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Increasing social complexity, climate change, and why societies might fail to cope

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The PEOPLE 3000 working group focuses on integrating archaeological and paleoecological case studies with mathematical modeling. We seek to understand how co-evolving human societies and ecosystems can successfully cope with the interrelated forces of population growth, increasing social complexity and climate change, and the diversity of trajectories of reorganization that social-ecological systems follow. Our work focuses on the observation that human societies experienced periods of social and economic development followed by major reorganizations throughout the Holocene. Thus, we are investigating explanations for what appears to be widespread and, potentially, climate-driven patterns.

Much of our research builds on the Variance Reduction Safe Operating Space (VRSOS) hypothesis (Anderies 2006). The VRSOS proposes that population growth, increasing complexity, and increasing energy consumption reduce variation in human subsistence economies. This, in turn, results in systems where individuals are well adapted to a specific range of climate variation, but where those same strategies are easily disrupted by climate change outside the range to which a society has adapted. Whether social-ecological systems follow a collapse trajectory or a new growth trajectory depends on the adaptive capacity of individuals within ecological and institutional constraints. To date, we have begun to explore such relationships with a series of related publications and grant proposals (Freeman et al. 2018a,b).

The May 2018 workshop moved our research forward by synthesizing radiocarbon, paleoecological, and subsistence data in ways that allow the working group to integrate them with mathematical models. The workshop resulted in the following outcomes:

1. The collation of radiocarbon and paleoenvironmental records from North and South America, Europe and Australia.

2. Outlines of manuscripts exploring ways the VRSOS hypothesis can predict broad shifts in human subsistence and settlement decisions across the Holocene. This hypothesis allows for the identification of periods when we would predict societal reorganizations and how those adaptive shifts may occur. Our data suggest that Late Holocene prehistoric societies across the globe experienced trajectories of adaptive reorganization, subsistence specialization, and sometimes societal collapse in response to environmental changes as predicted by the VRSOS.

3. Outlines of manuscripts deploying well-established logistical growth models derived from population ecology to understand how shifts in carrying capacity can condition demographic regimes across the Holocene. In this case we define a demographic regime as a one defined by a fixed carrying capacity. Shifting carrying capacity moves a population into a new demographic regime. We explore this idea by identifying different patterns of growth and climate-mediated collapses in the more distant past (Lima Arce 2014). For example, Figure 1a illustrates the long-term growth (trends) and medium-term fluctuations (peaks and valleys) of human populations and economies from the California (USA) case study discussed at the workshop. This case displays long-term growth, but with various medium-term spurts of growth and decline. However, although the broad trend displays long-term growth, the type of growth is variable. Figure 1b applies discrete time logistic growth models to the data and suggests that in California, the long-term growth of human societies was driven by a shift in their carrying capacity, either through social-technological change or climate change. This methodology allows us to compare demographic regimes and better understand how and why they change.

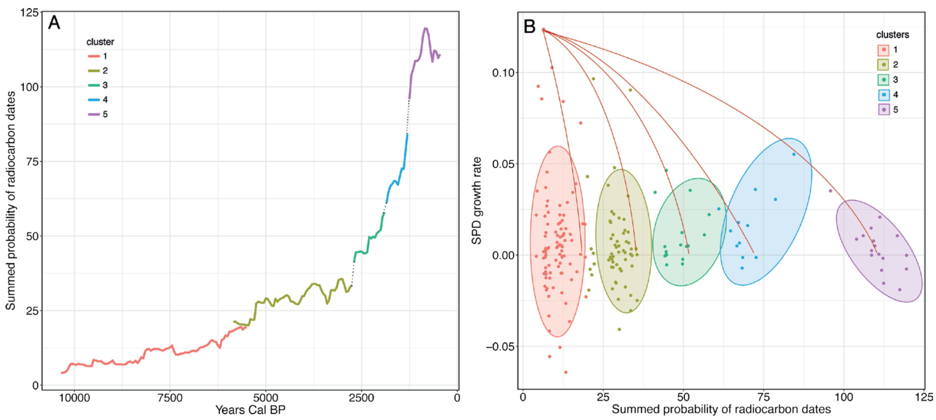

Figure 1: (A) Summed probability distribution of California, USA, radiocarbon ages against time for five demographic regimes. **(B)** Discrete time logistic growth models for each of the five demographic regimes for the California case study.

The workshop outcomes opened several new lines of research. Specifically, we will move forward by exploring relationships between archaeological and paleoecological datasets within the context of the VRSOS and logistic models discussed above. Of greatest interest to us are the ways that low-frequency, but high-amplitude, environmental events can prompt for societal adaptations resulting in either positive or negative demographic changes. Understanding what social and ecological factors conspire to condition the direction of demographic changes, and using this information to predict the direction and magnitude of change for specific archaeological phenomena, outline our next challenges – ones we aim to address in future studies.

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