Ecological Modelling 241 (2012) 30–41

Contents lists available at SciVerse ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

Modelling prehispanic Pueblo societies in their ecosystems

Timothy A. Kohler[a,b,d,*], R. Kyle Bocinsky[a], Denton Cockburn[c], Stefani A. Crabtree[a], Mark D. Varien[d], Kenneth E. Kolm[e], Schaun Smith[f], Scott G. Ortman[b,d], Ziad Kobti[c]

[a] Department of Anthropology, Washington State University, Pullman, WA 99164-4910, United States
[b] Santa Fe Institute, 1399 Hyde Park Rd, Santa Fe, NM 87501, United States
[c] School of Computer Science, University of Windsor, 401 Sunset Avenue, Windsor, ONT N9B-3P4, Canada
[d] Crow Canyon Archaeological Center, 23390 Road K, Cortez, CO 81321, United States
[e] Integral Consulting Inc., 285 Century Place, Suite 190, Louisville, CO 80027, United States
[f] Chevron Energy Technology Company, United States

ARTICLE INFO

Article history:
Available online 1 February 2012

Keywords:
Archaeology
Agent-based models
Simulation
US Southwest
Exchange in small-scale societies
Specialization in small-scale societies
Evolution of political hierarchy in small-scale societies
Village Ecodynamics Project

ABSTRACT

We review a suite of agent-based models developed by the Village Ecodynamics Project (VEP) to study ecological, economic, social, and political processes among prehispanic Puebloan ("Anasazi") populations in the Northern US Southwest in the context of a dynamic natural environment. Collectively these models shed light on processes that include the local intensification of turkey raising, the emergence of complex societies in this region, and the complete depopulation of the Northern Southwest in the thirteenth-century AD. Quantitative computational modelling contributes to the explanatory goals of a scientific archaeology and such models should eventually provide standards allowing for more rigorous comparison of distinct archaeological sequences.

> Archaeology is an undisciplined empirical discipline. A discipline lacking a scheme of systematic and orderly study based upon declared and clearly defined models and rules of procedure.—David L. Clarke (1968:xiii)

1. Introduction

Even 45 years ago, Clarke's assessment of the state of archaeology was as much a call-to-arms as a balanced and accurate characterization. In the intervening decades archaeologists have made various attempts to systematize the processes by which we learn about the archaeological record (e.g., Binford, 2001). Competing "communities of discourse" in archaeology (as reviewed for example in Hodder, 2012b) have developed their own rules for engaging empirical evidence, while numerous linkages among these approaches (Hodder, 2012a,b:6–11) prevent their programs from becoming entirely idiosyncratic. Moreover, rapidly accumulating data, and knowledge about prehistory constructed via a crossword-puzzle-like interplay between data and our interpretations of them (Haack, 1993), further constrain the possible range of models and approaches.

If, therefore, Clarke's polemic no longer hits the mark, most archaeologists would nevertheless agree that we still lack entirely satisfactory methods for decoding the processes that produce the patterns we perceive in the archaeological record. In this article—and in the companion pieces in this issue—we explore what quantitative models of past human behavior set in changing environments might contribute to connecting processes and patterns for building knowledge about prehistory. More specifically here, we draw on efforts over the last 15 years to develop simulation models of subsistence, settlement, and exchange for prehispanic Pueblo societies in the US Southwest (Axtell et al., 2002; Kohler et al., 2005). Our particular goal is to summarize the modelling aspects of the Village Ecodynamics Project (VEP). The VEP itself seeks to understand Pueblo societies as they existed between AD 600 and 1600, using a combination of computational modelling and empirical research.[1]

* Corresponding author at: Department of Anthropology, Washington State University, Pullman, WA 99164-4910, United States. Tel.: +1 509 335 2698; fax: +1 509 335 3999.
E-mail address: tako@wsu.edu (T.A. Kohler).

[1] The various models summarized here are more fully described in the references. The Swarm code for the VEP I version of the simulation is available for download at http://www.openabm.org/model/2518 or from http://village.anth.wsu.edu/appliance/.

0304-3800/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolmodel.2012.01.002

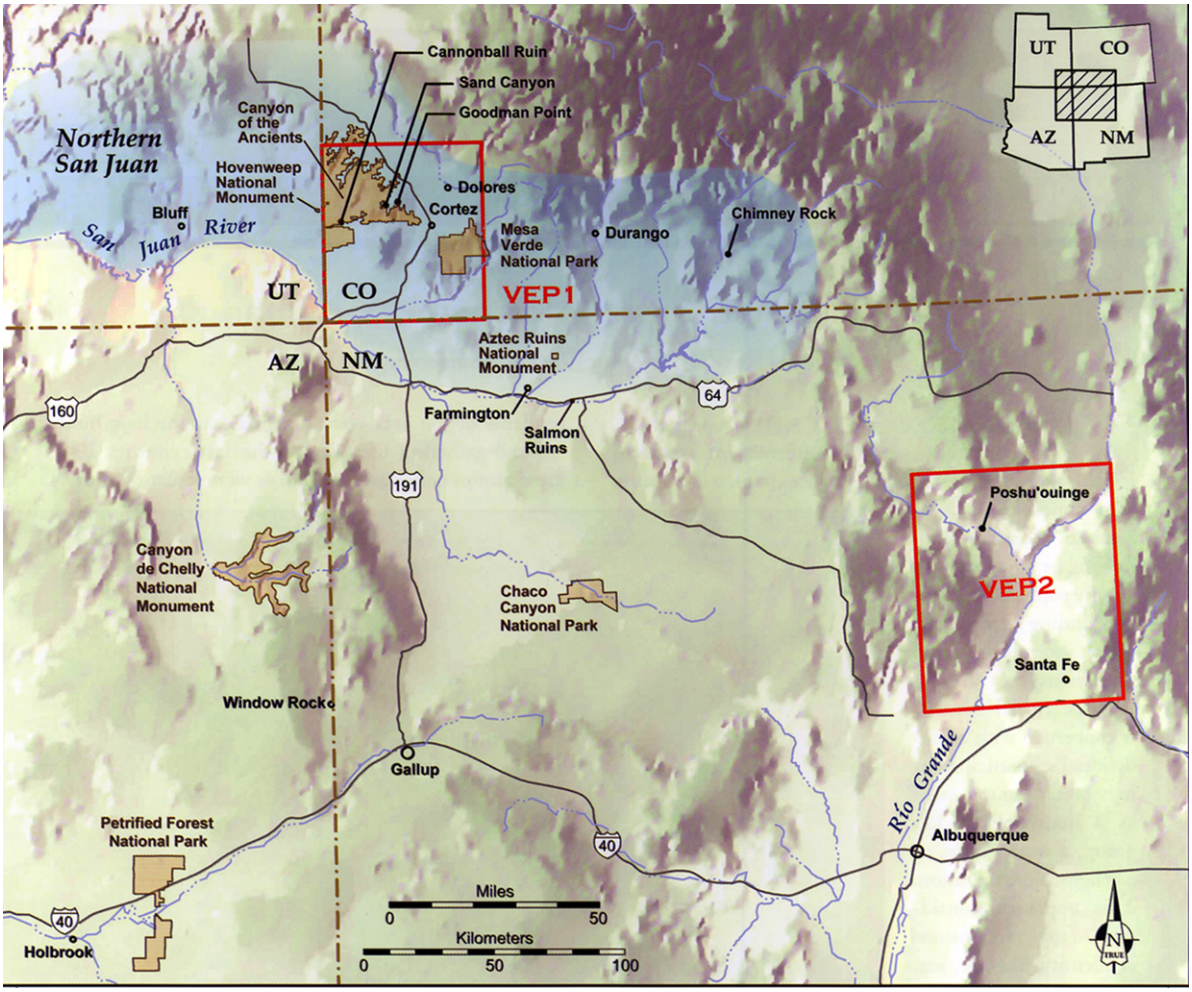

Fig. 1. The VEP I study area is the northwest portion of the area enclosed by the red rectangle in southwestern Colorado. Over 100 community centers were built within this area between AD 600 and 1280, including the three (Cannonball Ruin, Sand Canyon, and Goodman Point) named here (Glowacki and Ortman, 2012). The VEP II area occupies the remainder of the red rectangle in southwestern Colorado and the red rectangle in New Mexico.

These Pueblo peoples were heavily reliant on maize agriculture (Coltrain et al., 2006, 2007) and were increasing rapidly in number during most of this period, both within our study areas (Fig. 1) and throughout the Southwest (Kohler et al., 2008). This review concentrates on results from a study area in Southwestern Colorado in which farming populations underwent two cycles of population growth and decline. Each decline coincided with climate change decreasing the productivity of maize farming (Varien et al., 2007). The second decline occurred in conjunction with the complete depopulation of the Northern Southwest in the late AD 1200s.

The VEP has developed agent-based models (ABM, synonymous in our usage with the individual-based models of Grimm and Railsback, 2005) to investigate, among other things,

- the extent to which slowly regenerating resources (especially fuelwood and deer) were depressed over centuries of use by Pueblo societies, and whether this might have contributed to various changes in practice such as intensification in use of turkey, the only major food animal domesticated in prehispanic North America (Speller et al., 2010);
- why households were located where they were through time and why the size of residential sites, measured in numbers of co-resident households, changed through time;
- how various exchange practices affected settlement patterns and the overall size of the population;
- how the carrying capacity of our study area changed under various assumptions about rates of resource production and use;
- which factors lead to the emergence of more complex (larger, more socially differentiated and politically stratified) societies in this area; and
- the relative importance of various factors that might have led Pueblo societies to vacate vast portions of the Northern US Southwest in the thirteenth century AD.

In the family of models created to study these issues, simulated agents represent Pueblo households who jointly optimize their locations, and their resource use given those locations, in an approximate and myopic fashion. We track the ages and sexes of the members of each household. Household needs and actions depend on household composition. Birth and death rates in each household are in turn affected by the success of the household in meetings its needs. The total population size, and the locations of households, emerge from these interactions and are not directly programmed into the simulation. We compare the size and location of the simulated populations to the relatively precise estimates—generated by analyses of the archaeological record—for the locations and changing number of households actually inhabiting the VEP I study area