Dynamics of Alliance Formation in Pueblo Societies

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<u>Introduction:</u> Previous work within the Village Ecodynamics Project (VEP) has successfully established a detailed, semi-realistic, household-level model for Puebloan ecodynamics[1]. I propose to extend this household model to create agent-based models for conflict and cooperation in the context of the 700-year archaeological record of the central Mesa Verde region. Here, the formation of larger groups is linked in a complicated way with conflict, but it is also probable that mutualistic activities not motivated by between-group conflict contributed to these larger group sizes. This model will help us understand the years of peace within the Mesa Verde region, and the circumstances under which Puebloan people resorted to violence, as these cycles have been locally described by Cole[2]. The models I create will be applicable to other small-scale societies—and elsewhere, with appropriate caution.

<u>Background:</u> As resources dwindle, climate change is reshaping the earth, leaving us faced with problems with potentially dire consequences[3]. Repeated calls have recently been made to apply agent-based modeling to contemporary affairs[4], both to understand crises as they unfold, and to anticipate them. In these efforts, archaeology assists by providing a long-term view of the relationship between demography, distribution of human group sizes, environmental factors and violent conflict. My place at Washington State University in the context of the VEP will allow me to address these questions with support from archaeologists, geologists, geographers, computer scientists and economists engaged in VEP empirical and modeling efforts.

<u>Hypotheses:</u> My research will investigate how human cooperation affects the demographic success and spread of human groups. Specifically, my research will examine the following hypotheses: 1) both kinship- and non-kinship-based coalitions formed in response to environmental pressures, such as dwindling per-capita resources due to climate change or population growth; 2) coalitions do not form only as a response to external conflict; rather, they are leveraged by humanity's evolved sociality[5] and can serve to provide positive returns to increasing group size; 3) coalitions may fracture when within-group competitive pressures become too great, or when between-group competitive pressures relax.

<u>Research Plan:</u> Working with Dr. Timothy Kohler and the VEP, I will participate in ongoing field research in the Mesa Verde region. As an NSF Graduate Research Fellow, I will generate spatial goodness-of-fit measures between VEP simulations and the archaeological record to assess the general fidelity of the simulation to archaeological data from Mesa Verde, as well as to analyze and interpret the residuals. I aim to understand how accurately the existing agent-based models (ABM) predict the spatial distribution of households, subsistence and technology, and to evaluate the extent to which the simulations generate the archaeological record. Moreover, I will explore various methods of assessing spatial goodness-of-fit using over 4,000 archaeological sites in the VEP study area from AD 600 to 1280.

Next, I will create a model describing the emergence of alliances based on kinship and economic ties. Currently, the Village simulations do not allow for cooperation beyond that provided by exchange, or conflict beyond that generated through household-level competition for resources. Building upon Dr. Sergey Gavrilets' (University of Tennessee Knoxville, Biology) framework for alliance formation[6], I propose to create a stochastic model describing the emergence of cooperation resulting from between-group competition for key resources. I will gradually add levels of complexity to the unidimensional model as described by Gavrilets, which accounts for alliance formation only through competition for rank or mates. I will introduce a means of incorporating scalar stress in order to generate nested groups, in contrast to the

exponential growth of alliances in Gavrilets' model. An additional shortcoming of the previous model is that it only accounts for alliance-formation as a response to conflict, which ignores altruism and mutually beneficial relationships in coalition formation. Using the experimental test bed provided by the ABM, I will see whether approaches to generating cooperative networks modeled on the sodalities seen in Southwestern societies provide a better fit to the known facts of the archaeological record than do alliances generated out of between-group conflict. In modern Hopi societies, for example, sodalities form around a specific clan, "which own[s] the ceremonies, kivas, and ritual items used by each sodality. However, while sodalities are managed by specific clans, sodality members can come from any clan"[7]. My benchmark for comparison will be the well-known and precisely-dated archaeological record of the central Mesa Verde region, which provides a dataset that is unparalleled in the Neolithic world.

Broader Impacts: This novel approach will provide critical information on the nature of human alliance formation. As my research will analyze how issues such as control of resources influence the formation of alliances, I will be able to determine how these alliances break down when resources become scarce. My results may have widespread applicability as the human population continues to grow worldwide, stretching the resources of our fragile planet. Understanding what lead to the dissolution of civilizations in the Neolithic world may help policymakers anticipate future challenges. My research will inform efforts to understand sociopolitical impacts of climate change. Through agent-based models of the archaeological data, I will analyze how people reacted to fluctuating temperature, reduction of key resources such as woody fuels and water, crop failure, and inter and extra-tribal hostilities, which may have been induced from the changing environment.

Additionally, this research will examine the extent to which alliances form out of conflict, or as a means of providing positive per capita return in procurement of resources, and help us to understand not only the years of peace dominating the Mesa Verde region, but also the wave of violence that swept the area in its final years[2]. Future researchers will be able to build on these models to understand the complex dynamics of human relations in other societies. We are poised at a cross-roads as a civilization, plagued by many of the same issues that our ancestors faced. An understanding of our past will help us make informed decisions about our future.

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