contained by a *X* and its mile buffer. $V_X = \frac{B_X}{B_X + C_X}$



Compactness Index

$$CI_X = 1 - \frac{A_X}{AB_X}$$

The Compactness Index of *X* subtracted from 1, such that increasingly smaller cities approach 1 (perfectly compact) and larger cities approach 0 (perfectly non-compact).

The closer city X scores to 1 (perfectly compact), the more a mile of boundary expansion in any direction, as determined by the geometry of its boundaries, will affect its rate of growth. Conversely, the closer city X scores to 0 (perfectly non-compact), the less a mile of boundary expansion in any direction will affect its rate of growth.

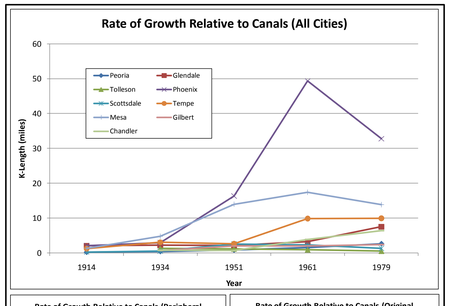
Scaled Containment Index

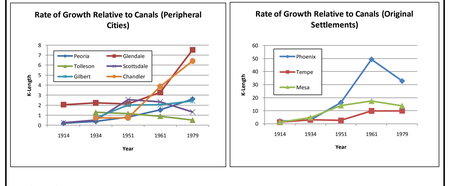
$$SCI_X = \frac{C_X}{Q_X(T_Y\left(\frac{AB_X}{402.67}\right))}$$

where T_Y = the total length of SRP canals for a given year, *Y*.

A ratio of the length of a canals contained by city *X* compared to the length of canals in a proportional city with a buffer region scaled to the total size of the SRP boundary (402.67 square miles), scaled by the containment index, *Q*, of city *X*.

The ratio of actual canal length versus expected canal length (proportional to the entire canal system) for city X. Therefore, if SCI_X is greater than 1, then city X contains a greater length of canals than would be expected for a city of its size, based on area and containment.





K-length

$$K_X = B_X Q_X$$

The Containment Index of a city *X* multiplied by the total length of canals in its buffer zone (excluding those contained within city boundaries).

A theoretical measure used in a time-series to determine the rate of change of growth, relative to the canal system, in each city between years. Predicts the length of peripheral canals (in miles) that will be incorporated as city X expands beyond its buffer, given that city X maintains the same proportion (Containment Index) of canals contained for the year in question.

Assumptions

1. A higher density of canals signals a greater intensity of land use;
2. The size of each city grows over time;
3. Within the SRP boundaries, the buffer generally signal agricultural land use;
4. Canals contained within city boundaries are assumed as either cultivated cultivation appropriated for development.

Findings

Three patterns of spatial organization that correspond to the theory of Path Dependence

1. Steady declines in containment and compactness with subsequent urban growth in **Tempe, Phoenix, & Mesa.**
2. High compactness indexes (until 1961) followed by modest growth amid steady declines in containment in urbanizing **Glendale, Peoria, Scottsdale;**
3. Limited boundary growth and overall steady *increases* in containment in **Gilbert, Tolleson, Chandler);**

Due to its rapid northward expansion from 1961-79 ***Scottsdale*** *becomes a sort of "wild card" city;*

Future Directions

1. Incorporating groundwater wells into the analysis. So far, only surface flow—more highly-valued by Salt River Valley farmers (Smith 1972)—has been examined.
2. Incorporating nucleated urban-peripheral settlements on minor branches of canals into the analysis. Additional data analyzed indicates these settlements in areas such as Lehi and South Central Phoenix. What role do these play in the Salt River Valley's spatial organization?

References

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Acknowledgements

- **Arizona State University NASA Space Grant Program**
- **Netra Chhetri,** Arizona State University Consortium for Science Policy & Outcomes
- **Change Is Hard research group**, Arizona State University School of Human Evolution and Social Change
- **University of Arizona Institutional Repository (UAiR)** for historical city boundary and SRP boundary shapefiles.
- **Arizona State University Library Map Collection**. Canal system shapefiles were digitized from a series of historical SRP Maps and 1:24,000 scale USGS Topographic Quadrangles held by the collection.