Climate change, Sustainability, and the Ancient City of Angamuco, Michoacán, Mexico

Christopher Fisher, Colorado State University, Ctfisher@colostate.edu

ABSTRACT

The societal impact of climate change in Central Mexico during the Postclassic Period is an important question in Mesoamerican archaeology. Here, using archaeological evidence from the ancient city of Angamuco, including LiDAR analysis, I argue that an engineered environment buffered the environment from reduced rainfall events mitigating the impacts of the Medieval Warming Period. Today the region is facing dramatic changes from global earth system change. This ancient case-study can serve as an important example for modern stakeholders and policy makers.

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INTRODUCTION

Since superstorm Sandy walloped the East Coast in 2012 the idea of climate proofing cities has gained significant traction in the United States. This follows a long trend globally where the impacts of global warming have been visible for over a decade, especially in Northern Europe. These plans seek climate mitigation and adaptation in urban areas through nature-based solutions broadly drawn from ‘traditional sustainability’ (Williams 2011; Calliari et al. 2019; Maes and Jacobs 2017). The problem in this literature is that it confuses the end points of long trajectories of coupled human/natural systems as synchronic cures. And the documentation of these landscape legacies are the domain of archaeologists who should be dominating this literature (Fisher et al. 2009).

A basic question for archaeologists in regard to this emerging domain of sustainability is did past societies ‘climate proof”? Or, more broadly, can we document ancient responses to climate change in ways that are meaningful to policy makers and stakeholders? One example centers on deciphering the impact of climatic variation in Central Mexico during the Postclassic period (CE. 1000-1530). Here I explore this question for the Lake Pátzcuaro Basin, Michoacán, Mexico (LPB) using evidence collected during the last decade as part of the LORE-LPB program of research. Specifically, Lake Pátzcuaro is throught to be an amplifier lake that responds directly to changes in climate. How variable was the climate and the level of the lake during the Postclassic? How might lake level have been impacted by the human constructed environment? Can we see any evidence that the ancient Purépecha ‘climate proofed’ the landscape in the centuries prior to European Conquest?
BACKGROUND

At the time of European contact (A.D. 1520) Central Mexico was dominated by two Empires – the Aztec or triple alliance centered within the Basin of Mexico - and the Purépecha (Tarascan) centered within the LPB (Figure 2). Compared to the better known Aztec, the Purépecha are relatively understudied though the area is a major tourist destination that is heavily settled and increasingly urbanized. We do know that at the time of Conquest the LPB contained an imperial city (Tzintzuntzan) that was at the heart of a centralized settlement system, socially stratified population, and an engineered environment (Fisher, 2005; Fisher et al., 2003; Pollard, 2003).

![Figure 1: Location of the Lake Pátzcuaro Basin in Central Mexico.](image)

As part of my early work in the LPB (Fisher et al. 1999; Fisher 2000; Fisher et al. 2003; Fisher 2005) I presented a model of landscape development that centered on increasing inputs of environmental labor investment (landesque capital) during the Early to Middle Postclassic (~CE.
1000-1350). This occurred mainly in the form of terraced landscapes though I did find evidence for raised fields, canals, and other types of water management (Fisher et al. 1999).

I argued that the goal of this construction was to solve for earlier land degradation along with increasing the agrarian potential of the LPB. The sequence ended at the close of the Late Postclassic with widespread demographic collapse and landscape abandonment which precipitated an environmental catastrophe (Fisher et al. 2003; Fisher 2005). This model was tested through archaeological fieldwork and geoarchaeological investigation in a small part of the South Eastern portion of the LPB. Beyond this section of the LPB there was only anecdotal evidence confirming this initial model.

In 2006 the Lake Pátzcuaro Basin Archaeological Project (LORE-LPB) begin investigation a 62 km² area between the three known Late Postclassic (CE. 1350-1530) cities of Tzintzuntzan, Ihuatzio, and Pátzcuaro to explore questions related to long-term settlement, the origins of urbanism, and the creation of the built environment. This zone includes several former islands that are today landlocked, several prominent cerros, one major malpaís zone, several important springs, and much former lakebed (Figure 2).
Figure 2: South Eastern portion of the Lake Pátzcuaro Basin showing the level of the lake at the time of European Contact and major settlements.

Over the last decade (2006-present) this work has included traditional full-coverage survey, urban mapping, remote sensing, LiDAR scanning and mapping, landscape analysis, and archaeological excavation (Fisher et al. 2011; Fisher and Leisz 2013; Fisher et al.). To date this work has documented well over 70 new settlements and thousands of landscape features such as terrace systems, water control features, and roads. Most notably this includes the discovery of the ancient city of Angamuco which covers roughly 26 km² including over 40,000 well preserved building foundations, pyramids, and other features. Importantly this work now provides the evidence needed to more fully evaluate the model for the Lake Basin as a whole.
REGION AND PREHISTORY

Lake Pátzcuaro is a shallow, highland lake on the Central Mexican Altiplano (Chacon 1993). The Lake Pátzcuaro Basin shares many characteristics with the more familiar Basin of Mexico (elevation, vegetation, monsoonal climate) though there are some important differences. At only 928 km² the Lake Pátzcuaro Basin is smaller than the Basin of Mexico (7,000 km²) and receives almost twice as much rainfall (900-1250 mm/year Pátzcuaro, 450-1000 mm/year Basin of Mexico (Pollard 1993; West 1948). Extensive paleoenvironmental research has been undertaken within the Lake Pátzcuaro Basin elucidating connections between humans, climate, and land degradation (Fisher et al. 2003). Lake Pátzcuaro is an ‘amplifier’ lake with climatic flux causing shifts in lake level as great as 10-13 meters in the last decade. Recent research has focused on a variety of lake cores recovered from the Mexican Highlands suggesting reduced rainfall and/or higher evaporation rates for the Pátzcuaro Basin between A.D. 700-1100 resulting in similarly low lake levels (Metcalf and Davies 2007). This would have resulted in a regression episode estimated to have been between 10-13 meters below the level of the lake at the time of European contact.

The settlement history of the study region is dominated by the growth and decline of the Postclassic city of Angamuco (Fisher et al.). There is evidence for settlement in the area by the Late Classic period and potentially before but our current understanding of these early populations is currently limited. Starting in the Early Postclassic (CE. 1000) there seems to be rapid and massive population growth in the region evidenced by the expansion and elaboration of the city of Angamuco. This growth is likely the result of migrations to the region sparked by massive volcanic events in greater West Mexico. This growth continues throughout the Middle Postclassic through which we see the largest population at Angamuco.
For much of the Postclassic period Angamuco must have dominated the eastern portion of the LPB with a population that may have exceeded 100,000 persons, an extensive built environment, several civic-ceremonial nodes, and an overall size that exceeds 26km² (Fisher et al.). The predominate Angamuco occupation falls during the Early-Middle Postclassic with a significant decline in population during the Late Postclassic after the formation of the Empire.

During the Late Postclassic (~CE. 1350-1530) the Lake Basin is consolidated by what quickly becomes the Purépecha (Tarascan) Empire. At this point Angamuco enters a period of decline perhaps eclipsed by the better documented Imperial cites such as Ihuatzio, Pátzcuaro, and the Imperial capital of Tzintzuntzan.

LAKE PÁTZCUARO AND CLIMATIC CHANGE

Lake Pátzcuaro is considered an amplifier lake and there is a direct correlation between climatic fluctuation and lake level change during the historic and modern period. Much of the archaeological and earth systems literature has assumed that this relationship was valid for the past as well with scholars commonly using ancient climatic variability as a proxy for lake level change. Indeed climatically induced lake level change has been implicated as a trigger for the development of the Postclassic Empire (e.g.(Pollard 1993, 2008). Previous archaeological and geoarchaeological investigation within the lakeshore zone in the SE portion of the LPB seemed to document settlements that were differentially distributed by time and elevation suggesting that this correlation was valid for the past as well (Figure 3) (Fisher et al. 2003).
Figure 3: Traditional model of lake level change from Fisher et al 2003.

Recent geological research in this area, however, shows significant tectonic disturbance, deposition, and disturbance meaning that the distribution of sediments/settlements in this region cannot be used for lake level reconstruction (Garduno-Monroy et al. 2011). This is confirmed with LORE-LPB remote sensing data that show significant uplift and deformation of land surfaces in this area of the LPB. This new work means that landform elevation data for this portion of the LPB cannot be used to reconstruct past lake levels.

In an attempt to rectify this error we conducted full coverage survey in the more stable sections of the LPB that are found in the SW portion of the region. Full coverage survey, coupled with sophisticated remote sensing on and around the former island of Apúpato, which is free of tectonic and other earth system disturbance, has yielded a detailed chronology of coupled lake level change and settlement spanning the Postclassic Period (Figure 4).
Figure 4: Late Postclassic settlement on the island of Apúpato, Michoacán, Mexico.

We used highly accurate submeter GPS and satellite data to pinpoint lake edge settlements and their elevations. The Apúpato record shows that there is no appreciable change in the lowest elevation of settlements on the island and that they stay at ~2043 m asl. throughout the Postclassic Period. If there is change in lake level it occurs toward the end of the sequence well after state/empire formation. These new data contradict the published literature, including my own, and show that the level of Lake Pátzcuaro remained relatively stable throughout the Postclassic.

This lack of lake level change is puzzling in that there is now significant evidence that the climate of Central Mexico was incredibly variable during the Early through Middle Postclassic.
associated with events related to the Medieval Warm Period (MWP) and the subsequent Little Ice Age (LIA). Indeed Dendrochronological research from Querétaro has led some to suggest a series of Megadrought episodes similar to those suggested for the Maya region (Figure 5 (Stahle et al. 2011)).

Given the prevailing model of landscape and lake level change for Pátzcuaro this should have resulted in a significant regression episode during the Early-Middle Postclassic followed by lake transgression during the Late Postclassic. Thus my earlier research is likely incorrect in that during the Postclassic period lake transgressions and regressions are not recorded in settlement distributions for the region.

Figure 5: Central Mexican tree ring record superimposed over major cultural events in the Lake Pátzcuaro Basin, Michoacán, Mexico. Tree ring data from Stahle et al. 2011
So what accounts for the relative lake level stability during the Postclassic during a time of dramatic rainfall variability? In the early 2000’s I suggested that the Early – Middle Postclassic in the LPB was characterized by massive programs of terrace construction aimed at repairing earlier degradation and to increase the agrarian potential of the region. Recent LORE-LPB research has now confirmed the presence of these terraces for the SW portion of the basin as well constituting a major investment in landscape engineering.

There is widespread evidence that ancient techniques of agro-engineering served to buffer populations from environmental change and the Purépecha were no exception. It is clear that massive landscape investment during this period created a built environment that buffered the impacts of climatic variation. Building on my previous research this infrastructure comes in the form of extensive areas of terraced landscapes, likely metapantli for maguey, raised and irrigated fields, and water management systems at the city of Angamuco which I will not discuss in this paper.

Like the valley of Oaxaca, the creation of these terraced landscapes forms a Purépecha ‘piedmont strategy’ (apologies to Stephen Kowalewski) that was less susceptible to climatic flux while at the same time repairing earlier land degradation. Purépecha land managers responded to Postclassic climatic fluctuation by creating a landscape that buffered them from change.

One example comes from the thesis work of Florencia Pezzutti on the Island of Apúpato. In this original fieldwork she was able to demonstrate the entire island was covered with systematically placed tracts of narrow agricultural terraces, check dams, and other agro-landscape features (Figure 6, Figure 7). These features are consistent with maguey (metapantli)
terraces from elsewhere in Central Mexico. Throughout the rest of the survey area roughly 28% of the land area contains such terraces mirroring the Apúpato example.

Figure 6: Ancient terraces and late Postclassic settlement on the former island of Apúpato. Taken after Pezzutti 2010)

Figure 7: Prehispanic terraced landscape from Apúpato
Further confirming evidence comes from terraced landscapes that are visible from the hinterland around Angamuco. Visualizations from LiDAR clearly show over 60 small settlements within tracts of narrow prehispanic terraces distributed in gently sloping areas around the Angamuco malpais. Most of these are under 2 ha and contain a cluster of foundations around a single central building (Figure 8, Figure 9).

Figure 8: Visualization from LiDAR data showing Angamuco and its hinterland.

In 2009 the LORE-LPB project intensively surveyed two such settlements that we interpreted as small farming hamlets. Each had a similar layout consisting of several wide habitation terraces with domestic ceramics organized around a large public building. In general character they are similar to public buildings that have been excavated from Angamuco and sites
within the adjacent Zacapu basin. Ceramics indicated initial occupations during the Middle Postclassic with a continued occupation during the Late Postclassic.

CONCLUSION

It is clear that the climate changed dramatically during the Postclassic in the Pátzcuaro region - or at least there was significant fluctuation in rainfall. And, following the modern environment there should be concomitant flux in the level of Prehispanic Lake Pátzcuaro. Here I have presented data that suggests that ancient landscape engineering effectively mitigated climatic variability to such a degree that it altered the capacity of the LPB environment to hold, release, and buffer rainfall. The breakdown of this social and environmental capital as a result of
demographic collapse and landscape abandonment during the early Conquest period may be the reason that there is such a close modern correlation between rainfall and lake level.

Can we invoke this case study as an ancient example of ‘climate proofing’? Yes in the sense that the resilience of this Purépecha landesque capital allowed for a stable and productive environment for centuries. But at the same time it also created a rigidity trap in that this brittle system needed constant inputs of high labor for stability. Once these labor inputs were removed at Conquest the system dissolved precipitating an environmental disaster.

Importantly we cannot demonstrate intentionality. As I have argued previously I believe that the impetus for creating the terraced landscapes was to solve for earlier land degradation. Ironically ‘climate proofing’ during the Postclassic may have been an unintended consequence.

Like the valley of Oaxaca and other areas of Latin America, the creation of these terraced landscapes formed a Purépecha ‘piedmont strategy’ that buffered populations from MWP-LIA climatic fluctuation that is visible in climatic records for the Central Mexican region. This means that Purépecha land managers responded to Postclassic climatic fluctuation and earlier landscape disturbance by creating an anthropogenic environment that buffered them from external change. Importantly, since Prehispanic land managers disconnected the landscape from much external agency, commonly used climatic indicators for the region, such as lake cores, will not reflect broader climatic trends.

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