Constructing Risk Landscapes: Mapping the Spatial Distribution of Risk to Food Shortfall across the Prehistoric U.S. Southwest and Northern Mexico

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Risk Landscapes and the American Southwest

Focusing on five case studies in the American Southwest (Zuni, Hohokam, Salinas, La Quemada, and Mimbres), the Long-Term Vulnerability and Transformation Project (LTVTP) investigates the relationship between social and ecological diversity and the persistence or collapse of our archaeological case study (Figure 1). Part of this research is defining how prehistoric people in each of our case studies managed the risk of food shortfall effectively or not. ***How, then, did these 5 case studies from the American Southwest vary in their ability to mediate risk to food shortfall in times of social or climatic change with appropriate risk mediation strategies?***

To address this question, we focus on LTVTP's concept of ***risk landscapes***, which models how vulnerability to resource shortfall, contributed to by climate change, would have varied across the American Southwest in the past. To model these risk landscapes, we create pixelated maps of how often different parts of each case study region may fail to obtain enough food in any given year. Modeling risk landscapes includes both defining what the limiting factors were for resource procurement and the spatial distribution of how often the ability to obtain food failed in each case study.

Here, we focus on one of our case studies: ***the Zuni region*** (Figure 1). Extensive archaeological, ecological, and ethnographic research in the Zuni region has shown that runoff fields are widely used and are essential to successful long-term agricultural productivity in the region (Homburg et al. 2005; Sandor et al. 2007). Generating runoff to the fields is highly dependent on a number of factors including precipitation amount, precipitation intensity, soil type, incipient soil moisture, and the slope of the field. The following analysis presents a first cut of this analysis ***by modeling how growing season precipitation necessary for the production of maize varies across the region***.

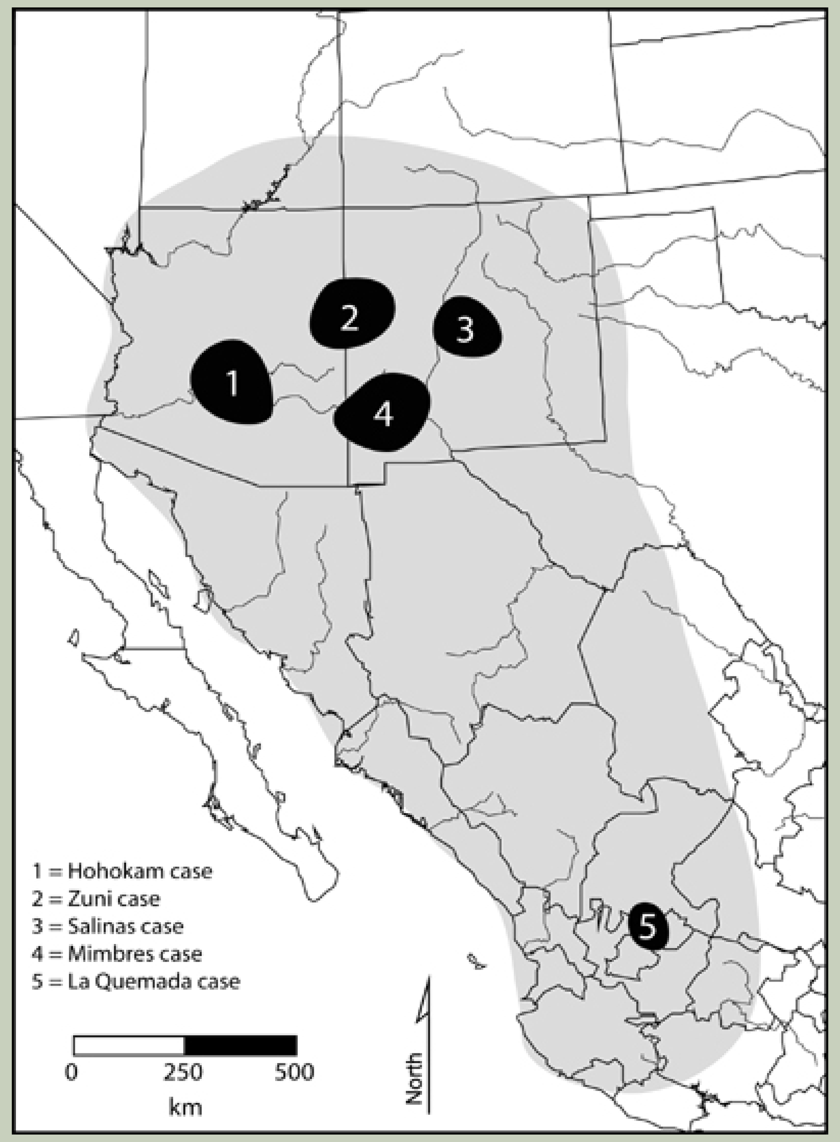

Figure 1: Case studies of focus of the LTVTP. The focus of this poster is on the Zuni Case (2).

Risk of Subsistence Shortfall and Buffering Strategies

Halstead and O'Shea (1989) outline four strategies - physical storage, movement, diversification, and exchange - employed by small-scale agriculturalists ethnographically in marginal environments to deal with expected and unexpected environmental perturbations. These buffering tactics can help prepare people for a variety of environmental fluctuations that can affect agricultural productivity.

Different spatial distributions of failure to procure food (or, a risk landscape) would mean different social approaches to obtaining food (or, risk buffering strategies) that we can link to social transformations in the archaeological record. If, for instance, the correlation of food failure was fine-grained (if one landscape pixel failed, a landscape pixel ½ mile away would produce enough food), a household could diversify its food procurement or move food through trade. If spatial distributions of failure were broad, then moving people may have been more efficient than moving food. We can link these maps with social transformations in the past to see if strategies to mediate risk to food shortfall in the past seemed sensible in light of the spatial distribution of risk. For example, did mass migration occur in a risk landscape that was fine-grained? Why does this mismatch in risk mediation strategy exist and did it lead to success or failure of the system?

Positive Pacific Decadal Oscillation
Modern Phase: AD 1925 - 1945
Reconstruction: AD 1300 - 1450

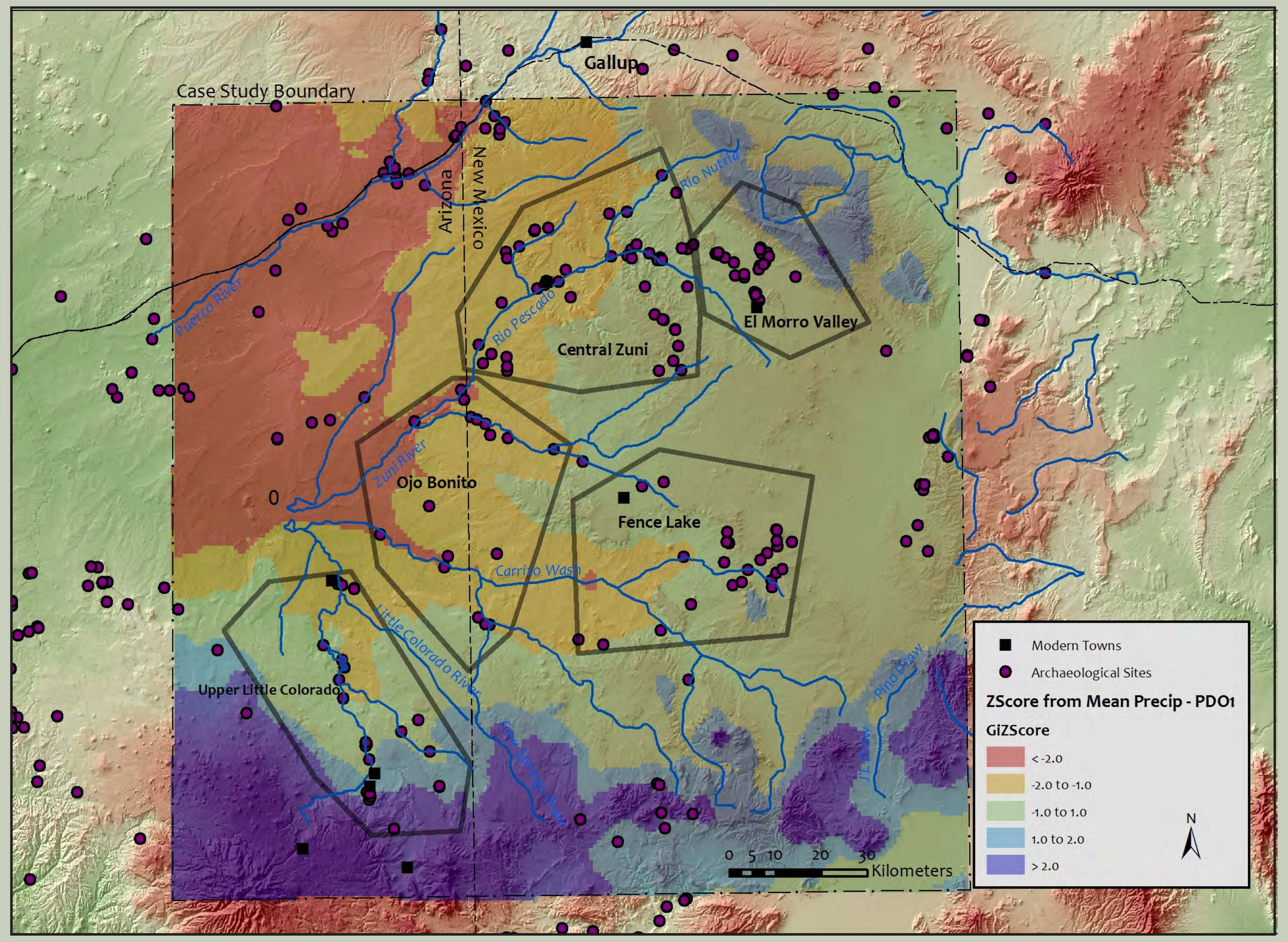

Figure 2: Spatial Distribution of Risk during Positive Pacific Decadal Oscillation Phase

Negative Pacific Decadal Oscillation
Modern Phase: AD 1946 - 1976
Reconstruction: AD 1000 - 1150

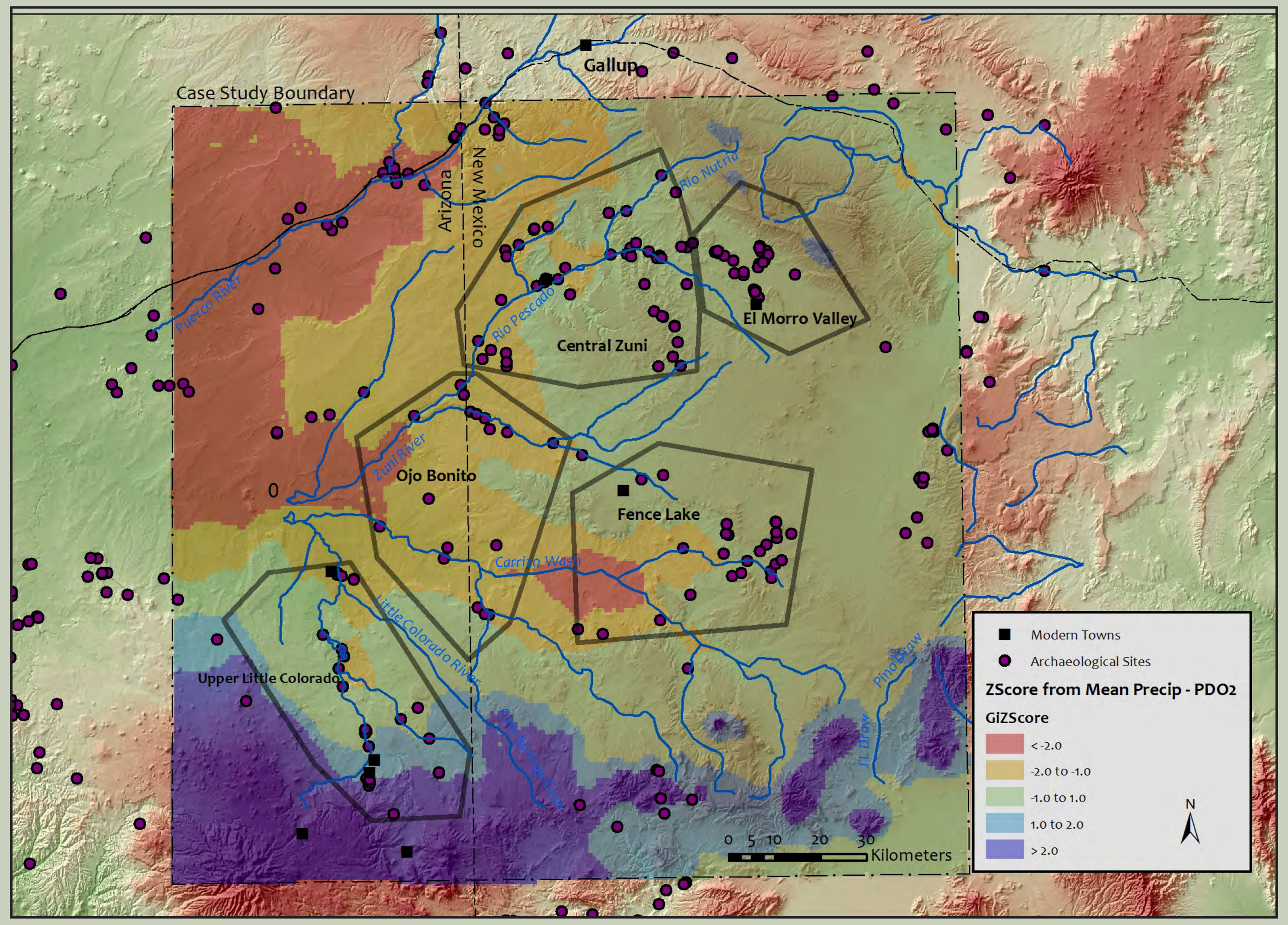

Figure 3: Spatial Distribution of Risk during Negative Pacific Decadal Oscillation Phase.

The Pacific Decadal Climatic Oscillation

To examine how climatic regimes may have affected the distribution of risk, we focus on the Pacific Decadal Oscillation – a driving factor of annual precipitation and temperature regimes in the American Southwest. Operating on a cycle of 20-30 years, the PDO has been shown to enhance El Nino and La Nina conditions.

Positive PDO phases enhance El Nino conditions, leading to higher winter rainfall amounts (CLIMAS 2012).

- Modern PDO Years: AD 1925 – 1945 (Figure 4)
- Corresponds to the reconstruction from AD 1300 - 1450 (figure 5)

Negative PDO phases enhance La Nina conditions, leading to drier than average conditions (CLIMAS 2012).

- Modern PDO Years: AD 1946 - 1976
- Corresponds to the reconstruction from AD 1000 - 1150

Figure 3 shows modern PDO Phases, and Figure 4 shows the reconstructed PDO Phases for the past millenium.

The PDO and Mapping Risk Landscapes

Hypothesis: PDO cycles are highly related to the spatial distribution of the risk of maize failure across the Zuni Region and control the distribution of growing season precipitation.

- Monthly modern precipitation data (PRISM) was aggregated and averaged by growing season and PDO phases.
- A shapefile was created of the average growing season rainfall (May-September) for each PDO cycle.
- Spatial autocorrelation and Z-Score Hot Spot Analysis was performed on the shapefile to understand the spatial distribution of how far each pixel deviates from the average growing season rainfall in each PDO cycle.

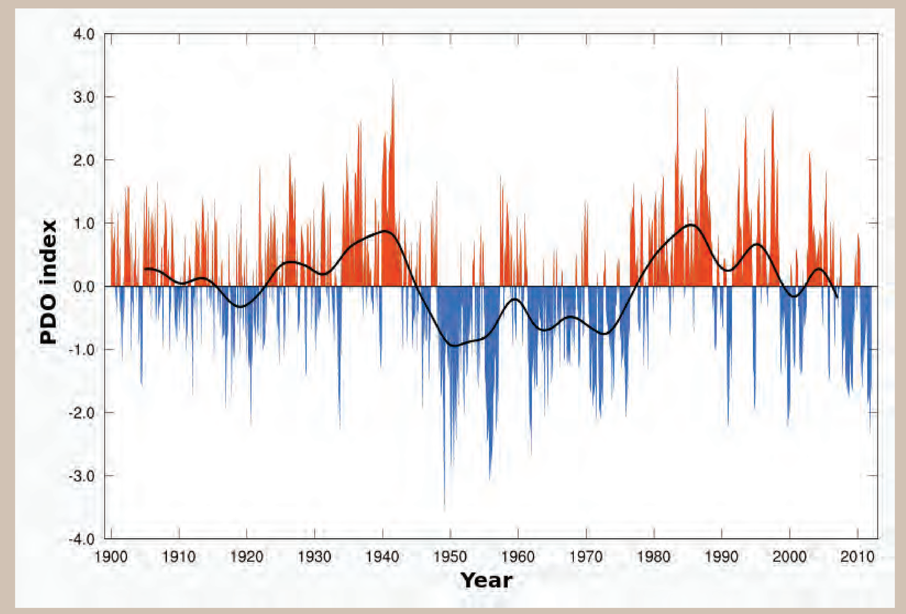

Figure 4: Modern Pacific Decadal Oscillation Indices (Macdonald via Wikipedia).

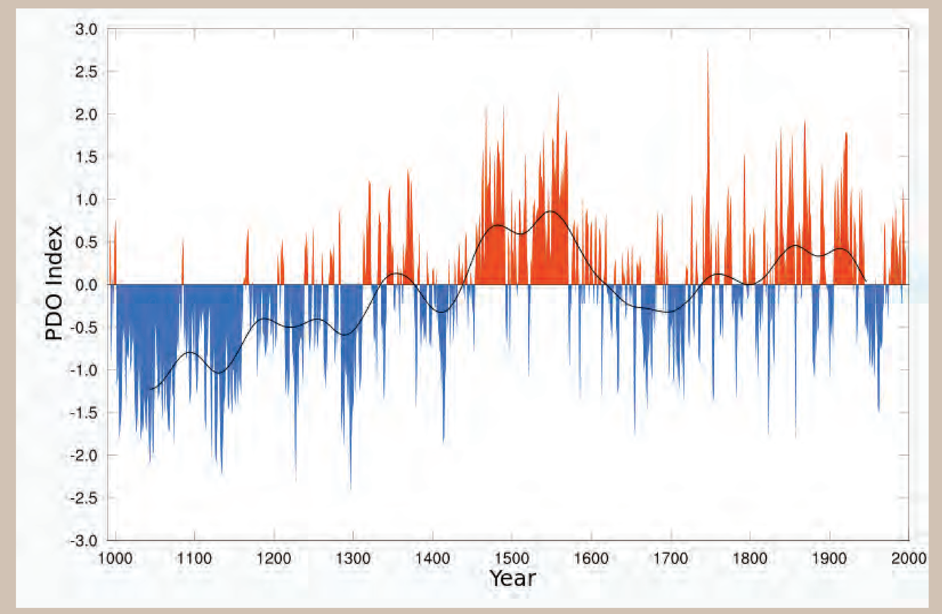

Figure 5: Reconstructions of Pacific Decadal Oscillation Indices (MacDonald via Wikipedia)

Risk Landscapes and the Link to Social Transformations at Zuni

By analyzing the spatial distribution of risk, we can begin to evaluate how people living in the Zuni region prehistorically could have managed risk. **First, changes in the Pacific Decadal Oscillation does not change the distribution of risk across the landscape.** The deviation from the mean (see Figures 2 and 3) growing season precipitation does not change as the PDO shifts. **Second, the distribution of risk to not receiving enough precipitation to produce maize during the growing season goes down from west to east and south, and the distribution of risk is highly clustered to the west.**

For people farming in the Zuni region, this distribution of risk would have meant interesting buffering strategies that should have included networks across the entire case study region. People farming in the western portion of the region likely created networks with people living in the east to mediate against precipitation shortfall. This analysis will now be linked with social diversity data to understand the buffering strategies that were created prehistorically and whether they match the prehistoric risk landscape.

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