Sandpiles and Settlement Shifts in the American Southwest

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In the late 19th century, the discovery of the great empty cliff dwellings of the Mesa Verde set off more than a century of research into the causes of their abandonment. The most recent work (Varien et al. 2007; Kohler et al. 2010) shows that several tens of thousands of people left the Four Corners area of the Southwest between AD 1250 and 1300. Archaeologists have also demonstrated that many parts of the greater Southwest experienced large and rapid population changes between AD 1200 and 1500 (Hill et al. 2004).

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Archaeologists have attempted to attribute these settlement shifts to climate change, warfare, resource depletion, population aggregation, and socio-political reorganizations, acting singly or combination (Lipe 1995; Kohler et al. 2010). The working assumption has been that major changes would need major causes. But what if the Southwest population as a whole is a “critically organized system” (Bak 1996; Bak et al. 1988).

Complex systems in a state of “self-organized criticality” may be subject to occasional very large perturbations triggered by “ordinary” events. Physicist Per Bak presented the “sandpile game” as an intuitive example. When a sandpile’s slopes are at the angle of repose, the repeated addition of single grains to the pile results in landslides ranging from many tiny ones to a few very large ones. The sizes of the landslides depend on the specific way the sand grains are interlocked prior to each event.

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One marker of critically-organized systems is that their output follows a power law, rather than a “normal” distribution. For example, the sizes of earthquakes, forest fires, business failures, stock market fluctuations, and biological extinction episodes have been claimed to show power law distributions.

Do shifts in settlement size and location in the prehistoric American Southwest indicate that the regional population was in effect a critically organized system? To address this question, we subdivided the Southwest into a grid of 7 x 7 km cells and tracked archaeologically derived estimates of changes in population size at 50 year intervals for each cell. Then we graphed the changes from one time period to the next for the whole Southwest to assess whether the size distributions conformed to a power law. Two sample graphs are at right.

Sources of population data. The Community Coalition Database (Hill et al. 2004) provides population estimates, at 50 yr. intervals, for the hundreds of sites shown above.

Log Population Change

Log number of Cases

Log number of Cases

Population density, AD 1275

Population density, AD 1325

Population density, AD 1375

population changes, AD 1275-1325

population changes, AD 1375-1425

• Contour intervals from light to dark represent 10, 50, 100, 250, and 500 persons per square kilometer

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References


Concluding comments: Archaeologists should not assume that major changes in settlement systems require major changes in the factors influencing them. Rather, analysis should focus on the historically developed interaction of multiple variables. For example, depopulation of the Mesa Verde area may have resulted from a historically unique configuration of drought, warfare, high population density, overdependence on maize, constraints on household mobility, and the attractions of growing Pueblo societies to the south and southeast.

Future research: Evaluate the statistical validity of the power law fits (Clauset et al. 2009); assess effects of varying bin sizes; Explore whether similar patterns occur at differing geographic and temporal scales.