Modeling Past Human Societies

Digital archaeology, agent-based models, and complex systems

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What is archaeology anyways?
Modern Challenges, Archaeological Approaches
Main Challenges in Archaeology
Main Challenges in Archaeology
How small choices and individual interactions lead to large, overarching structures
American Southwest

Western Desert of Australia

Mongolia

Gaulish France
Food web modeling

Social network modeling

Agent-based modeling
Why model?

• “Wind back the tape of life to the early days of the Burgess Shale; let it play again from an identical starting point, and the chance becomes vanishingly small that anything like human intelligence would grace the replay” (Gould, 1989:14).
A recursive process

Models

Theory
A complex adaptive systems approach
The Mystery

- When the Wetherill brothers came upon Mesa Verde in the late 1800s they saw completely abandoned stone dwellings.

- Where did they go? Why did they leave?

- The “Great Drought?” Hostile invaders?
How can we understand why they left (if we don’t know how they lived)?

- My approach: studying the 700-year occupation of the central Mesa Verde.

  1. How was their society formed?

  2. How did it change over time?

  3. How did Ancestral Pueblo people interact with their ecosystems?
The American Southwest

- Ancestral Pueblo farmers entered the Central Mesa Verde area ~A.D. 600 and permanently left by A.D. 1280.

- Around 80% of the diet was maize, grown without irrigation.

- They hunted deer, rabbit, hare, domesticated turkey and had domestic dogs as pets.

map courtesy: Encyclopedia Britannica
HOW TO MAKE A POLITY (IN THE CENTRAL MESA VERDE REGION)

Stefani A. Crabtree, R. Kyle Bocinsky, Paul L. Hooper, Susan C. Ryan, and Timothy A. Kohler

The degree to which prehispanic societies in the northern upland Southwest were hierarchical or egalitarian is still debated and seems likely to have changed through time. This paper examines the plausibility of village-spanning polities in the northern Southwest by simulating the coevolution of hierarchy and warfare using extensions to the Village Ecodynamics Project’s agent-based model. We additionally compile empirical data on the population size distribution of habitations and ritual spaces (kivas) and the social groups that used them in three large regions of the Pueblo Southwest and analyze these through time. All lines of evidence refute an “autonomous village” model during the Pueblo II period (A.D. 850–1145); rather, they support the existence of village-spanning polities during the Pueblo II and probably into the Pueblo III period (A.D. 1145–1285) in some areas. One or more polities connecting the northern Southwest, with tributary flowing to an apex in Chaco Canyon, appears plausible during Pueblo II for the areas we examine. During Pueblo III, more local organizations likely held sway until depopulation in the late thirteenth century.
Chaco Culture National Historical Park
Canyon with ancestral...
Anasazi versus Ancestral Pueblo?

Same groups.
Anasazi in Navajo can translate to “ancient enemy.” Archaeologists use the term “Ancestral Pueblo” now to refer to people who lived in the Four Corners area of the US Southwest, so Mesa Verde, Chaco Canyon, the Bears Ears, etc.
Hypothesis

- The growth of the Chacoan regional system signifies a political hierarchy in the American Southwest.
Building a simulation to test this…

- Environment ->
- People ->
- Groups of people
AD 501

Bocinsky et al. 2016 Science Advances
Building a simulation to test this...

- Environment ->
- People ->
- Groups of people
Village Ecodynamics Project

• Long-running project looking at how Ancestral Pueblo society could grow from household level processes.

• “Emergence and Collapse of Early Villages”—>
Base Village

• Agents are households composed of individuals. Individuals marry and reproduce.

• Households try to maximize their caloric intake by farming on productive lands.

• Households also hunt deer, rabbit and hare.

• Households can exchange calories and protein since rainfall is somewhat stochastic.
Building a simulation to test this...

- Environment ->
- People ->
- Groups of people
This model

• Territoriality

• Conflict over arable land (Lanchester’s Laws)

• Hierarchical chains with tribute flow

• Territory size can be measured at group or group-of-group level.
Theory: Tribute flow leads to power. Power leads to hierarchy.

- Steponaitis (1981): Tribute flow is a defining characteristic of power in complex societies.
- 15-22% of individuals can be non-producers.
- Flow of tribute allows for growth of hierarchy.
So now what?
How to detect leadership

• In the southwest we have kivas, circular structures that were used for both mundane and sacred purposes.

• We could also look to the size of settlements to see which might be the most ‘important.’
Finding Kivas

- We look to these circular features and suggest that they would act as gathering places.
- We estimate the number of revelers they could accommodate to suggest how integrative they may have been.
- Data: over 450 kivas.
Finding Settlements

- We have population estimates for different sites in our simulation boundary.
- Larger settlements may be more ‘important’ so we can look to distribution of large-to-small settlements for clues.
How to compare these three disparate datasets?

- Distributions of sizes of data: size of simulated groups, size of kivas, size of settlements.
- Detect scaling relationships.
- If data is a power law, indicates a “rich get richer” phenomenon. If log normal, indicates a leveling mechanism.
- Strength of these analyses is I can simplify data to distributions to compare them easily, agnostic of what I’m measuring (kivas, settlements).

Early on, in all three datasets, distributions are log normal indicating non hierarchical data.

At the height of Chaco all three datasets indicate consolidation of power. Power laws in all datasets.

Late in occupation data begins to fall apart and move toward a more local consolidation of power—agreed data among three datasets.
Does this mean hierarchy?
Does this mean hierarchy?
Other CAS approaches

- Building a full food web of the Ancestral Pueblo Southwest.
- Demonstrates how a hierarchical and aggregated society would impact an ecosystem.
- This approach demonstrates vulnerabilities and resilience of Ancestral Pueblo Culture.
Food Webs Results

• While we see large patterns, this work shows that individual decisions matter. Whether to intensify farming, what animals to eat, where to live, and how to interact with ones neighbors.

• The choices people made at the time for short term optimality had long-term consequences.

• Resilience of the Ancestral Pueblo culture can be seen in the ability to migrate away from the Four Corners area.
Back to the recursive process
Questions?