



Drought, epidemic disease, and the fall of classic period cultures in Mesoamerica (AD 750–950). Hemorrhagic fevers as a cause of massive population loss

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Summary The classical period in Mexico (AD 250–750) was an era of splendor. The city of Teotihuacan was one of the largest and most sophisticated human conglomerates of the pre-industrial world. The Mayan civilization in southeastern Mexico and the Yucatan peninsula reached an impressive degree of development at the same time. This time of prosperity came to an end during the Terminal Classic Period (AD 750–950) a time of massive population loss throughout Mesoamerica. A second episode of massive depopulation in the same area was experienced during the sixteenth century when, in less than one century, between 80% and 90% of the entire indigenous population was lost. The 16th century depopulation of Mexico constitutes one of the worst demographic catastrophes in human history. Although newly imported European and African diseases caused high mortality among the native population, the major 16th century population losses were caused by a series of epidemics of a hemorrhagic fever called Cocoliztli, a highly lethal disease unknown to both Aztec and European physicians during the colonial era. The cocoliztli epidemics occurred during the 16th century megadrought, when severe drought extended at times from central Mexico to the boreal forest of Canada, and from the Pacific to the Atlantic coast. The collapse of the cultures of the Classic Period seems also to have occurred during a time of severe drought. Tree ring and lake sediment records indicate that some of the most severe and prolonged droughts to impact North America–Mesoamerica in the past 1000–4000 years occurred between AD 650 and 1000, particularly during the 8th and 9th centuries, a period of time that coincides with the Terminal Classic Period. Based on the similarities of the climatic (severe drought) and demographic (massive

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population loss) events in Mesoamerica during the sixteenth century, we propose that drought-associated epidemics of hemorrhagic fever may have contributed to the massive population loss during the Terminal Classic Period.

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Introduction

Mesoamerica, the region extending from central Mexico to Central America, is considered one of the cradles of human civilization. Beginning approximately five thousand years ago, cultural evolution led to an era of splendor known as the Classic Period (AD 250–750). During this time Mesoamerica was home to some of the most advanced civilizations of the pre-industrial world, among them the Teotihuacan, Maya, Zapotec, Mixtec, and other cultures [1,2]. This prosperity came to a sudden end during the Terminal Classic Period (AD 750–950), with massive population loss throughout Mesoamerica. This is indicated by the permanent abandonment of large urban centers and villages, the end of commercial exchange, the cessation of large construction projects, and a marked decline in the manufacture of luxury items such as fine pottery. The end of the Classic Period was heralded by the fall of the city of Teotihuacan around AD 650–750. In the Mayan area, the first signs of disintegration began about AD 770. Between AD 770 and 890 the cities of Bonampak, Palenque, Uxmal, Yaxchilan, Copan, Caracol, Tikal and many others were deserted. By AD 950 the entire Mayan region was uninhabited [3–5]. During the same period, the Zapotec, Mixtec and Cholula cultures also collapsed [6]. Current explanations for Classic Period decline include limited agricultural potential of the region, soil erosion, drought, famine, hurricanes, earthquakes, social upheaval, warfare, and political failure to sustain the complex urban infrastructure and far-flung trade networks. However, none of these arguments are supported by unequivocal evidence and the precise cause of the collapse remains unknown [3–5].

Sixteenth century population collapse in Mexico

Mesoamerica experienced another episode of massive depopulation in the sixteenth century. Estimates of the number of inhabitants in 1519, the year of the arrival of the Spaniards, vary from 10 million up to 30 million. Without entering the debate about the size of the Mesoamerican popula-

tion of 1519, what is indisputable is that by 1600 only two million individuals remained in the area. Thus, based on the high estimate of 30 million the total mortality was 93%, while for the low estimate of 10 million total mortality amounted to 80%. In any case, the decimation of the native population in Mexico between 1519 and 1600 constitutes one of the worst demographic catastrophes in human history [7]. It is true, of course that newly imported diseases such as smallpox, measles and mumps caused high mortality among the immunologically unprotected native population, leading to approximately seven million deaths [7]. The major population losses, however, were caused by a series of epidemics of a hemorrhagic fever called Cocoliztli, a disease unknown to both Aztec and European physicians. The first cocoliztli epidemic started in 1545, and caused eleven million deaths, or 84.6% of the pre-epidemic population, leaving a population of only four million inhabitants [8,9]. A second epidemic of cocoliztli began in 1576, resulting in the death of another two million people [10].

Although the etiological agent of cocoliztli remains unidentified, we know that the disease was swift and deadly. It started with high fever, severe headache, insatiable thirst, weak pulse, and jaundice. Next, patients became demented and restless. Hard painful nodules appeared behind one or both ears, sometimes so large that they occupied the entire neck and half of the face. This was accompanied by intense chest and abdominal pain and dysentery. Blood flowed from the ears, anus, vagina, mouth and nose. Relapses were common and the few survivors were left emaciated and extremely weak. Autopsies of those who succumbed to the disease showed the liver to be enlarged and hard. Splenomegaly and lung hemorrhage were also found. Hemorrhagic fevers reappeared briefly during the 17th, 18th and 19th centuries, although by this time the disease was called Matlazahuatl. Those epidemics also caused high mortality [9].

Did eight century drought contribute to classic decline?

The 16th century cocoliztli epidemics occurred during a severe and sustained megadrought, when

drought extended at times from central Mexico to the boreal forest of Canada, and from the Pacific to the Atlantic coast [11]. Subsequent outbreaks of hemorrhagic fevers in the 17th, 18th and 19th centuries were also associated with drought [11]. Here, we propose the hypothesis that the massive population loss of the Terminal Classic Period in

Mesoamerica (AD 750–950) may have been due in part to epidemics of hemorrhagic fevers during the megadroughts of the eighth, ninth and tenth centuries. Our hypothesis is based on the similarities of the climatological (drought) and demographic (large population loss) events of the sixteenth century in the same area.

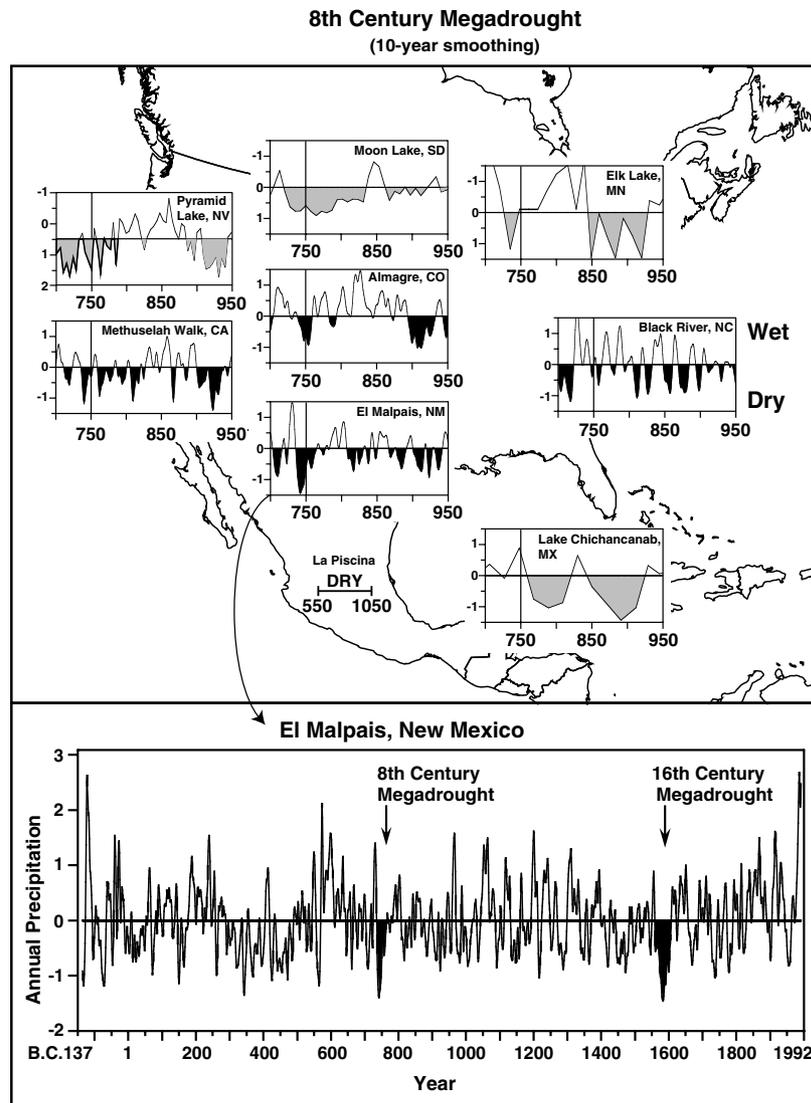


Figure 1 Selected climate proxies from North America provide preliminary documentation of widespread and prolonged drought during the Terminal Classic Period (10 year smoothing has been applied to all normalized proxy time series). Tree ring and lake sediment data indicate that the 8th and 9th century megadrought extended from the northern Great Plains, across the southwestern United States, and into central Mexico and the Yucatan peninsula (top). The annual precipitation reconstruction for El Malpais, New Mexico (bottom), based on tree rings indicates that the 8th century megadrought was one of the worst multi-decadal droughts in the past 2000 years. Tree-ring data from Colorado and New Mexico document severe drought from AD 735 to 765, and may provide accurate and precise dating for the onset of the epic droughts of the late first millennium AD. Sedimentary records from Elk Lake, Minnesota; Moon Lake, South Dakota; Pyramid Lake, Nevada; La Piscina de Yuriria, Guanajuato; and Lake Chichancanab, Yucatan, suggest much greater persistence to the 8th century megadrought than indicated by the tree-ring data, and show a strong second pulse of prolonged drought late in the first millennium (ca. 900). Recent analyses of sediments from the Cariaco Basin in the southern Caribbean Sea indicate that severe decadal drought during the 8th and 9th centuries extended to the coast of Venezuela [17].

Precipitation reconstructions from El Malpais, New Mexico and Durango, Mexico, together with a recently developed tree-ring chronology from Puebla in central Mexico, indicate that the drought from 1540 to 1625 was the worst event to impact North America and Mesoamerica in the past 1000 years [12]. In fact, the 16th century megadrought appears to have begun in central Mexico and spread north and eastward into the United States and southern Canada. A closer analysis reveals that both the 1545 and 1576 cocoliztli epidemics occurred during brief wet episodes within the era of prolonged drought. This pattern resembles the sequence of dry-then-wet extremes that prevailed during the initial outbreak of Hantavirus pulmonary syndrome in 1993 and 1994 in the Four Corners Area [13]. The Hantavirus reservoir *Peromyscus maniculatus* proliferates in response to rain after a prolonged drought. This experience provides a model for cocoliztli, in which an animal reservoir may amplify the etiological agent of cocoliztli in response to rain after being subject to the constraints of a long drought.

Proxy evidence for terminal classic drought

The collapse of Mesoamerican cultures appears to have occurred during a period of severe drought [14–18]. Between the 8th and 10th centuries a severe and prolonged drought impacted a huge region over North America and Mesoamerica extending from the Mayan area, across Mexico to the southwestern United States and into the northern Great Plains (Fig. 1). This is indicated by long tree ring and sediment records extending across much of western North America, Mexico, and the Caribbean Sea. Together, these data indicate generally dry conditions between AD 650 and 1000, particularly during the 8th and 9th centuries, which coincides with the Terminal Classic Period (AD 750–950). These appear to have been some of the most severe and prolonged droughts to impact North America–Mesoamerica in the past 1000–4000 years.

The best documentation of severe sustained drought during the mid-8th century may be seen in the El Malpais tree-ring record from New Mexico (Fig. 1). Analyses of instrumental precipitation and drought indices during the 20th century, along with tree-ring reconstructions of climate in Mexico and the Southwestern United States, indicate that annual and decadal droughts can both simultaneously impact the entire region from New Mexico and

Texas down into central Mexico. The 1950s drought, for example, persisted for a decade and extended from the Colorado Plateau in the southwestern USA southward into the Mesa Central of Mexico.

The tree-ring data from New Mexico also indicate several short periods of abundant rain within the 8th century megadrought (not shown). As in the 16th century, these short wet periods within the megadrought may have created the favorable conditions for the outbreaks of hemorrhagic fevers. This could be explained by the existence of a drought-rain sensitive reservoir that multiplies the etiological agent.

Severe multi-decadal drought is indicated for the Terminal Classic Period by most of the proxies presented in Fig. 1 (excluding North Carolina), but the only high resolution record available for this time period in Mesoamerica was recovered from Lake Chichancanab in the Yucatan [14,15]. Exactly dated, climate sensitive tree-ring chronologies and other high resolution paleoclimatic proxies will have to be developed in Mexico for this time period before the magnitude and spatial scale of Terminal Classic drought can be determined for Mesoamerica. Nonetheless, the available data from the Yucatan and southwestern USA imply widespread drought over Mexico in the 8th and 9th centuries.

Conclusions

The events during the Terminal Classic Period were very likely complex, dynamic, and distributed over a long time. The effects of hemorrhagic fevers do not exclude other concurrent disasters promoted by drought such as famine or war. A definitive test of the drought and disease hypothesis would be the identification of the same etiological agent in human remains from Terminal Classic Period and the sixteenth century. Perhaps in the future, and with the help of new molecular technologies this may be achieved [19].

The massive population losses of the Terminal Classic Period and 16th century caused catastrophic and irreversible damage to Mesoamerican society. At the end of the Classic Period, entire civilizations headed by large urban conglomerates disappeared. In the case of the epidemics of cocoliztli of the 16th century, Mesoamerica went from being an overwhelmingly Indian population before the epidemics, to a predominantly mestizo society, creating the culture and demographics of modern Mexico. Four hundred years passed before the

country recovered the population level of 1544. Indeed, many questions remain to be answered about the role of epidemic disease in Mexican history and prehistory. But perhaps the most important for the present is if whether there may be a highly lethal microorganism still present in a climate-sensitive animal reservoir in Mesoamerica.

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