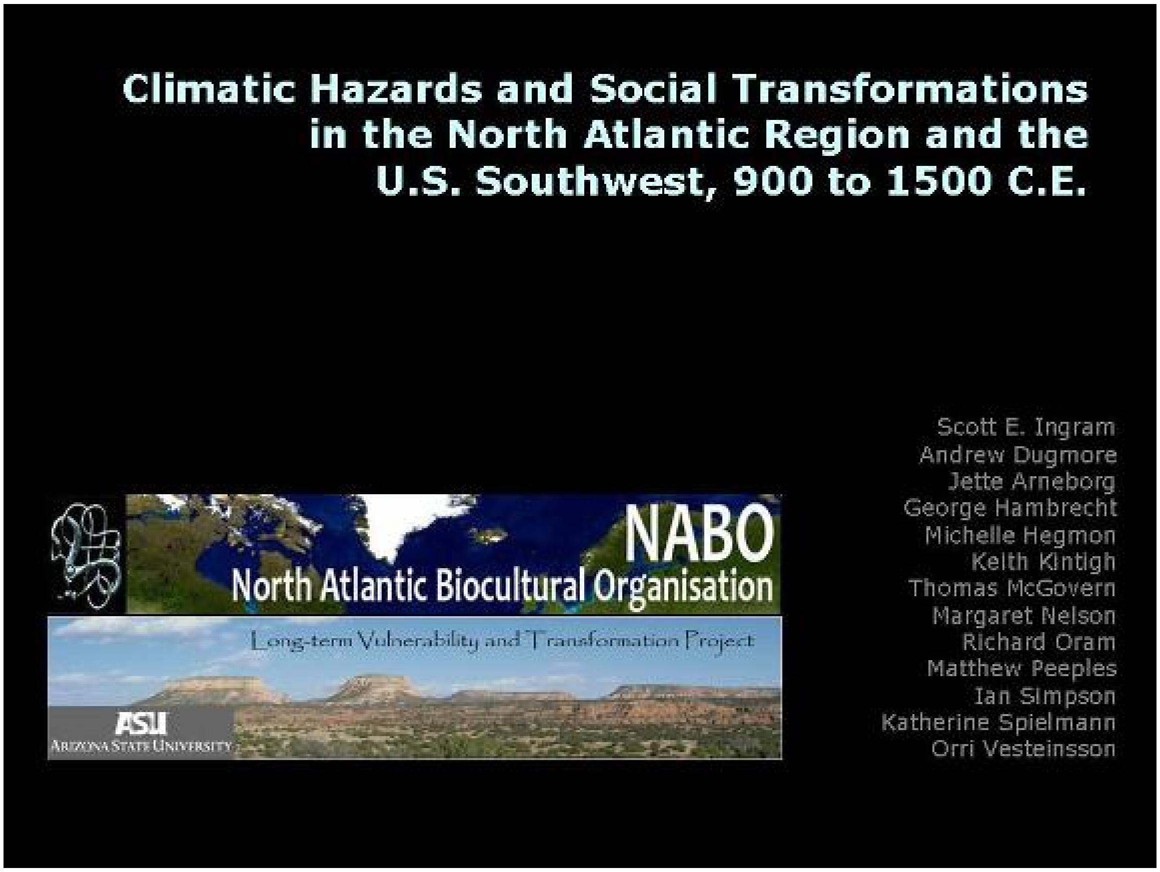
Climatic Hazards and Social Transformations in the North Atlantic Region and the U.S. Southwest, 900 to 1500 CE

by Scott E. Ingram, Andrew Dugmore, Jette Arneborg, George Hambrecht, Michelle Hegmon, Keith Kintigh, Thomas McGovern, Margaret Nelson, Richard Oram, Matthew Peeples, Ian Simpson, Katherine Spielmann, Orri Vesteinsson

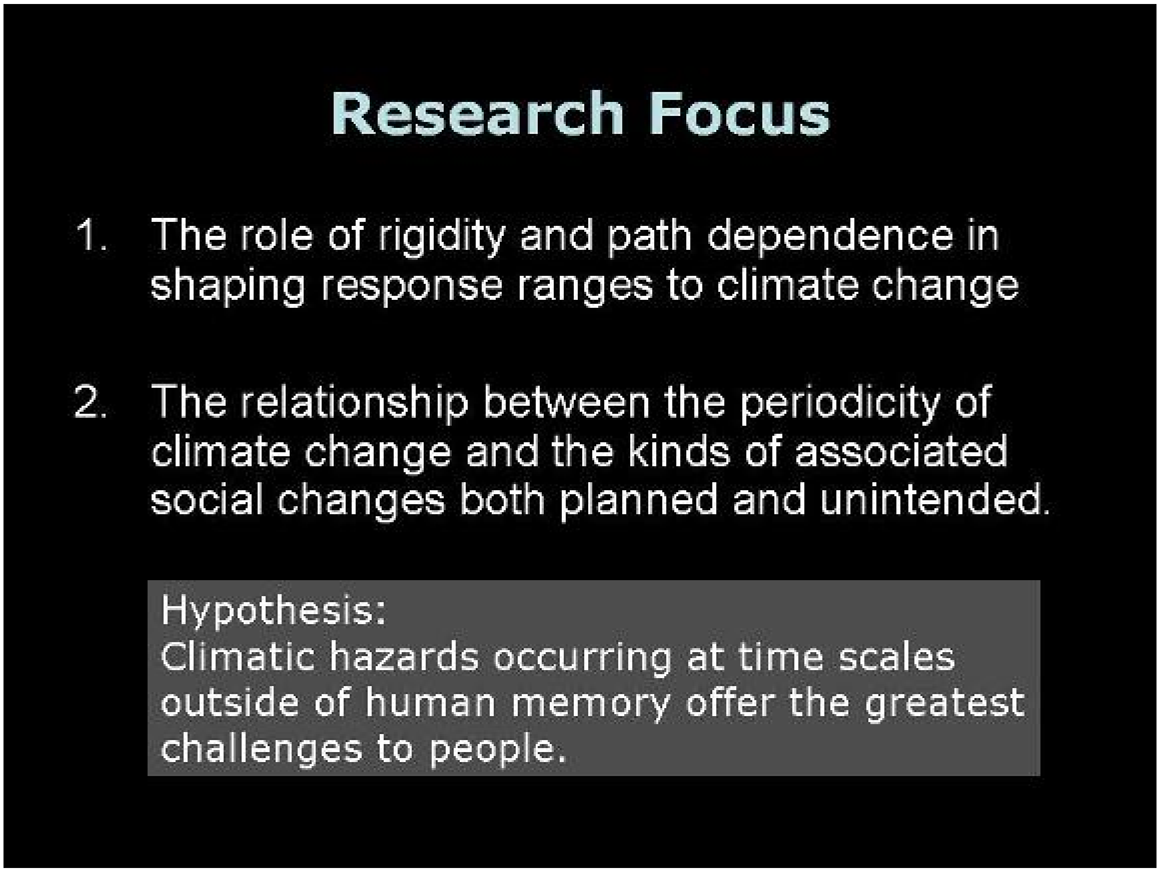


[ABOVE] This presentation addresses the relationship between climatic hazards and social transformations in the North Atlantic region and the U.S. Southwest from 900 to 1500 CE.

The research team considering this problem is a unique collaboration between two long-term archaeologically-focused projects that have been investigating human-climate-landscape interactions within different social and ecological conditions.

The North Atlantic Biocultural Organization promotes international and interdisciplinary research collaboration in the North Atlantic portion of the circumpolar north. The Long-Term Vulnerability and Transformation Project examines relationships between vulnerabilities in social and ecological realms and the magnitude and scale of social-ecological transformations in the arid and semi-arid US Southwest.

The US National Science Foundation has recently funded this pilot collaboration between our two teams. We first met last December in Southwest and will meet again this September in the North Atlantic Region. We are currently synthesizing our archaeologically known sequences in ways that are relevant for both archaeology and current climate change policy. Our goal is to generate insights regarding resilience and vulnerability to climate change derived from comparative study of long-term sequences of social change and stability.



[ABOVE] We are examining two aspects of human ecodynamics pertaining to resilience and vulnerability to climatic conditions:

1) the role of rigidity and path dependence in shaping response ranges to climate change, and,

2) the problem we will be addressing today: the relationship between the periodicity of climate change and associated social changes.

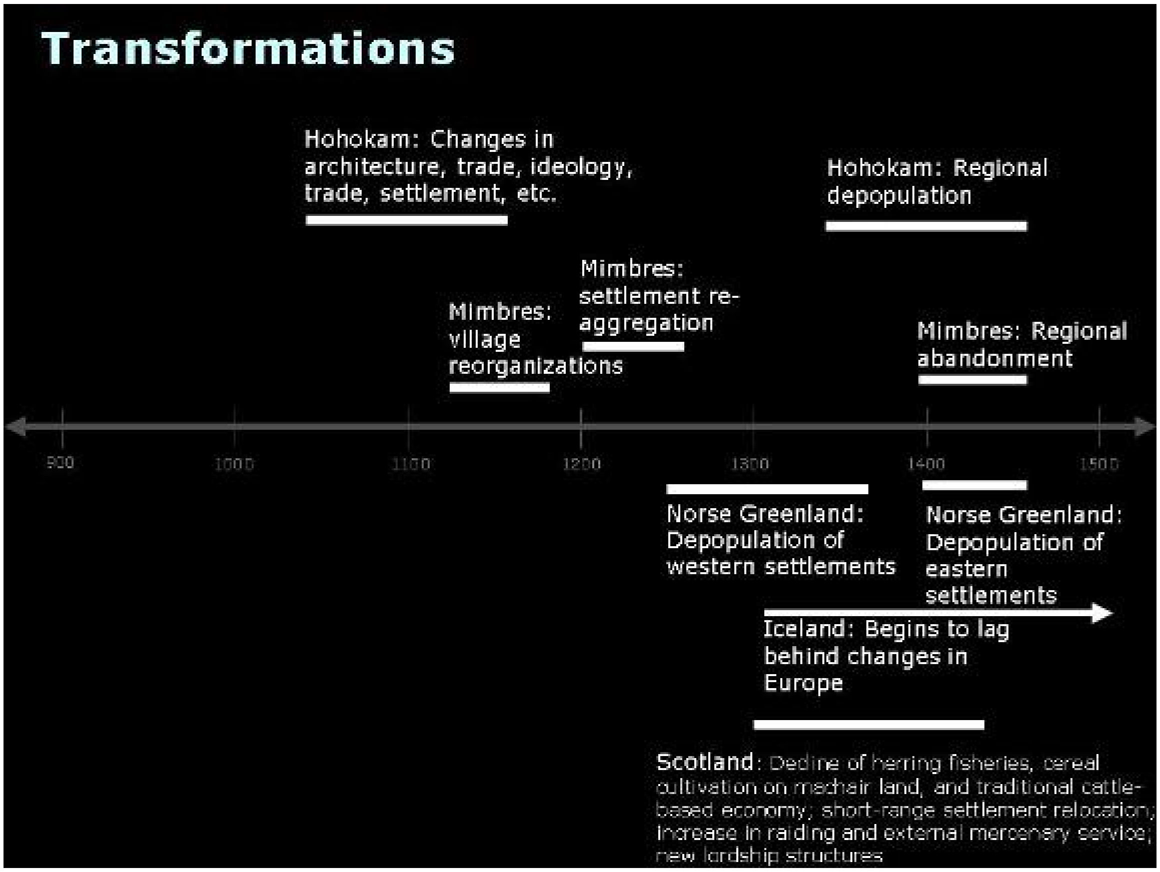
To investigate this relationship, we hypothesize that climatic hazards occurring at time scales outside of human memory offer the greatest challenges to people.

Before I present a few of our preliminary findings, I will provide some comparative background on our two regions.

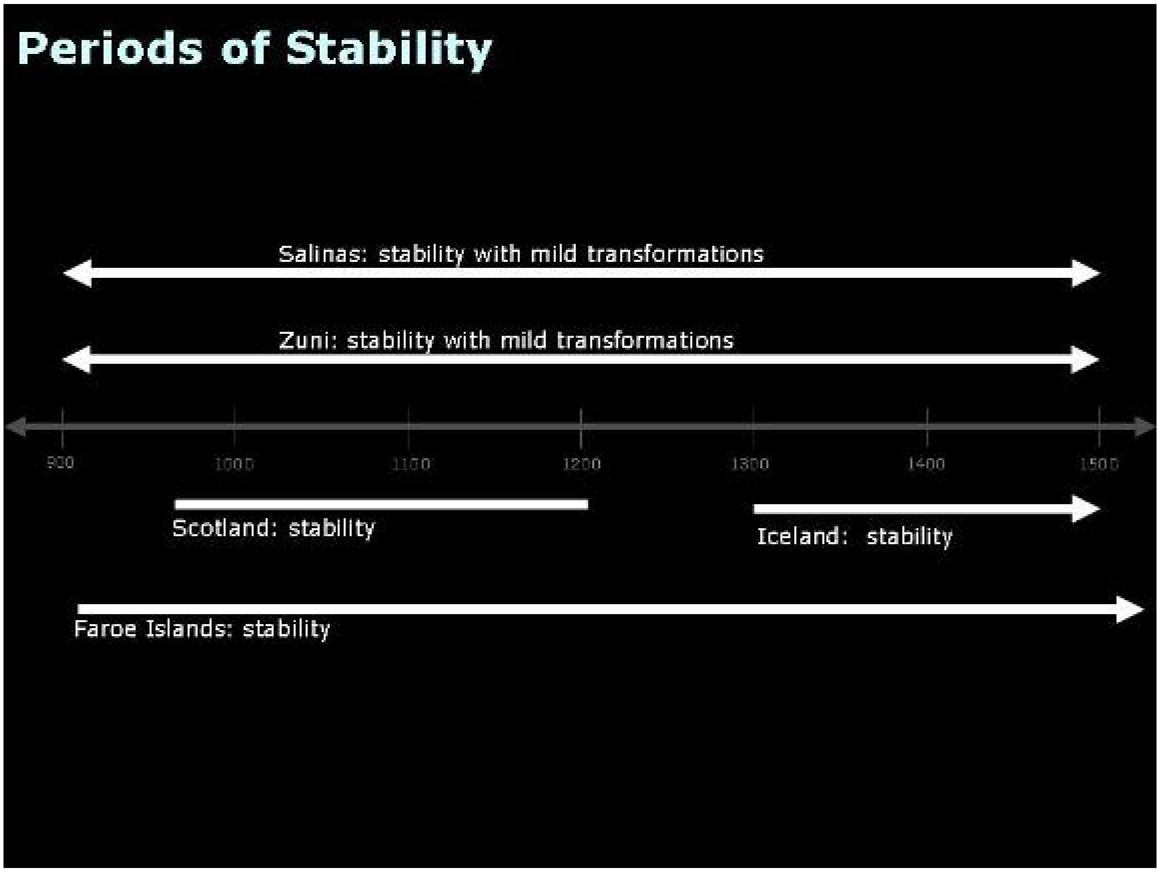
[ABOVE] In the North Atlantic region, we are considering the climatic and human histories of Iceland, Greenland, Faroes, and the Atlantic seaboard portion of Scotland. In the US Southwest, we're considering the prehistoric peoples of the modern-day states of Arizona, New Mexico, southern Utah and southern Colorado.

[ABOVE] In the Norse North Atlantic, Viking Age explorers, hunters, and colonists ventured westwards to colonize much of our study area beginning about 800 CE. Communities in the Atlantic islands faced different challenges, made different choices, and faced different outcomes in the context of similar climatic challenges.

[ABOVE] In the US Southwest, population growth was largely in situ with evidence of settled, irrigated agriculture as early as 1200 BC. The region was occupied by peoples with different languages, material culture, architecture, social structure, and beliefs. Differences in basic cultural patterns arose through a combination of their own invention and influences from outside groups, especially Mesoamerican culture.



[ABOVE] We have identified in each region periods of social transformation and stability. By transformation, we mean periods of significant social change. For example, the depopulation of Norse Greenland and the Hohokam region of central Arizona in the mid-1400s is a transformation. After hundreds of years, human populations in these places moved away or died. In the Mimbres region of the Southwest, transformations included village reorganizations and ultimately regional abandonment. In Iceland, we are interested in the period around 1300 when a threshold of some kind is reached and Iceland begins to lag behind socio-political and economic changes in Europe. In Scotland, we are interested in the 1300 to 1450 period characterized by declines in herring fisheries, cereal cultivation on machair land, and the traditional cattle-based economy.



[ABOVE] We are also interested in periods of relative stability. These periods may be examples of resilience when the socio-ecological systems were able to effectively absorb disturbances, such as climatic hazards, and maintain essential structures and functions. They might also be periods known in the resilience literature as "rigidity traps" when diversity is diminished and institutions become highly connected, rigid, and inflexible. The Faroes Islands, Salinas, and Zuni provide examples of periods of stability as any social changes occurring in these places were relatively mild. Other examples of stability include Scotland from 950 to 1200 and Iceland after 1300.

Primary Climatic Hazards and Potential Influences on Human Behavior

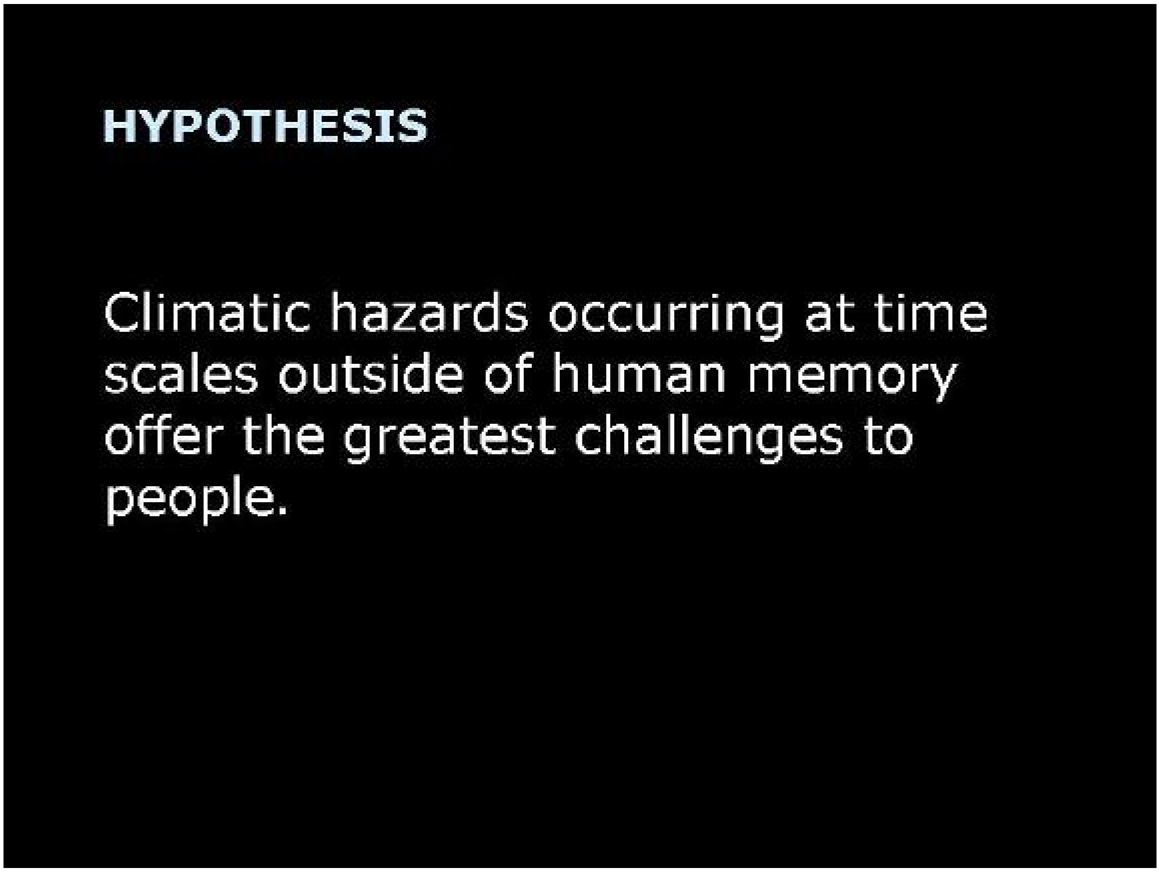
Region	Hazard	Proxy	Impact on Subsistence Systems	Potential Influence on Human Behavior
North Atlantic	Cool periods	Ice cores	Decreases grazing area and quality for domesticated animals, increases winter feeding of stock, reduces growing season, increases sea ice	Catalyst to population movement if population-resource imbalance results, challenges agricultural planning, increases risks of sea navigation
	Storminess	Na+ ice cores	Wind erosion of cultivated areas	Increases risks of sea navigation including success of marine mammal hunting and fishing
US Southwest	Dry periods	Tree rings	Decreases productivity of cultivated (corn, beans, squash) and wild food (plants and animals)	Catalyst to population movement to manage risk of food shortfalls, challenges agricultural planning

[ABOVE] Our interest in the relationship, if any, between climatic hazards and human behavior requires an understanding of the linkage between specific climatic changes and potential human responses. We understand that the relationships are complex, indirect, and socially mediated. This is especially so in the potential relationship between particular climatic hazards and social transformations.

We also understand that climate impacts subsistence strategies and thus successes and failures in food provisioning. And, climatic events that challenge one provisioning strategy might benefit another. For example, in Greenland the focus on the spring seal migration creates a key relationship to changes in sea ice, but hunting of ice riding seals can benefit from conditions that are not good for the farms.

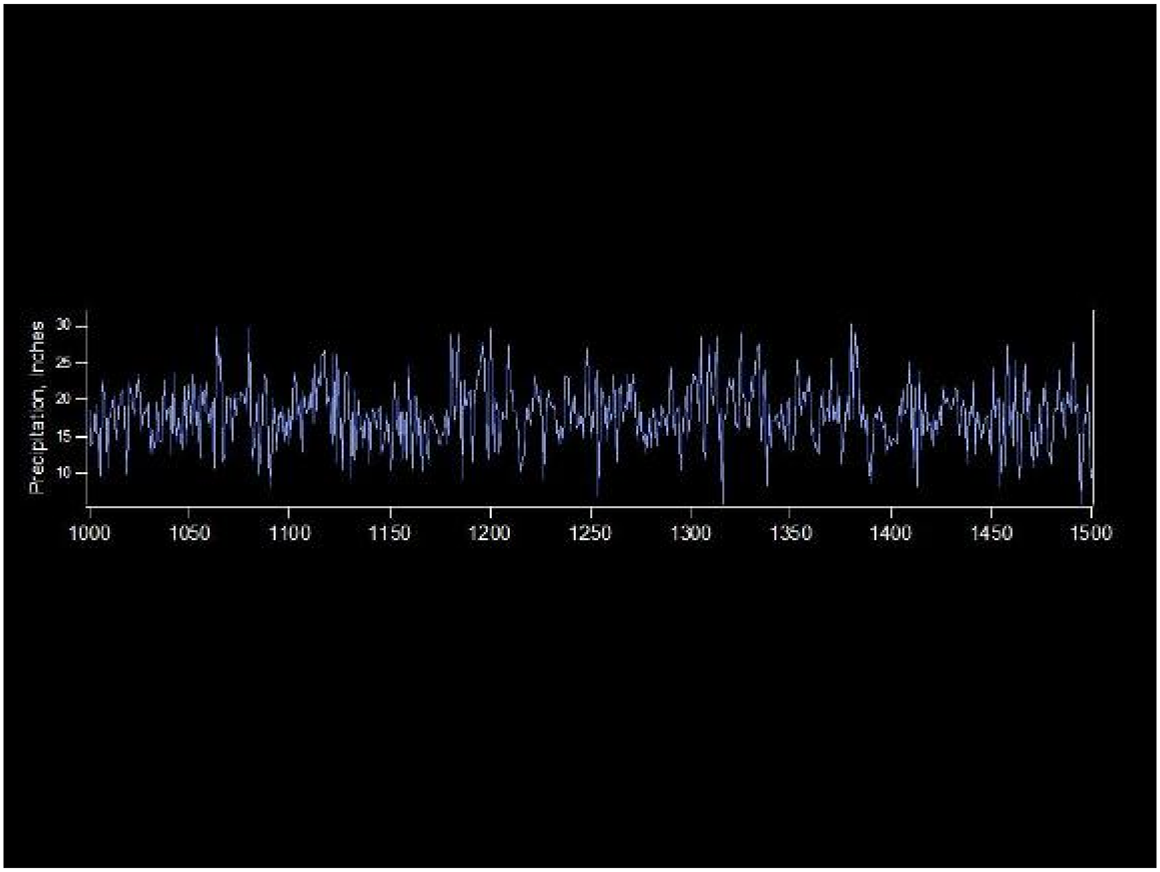
The climatic hazards we consider strongly influence the success of food provisioning. In the North Atlantic, cool periods decrease grazing area and quality for domesticated animals, increase winter feeding of stock, and reduce the growing season. Storminess challenges sea navigation and the success of marine mammal hunting and fishing. In the SW, dry periods decrease the productivity of wild and cultivated foods. Each hazard increases the risk of food shortfalls and may prompt human responses to manage these risks.

Differences between our regions in provisioning are substantial: in the Southwest, there are no domesticated animals, fishing resources are minimal by comparison, no longdistance trade in food provisions, and greater reliance on cultivation.   Similarities between the regions include comparable regional-scale population levels, a marginal environment for food provisioning, and surprising coincidences in the dates of key human events.

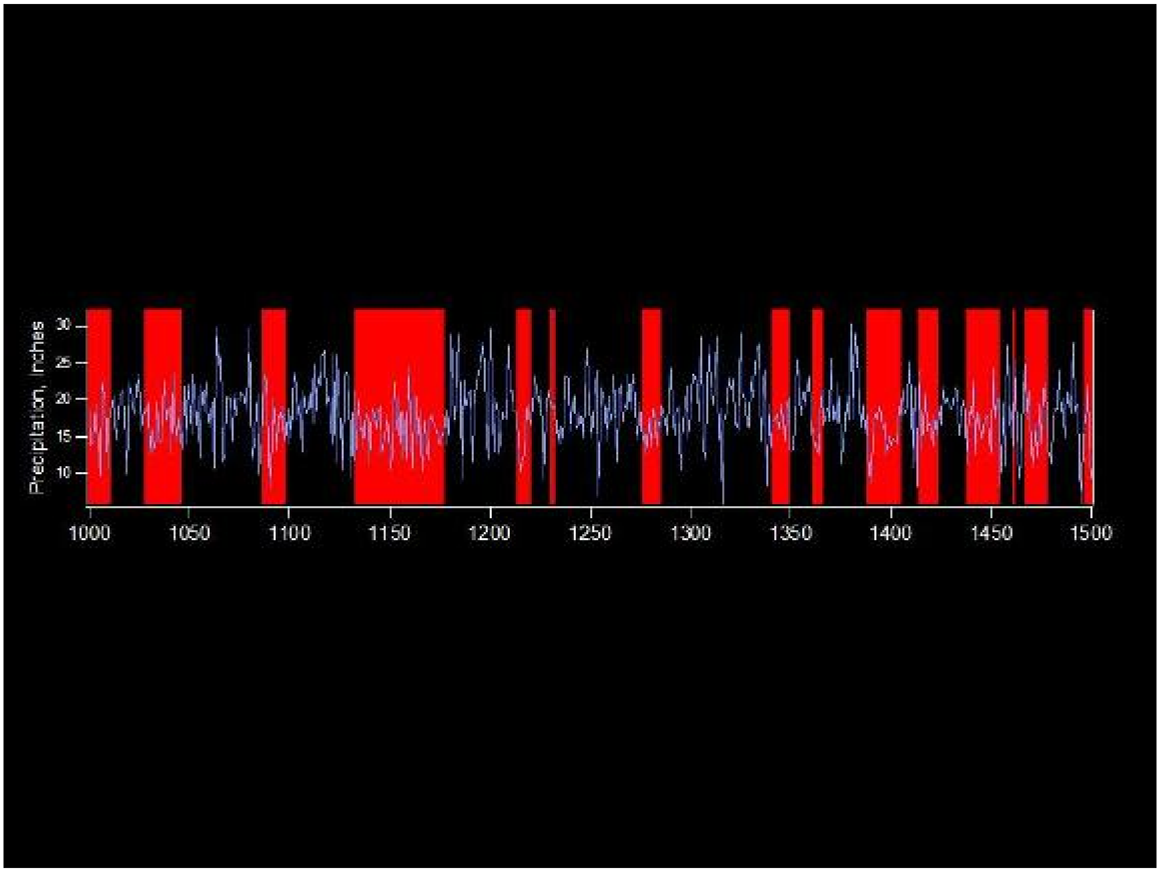


[ABOVE] Today, we have time to describe one representative analysis resulting from our collaboration. In response to commonly held beliefs that people adjust to frequent, small-scale climatic fluctuations, we examine the proposition that climate hazards occurring at time scales outside of human memory offer the greatest challenges to people. If so, we expect that these hazards will lead to dramatic transformations, which can represent both constructive changes and collapses.

For now, we address this empirical question with data from the US Southwest. As we are at the beginning of our collaboration, the results I present today are partial and preliminary.



[ABOVE] In brief, I identified the dry periods that occurred in seven areas of the Southwest. This is a traditional precipitation reconstruction using tree tings and I have statistically identified the dry periods indicated in red [BELOW]. But, looking at climatic conditions with only traditional x/y graphs obscures more than they reveal. We can use the same data to identify characteristics of dry periods that would likely have been meaningful for human behavior.


Precipitation, Inches
30
25
20
15
10
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500

Paleoclimatic record of dry periods in one area of the US Southwest

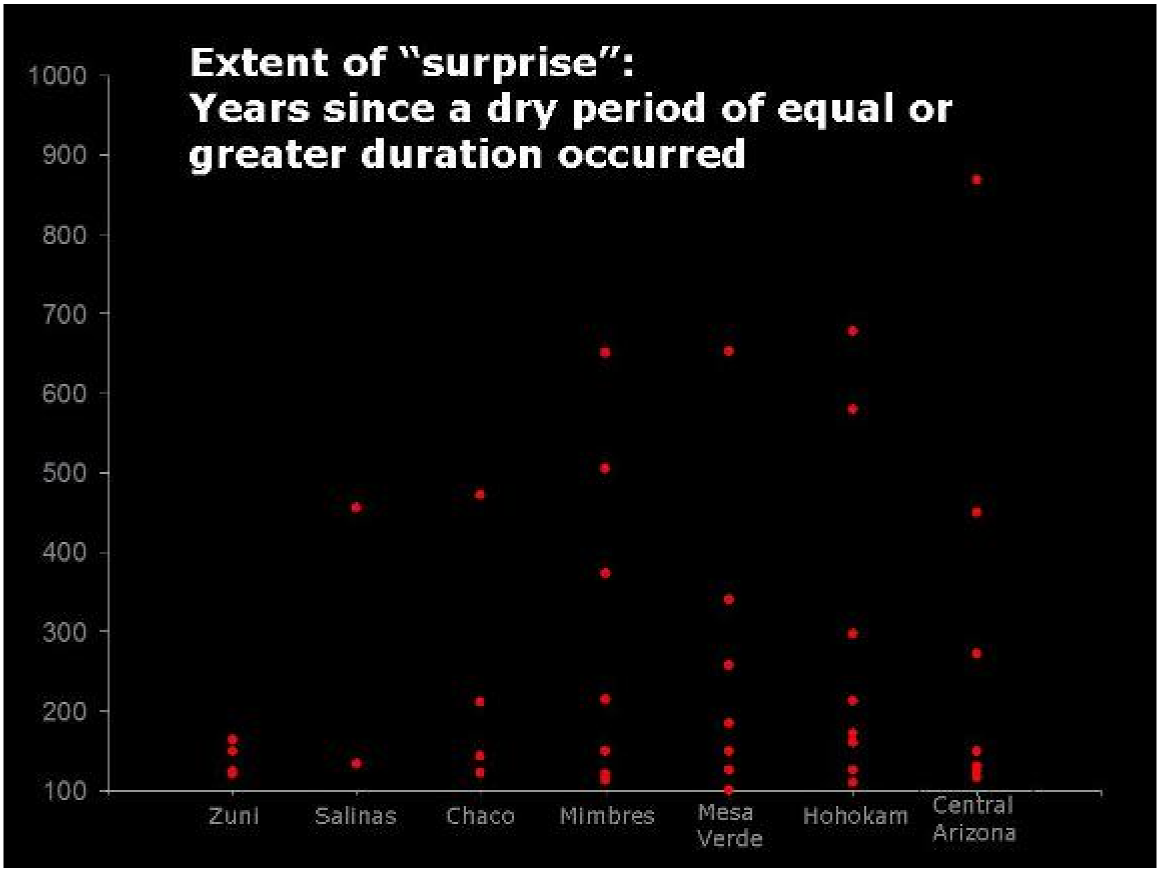
Dry Period Began	Dry Period Ended	Duration	Years Since a Dry Period of Equal or Greater Duration
[572 CE start of reconstruction]			
594	600	7	-
662	666	5	62
697	725	29	>125
740	758	19	15
790	795	6	32
904	909	6	109
918	924	7	160
971	983	13	213
984	998	5	11
1022	1025	4	24
1032	1043	12	49
1066	1072	7	23
1092	1101	10	49
1133	1140	8	32
1214	1224	11	171
1250	1255	6	26
1280	1292	13	297
1338	1352	15	580
1389	1393	5	37
1408	1414	7	58
1436	1452	17	678
1496	1503	8	44

[ABOVE] This slide shows the dry periods in one area. We have independent precipitation reconstructions for each of the groups and places we are considering. I calculated how rare and potentially surprising each dry period was relative to previous dry periods that had occurred in each area. I used the duration of each dry period to identify its rarity. Longer dry periods are more rare and challenging to food provisioning than shorter dry periods.

I calculated the number of years since a dry period of equal or greater duration occurred. The results are in the far right side column of this table. For example, the 1280 to 1292 dry period is 13 years long. If you scan the duration column you see that the last time a dry period that was at least 13 years in duration was from 971 to 983.

Subtracting the end of this dry period, 983, from the beginning of the 1280 dry period, you get the result 297, which are the years since a dry period of equal or greater duration occurred. This number allows dry periods to be compared by their extent of surprise and rarity. The higher the number of years since a dry period of equal or greater duration, the more surprising and rare the dry period.

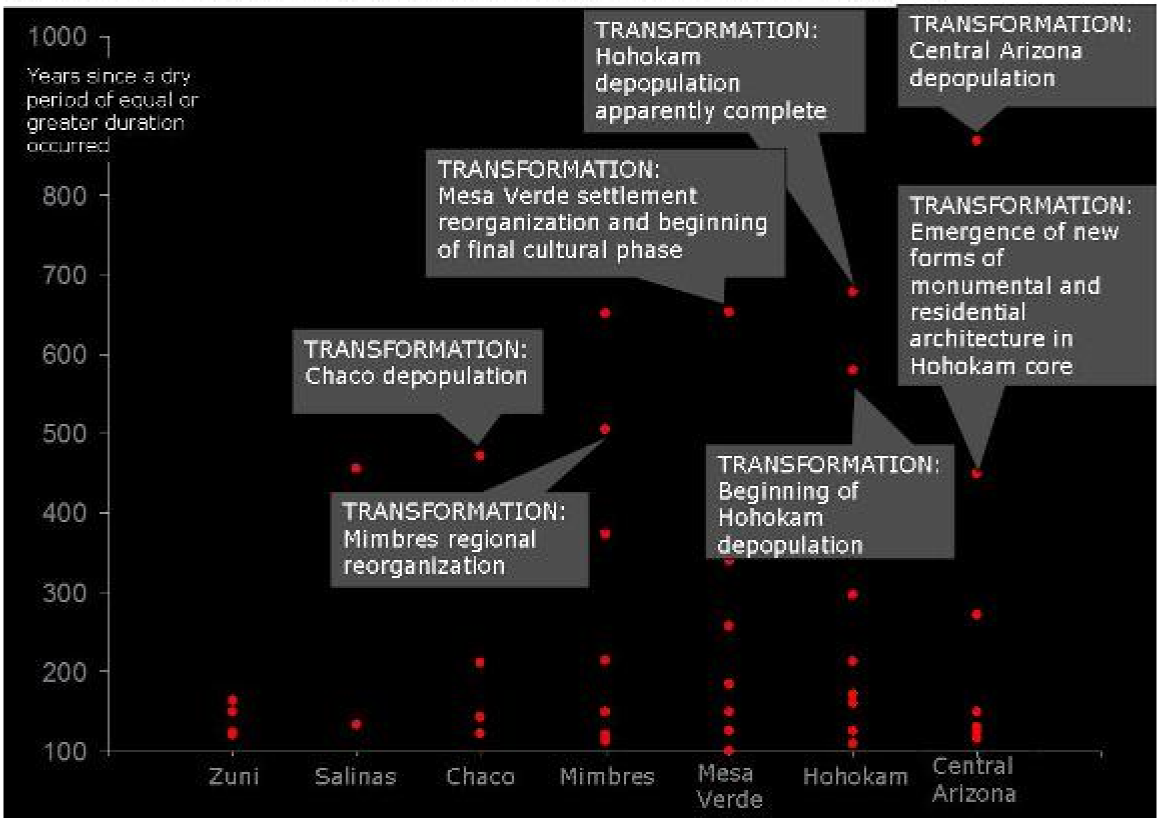
This characterization of dry periods is a new methodological advancement. It can be used with any annually resolved proxy climate record where the investigator is interested in considering the social memory of rare climate events.



[ABOVE] This is the result of the characterization. Each red dot is a dry period and the height of the dot is determined by the number of years since a dry period of equal or greater duration occurred. These years are indicated on the y axis. I ignore all dry periods in which less than 100 years had passed since a dry period of equal or greater duration had occurred. I assume these dry periods were not outside of human memory or existing adaptive strategies. The results presented here identify the longest and most rare dry periods that occurred during our period of interest going back until the start of each precipitation reconstruction.

To evaluate the hypothesis that climatic hazards occurring at time scale outside of human memory offer the greatest challenges, I conduct a preliminary test to determine if there is a temporal relationship between these very rare dry periods and the social transformations we are considering. We all agree that temporal correlation does not demonstrate a causal relationship. However, multiple cross-case examples of temporally coincident rare climate events and social transformations are highly suggestive that we are observing something more than correlation and further investigation is warranted.

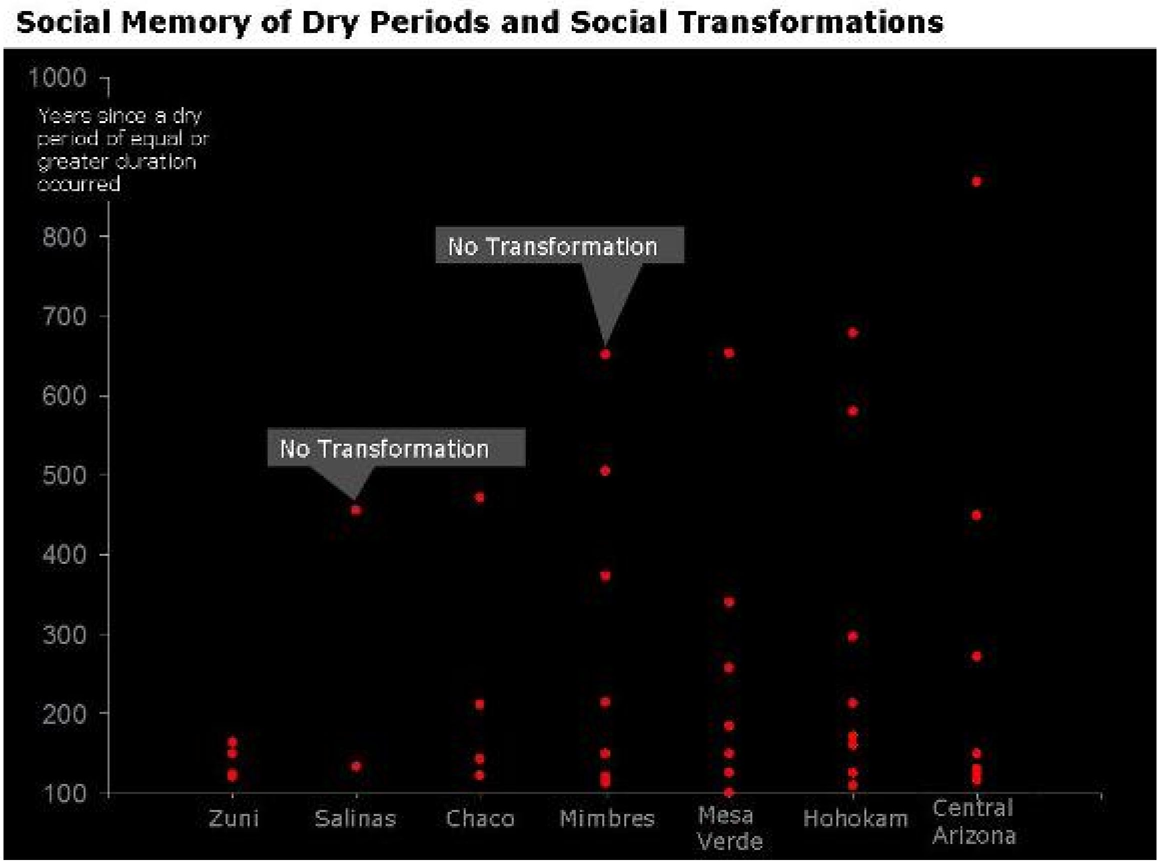
Social Memory of Dry Periods and Social Transformations



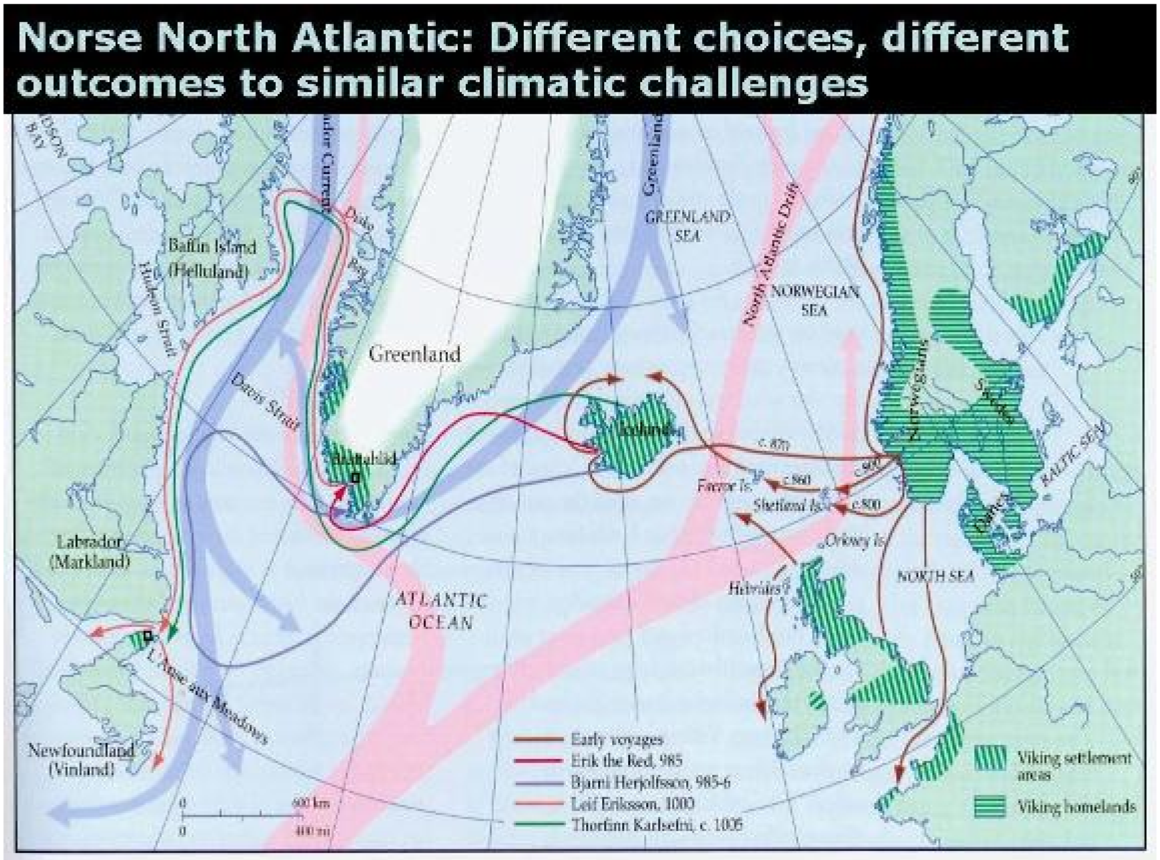
Here are the results: [ABOVE] The Mimbres regional reorganization is coincident with a rare dry period—one in which at least 500 years had passed without a dry period of this duration.

The Hohokam depopulation begins and is complete coincident with the rarest dry periods. I added several other well-known cases to this test: Chaco, Mesa Verde, and central Arizona with similar correlations resulting. Thus, many of the major transformations in the SW are temporally coincident with very rare climatic events—events that were likely unprecedented in social memory.

It's also important to note that in the case of Zuni, one of our examples of long-term stability, there were no extremely rare dry periods as there were with the other cases. This further supports an interpretation of the relationship between rare climatic events and social transformation.



This is not the end of the analysis; it is the beginning. Let's look closely at this slide. [ABOVE] There are other rare dry periods not associated with social transformations. For example, in the Mimbres region, why was a social transformation not associated with the rare and extreme 1273 to 1295 dry period of 23 years duration? Or, in the Salinas region, why was a social transformation not associated with the 1335 to 1351 dry period of 17 years duration? And, not all of the transformations we are interested in are coincident with rare climate events. By identifying key social and environmental variables and potential vulnerabilities in each place through time we may find patterns that cross-cut our cases and explain differences in vulnerability and resilience.



[ABOVE] In the North Atlantic the unfolding story is similar and enriched by the historical record. Each of our study areas had different outcomes in the context of similar climatic challenges. Not all climatic hazards occurring at time scales outside of human memory resulted in a proportional social transformation. Differences in conditions and outcomes allow us to investigate the impact of a range of societal choices on vulnerability to climatic hazards. In other words, we have multiple “completed experiments” in resilience and vulnerability to learn from.

[ABOVE] For example, in the Faroe Islands, the challenges of unpredictable climate change were met with minimal environmental change and no major social transformation. Why? Perhaps closer integration with Norway and thus less marginalization in the context of the changing political climate after 1300 played a role in long-term stability. Population levels were also relatively low. The diverse subsistence system that included terrestrial, marine, domesticated animals, wild resource, cultivation, and trade probably also contributed to the resilience of the Faroese system. Climatic conditions that are bad for pastoralism are not necessarily equally bad for fishing and hunting.

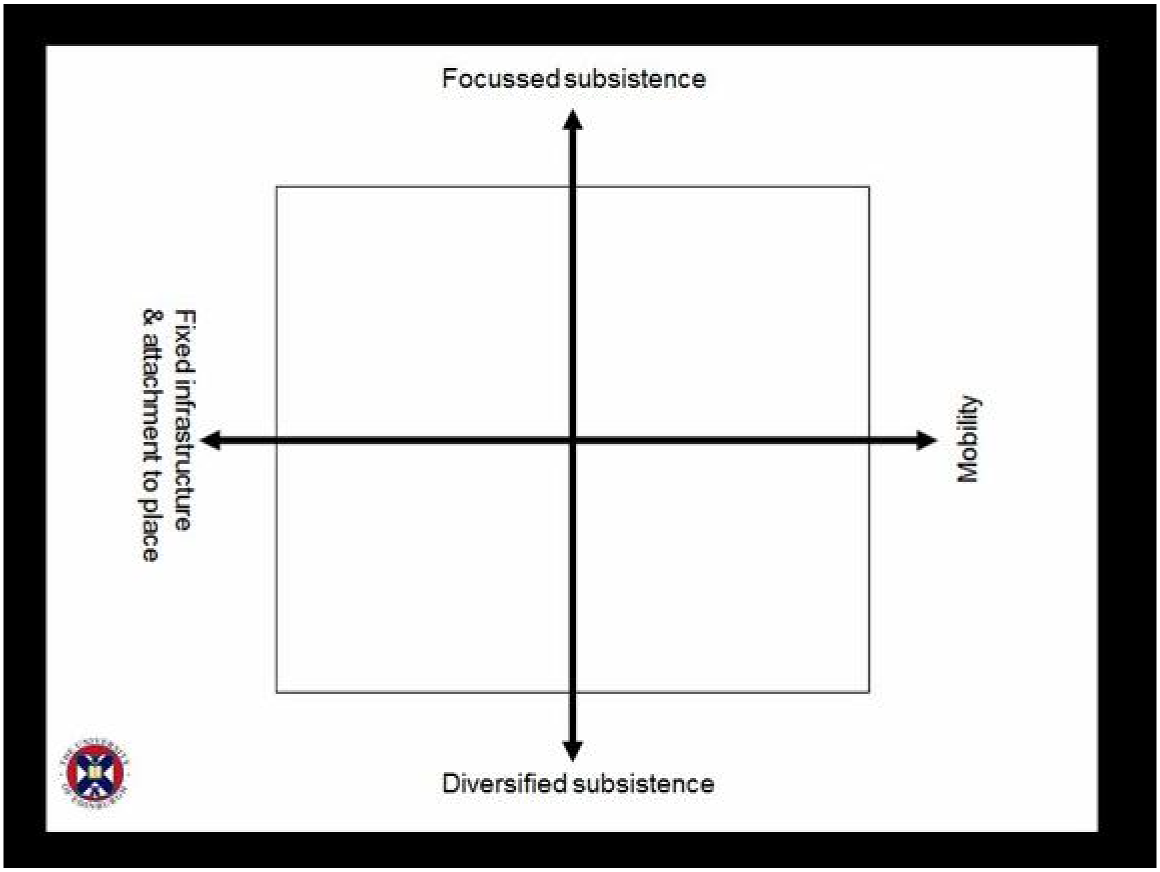
[ABOVE] In Iceland, in the face of climatic change, disease, volcanic eruptions, and changing relations with the outside world, Iceland continued with no major changes in settlement patterns, land use, technology, material culture, and social organization. The life of the ordinary Icelander in the 1850s was similar to that of the 950s. There is, however, evidence of environmental degradation which can be linked to unpredictable climatic shocks. Perhaps a conservative social system contributed to their social resilience to climatic hazards.

[ABOVE] In Norse Greenland there is no question of transformation: Norse settlement on the island ended during the early 15th century. However, there is disagreement regarding the causes of the depopulation and the role of climatic challenges. One perspective is that the Greenlanders adapted well to climatic changes and that it was not a subsistence crisis that led to the demise of Greenlandic settlements. Rather, it was a crisis of perception and self-definition. Greenlanders forged close ties with Norwegian kings at least from the 13th century and when the Norwegian kingdom came to an end as a separate entity in 1387, the interest in Greenland and its resources declined. Thereafter, the center of gravity of power and trade shifted to the Baltics and elsewhere. In response to a series of major climatic hazards in the 14th century, people appear to have adapted by intensifying marine mammal resource use.

A complementary perspective suggests multiple adverse impacts: cooling, storminess, less European contact, more direct Thule contact and competition, the impact of the black death in Iceland, Norway, and Scotland contributed to the depopulation. Thus, the Greenland case offers the opportunity of investigating a variety of factors that may have contributed to vulnerability and resilience to climatic hazards.

[ABOVE] In Scotland, increased storminess, cooling, and wettening of conditions likely triggered social changes by reducing the range of exploitation options available. Furthermore, social changes triggered by environmental shocks may have been manipulated to deliver the resource base necessary for regional rulers to maintain their status domestically and to enable them to act as power brokers.

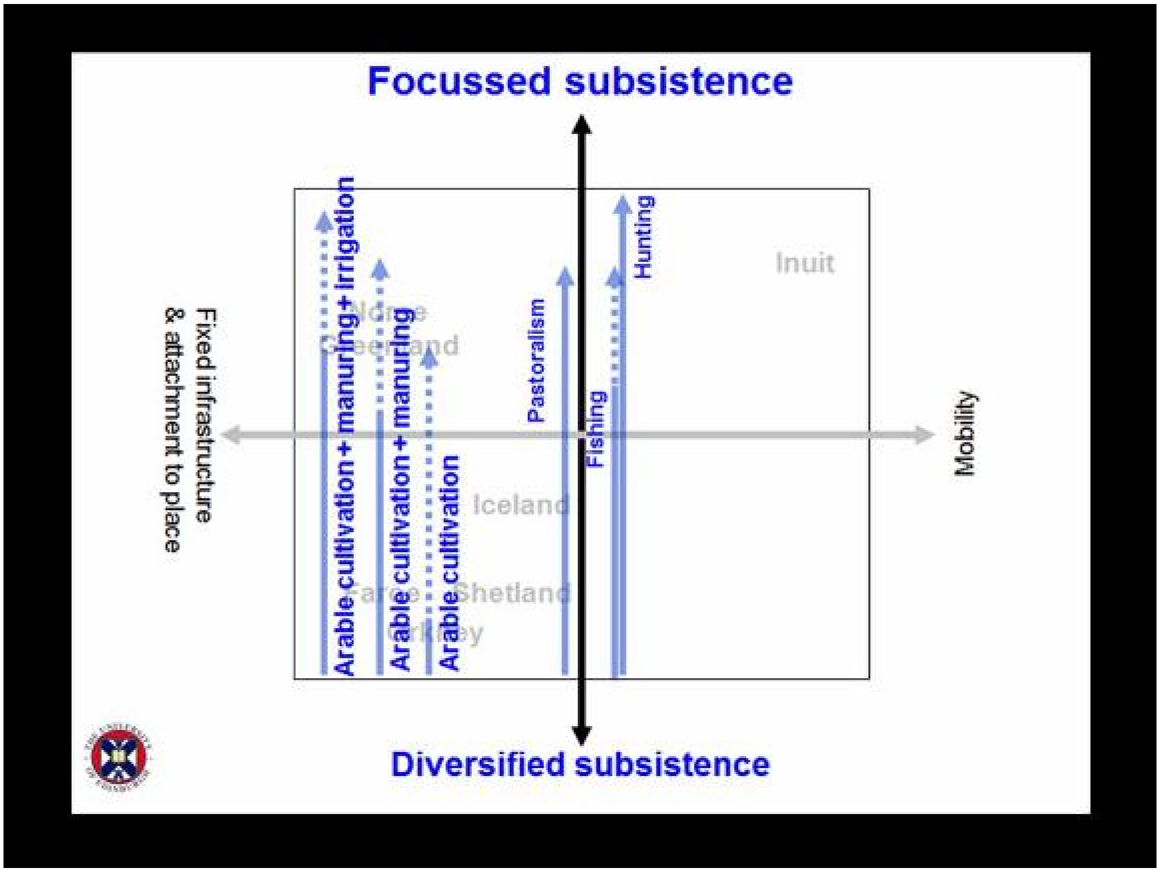
A challenge for any interregional comparison is to find comparable parameters which can be assessed. We are using a number of key indicators of potential vulnerabilities such as the extent of social hierarchy, surplus, isolation, conflict, and infrastructure intensification to understand how the choices each group made may have affected differences in outcomes.



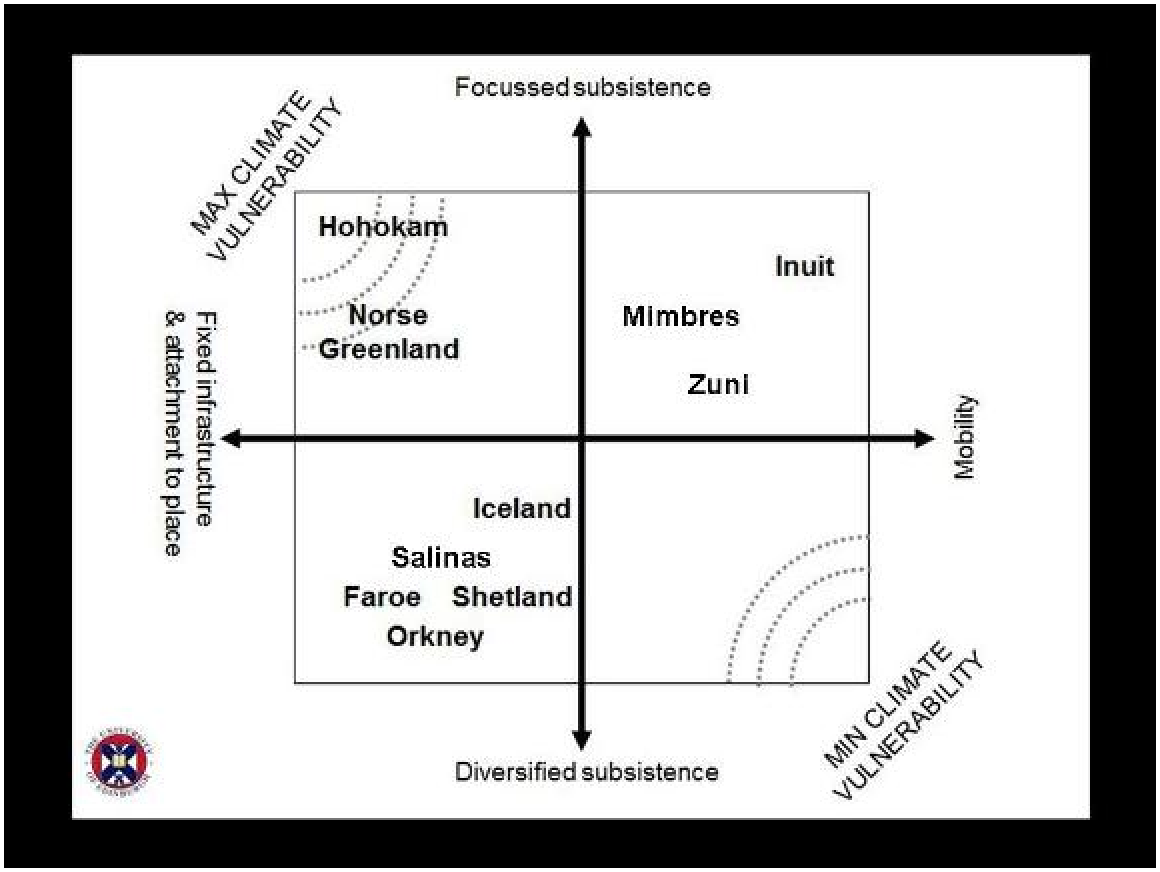
[ABOVE] For example, when considering the general themes of long-term settlement, sustainability, resilience, adaptation, threshold crossing events and transformations, two fundamental sets of interactions with the environment are apparent.

First, there is how people choose to base their subsistence …and broadly this may be considered to be focussed (on a limited range of foods, on a particular region, on a particular time period) or diversified (in terms of the same parameters). This may be conceived as an axis of variation.

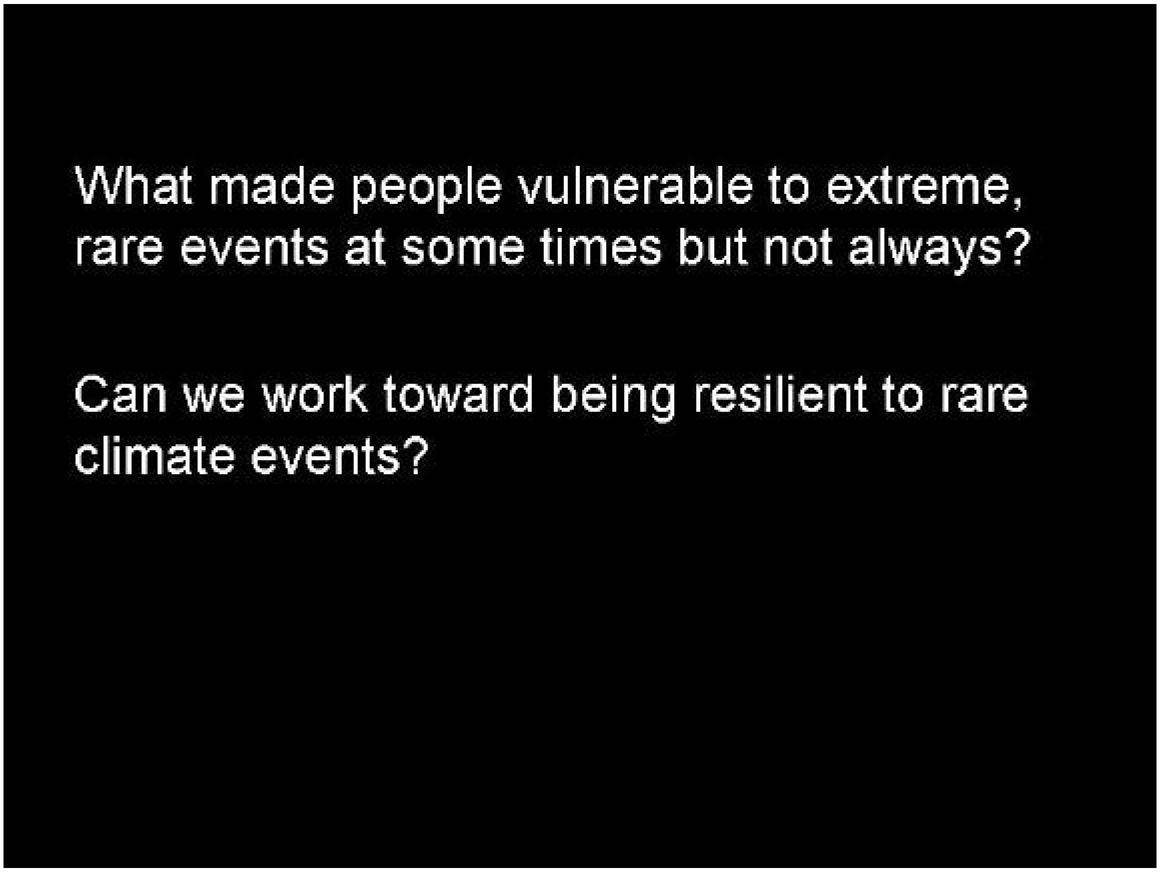
Second, there is where people choose to live (in one location, in several that they return to at different times, or many and varied places) and what effort they put into fixed infrastructure (in terms of buildings, other structures or field systems). This may be conceived as another axis of variation.



[ABOVE] Here we consider the subsistence axis and we can identify a number of different strategies and choices that change in intensity from the bottom to the top of the graph, and may be ordered from left to right in terms of place and infrastructure.



[ABOVE] These two axes of variation can be used to describe the different societal strategies and make inter-regional comparisons. In general terms, we are tempted to suggest that societies with large investments in fixed infrastructure and attachment to specific places who also have very focussed subsistence strategies may have the greatest potential susceptibility to climatic hazards (or that climatic hazards may pose the great potential challenge). However, our work on these issues continues.



[ABOVE] In conclusion, what our initial efforts lead us to is twofold: first, we need to look at what made people vulnerable to extreme, rare events at some times but not always; and, second, it suggests that for contemporary social-ecological systems we need to consider whether we have created vulnerabilities to extreme, rare conditions in domains we can predict (such as dry periods in the US Southwest or extreme cold in the North Atlantic) and whether we can work toward being resilient to them. We are excited by the possibilities of investigating these issues with long-term climate and human histories from contrasting regions of the world.