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Climatic and Cultural Transitions in Lambayeque, Peru, 600 to 1540 AD: Medieval Warm Period to the Spanish Conquest

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Abstract: The Lambayeque Valley on the north coast of Peru offers a cautionary case study on the relation between climatic and cultural change. Three archaeological site complexes dating from late in the first millennium AD to the middle of the second millennium AD rose and were abandoned in sequence. Each abandonment was associated with a conflagration on the main pyramidal mound(s). In this region, El Niño is the most significant climatic disruption now and for millennia past. By tracking proxy records for El Niño intensity, we found that only the first episode of abandonment and burning was associated with a strong peak in El Niño intensity, while the final episode was the outcome of the Spanish Conquest of the Andes, a distinctly non-climatic driver. These records suggest that equifinality is operative and urge caution in over-interpreting climate as culture-changing catastrophe.

Keywords: El Niño; climatic change; cultural change; Peru; Lambayeque; archaeology

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1. Introduction

The Lambayeque Valley complex in northern Peru (6.5–7° S) is the largest contiguous area of irrigable land along Peru's desert coast. For the agrarian societies of the last four millennia, this valley has been an important and coveted hub of production. Three sequential centers dominated the cultural landscape of Lambayeque during the final pre-European periods: Pampa Grande (ca. 600–750 AD) [1], the Sicán Precinct at Batán Grande (ca. 750–1100 AD) [2], and Túcume (ca. 1100–1532 AD) [3]. Each of these sites was built around one or more large adobe and fill mounds; at the close of occupation, mound construction ceased, the mounds were burned, and the sites were wholly or partially abandoned. Proxy records of El Niño measured in a marine sediment core from the Peruvian coast, an ice core from Quelccaya in southern Peru, and a lake sediment record from Pallcacocha in highland Ecuador demonstrate a strong temporal correlation between the onset of the Medieval Warm Period at ~750 AD, high El Niño intensity, and the first pre-European abandonment [4–7]. However, the second abandonment is only associated with a small peak in El Niño intensity. The first two events were followed by diminished El Niño intensity and the establishment of new mound centers. In the context of both economics and Andean belief systems, climate likely played a role in the first of these events and perhaps in the second. The final abandonment (Túcume) is a consequence of the Spanish Conquest and is not obviously correlated with climatic change. These data demonstrate equifinality and support caution in the over-interpretation of climatic change as a driver of cultural change.

Our review of the Lambayeque data supports calls for caution in over-interpreting climatic change as a dominant driver of cultural change; each case study must be examined in detail to determine the role of climatic change and resilience (for the Peruvian coast [8–11] inter alia). In prior research, we and others have ascribed a dominant causal role to

El Niño in large scale cultural change. However, in 2001 [12], although we postulated a causal connection between a sudden increase in El Niño frequency at about 3000 cal BP and cultural change, we also noted that "[t]echnology, history, cultural practices, religion, perception, and individual and group idiosyncrasies can all affect the way a society and its members respond to change." The same year, Van Buren [8] perspicaciously called attention to the over-emphasis of El Niño as a causal factor in coastal collapse scenarios and pointed out that disasters are defined by humans who have many potential means to mitigate them. Following this lead, Caramanica et al. ([9]. See also [10]) documented El Niño-resilient agricultural infrastructure in the Chicama Valley of the north Peruvian coast dating to the 1500 years prior to the Spanish Conquest. We [11] reviewed a wide range of resilient responses to El Niño on the Peruvian coast. Recently, a symposium at the Annual Meeting of the Society for American Archaeology [13] was dedicated to El Niño and resilience in this region.

Proxy records of climatic change from Peru and Ecuador show a very strong and abrupt signal in northern and western South America at the onset of the Medieval Warm Period around 750 AD [4–7] that correlates with variation in El Niño intensity. El Niño has been shown to affect cultural and economic systems not only in the present but also in the historic [14,15] and pre-European past (e.g., [11,16]). Here, we examined the correlations between regional climatic change over the final millennium (600–1540 AD) of pre-European societies in the Lambayeque Valley in northern Peru, the largest contiguous area of irrigable land on the Peruvian coast, specifically the major cultural transitions at about 750 AD, 1100 AD, and 1532 AD (the Spanish Conquest). Prior research on the link between climatic and cultural change in this area has focused on an earlier transition at 600 AD [17], while Shimada [1,2] has noted the 750 AD and 1100 AD climatic events as then known from the Quelccaya record.

2. Materials and Methods

2.1. Lambayeque Culture History

For millennia, the Lambayeque Valley in northern Peru has benefitted from its rich and extensive irrigated fields [18,19]. During much of the first millennium AD, the north coast of Peru was dominated by the Moche society that originated in the Moche Valley at 8.1° S (Figure 1), [20]. From early to middle Moche (ca. 0 to 600 AD), the principal center of this society was the Moche Valley site of Huacas de Moche. During the 6th century AD, enhanced El Niño activity may have contributed to an important transition to Late Moche at about 600 AD [17,21]. During the final phase, Moche V, the largest center was Pampa Grande (~600–750 AD) in the Lambayeque Complex, at the neck of the Chancay River, one of three streams whose deltas coalesce to form the coastal Lambayeque Valley [1] (Figure 2). Pampa Grande covers 600 ha and is dominated by a single large mound, the Huaca Fortaleza. Based on two calibrated radiocarbon dates reported by Shimada to date to the end of the occupation, this site was abandoned shortly after 750 AD (Figure 3, middle, blue line; Table 1), at which time the Huaca Fortaleza was burned [1]. The site was not reoccupied. Shimada ([2]: pp. 365–366) notes evidence for flooding at the end of Moche V in the Lambayeque Valley.

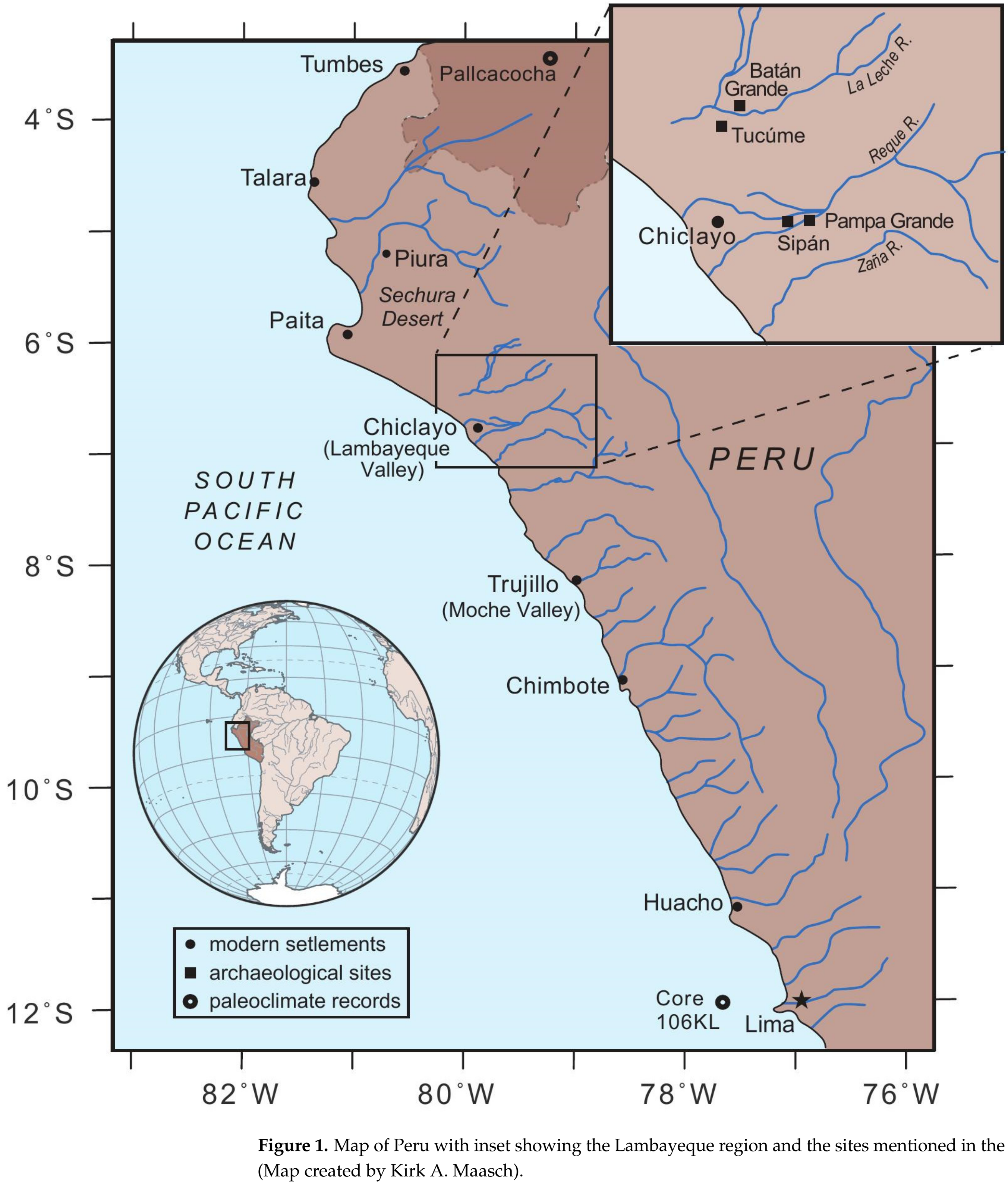

Figure 1. Map of Peru with inset showing the Lambayeque region and the sites mentioned in the text. (Map created by Kirk A. Maasch).

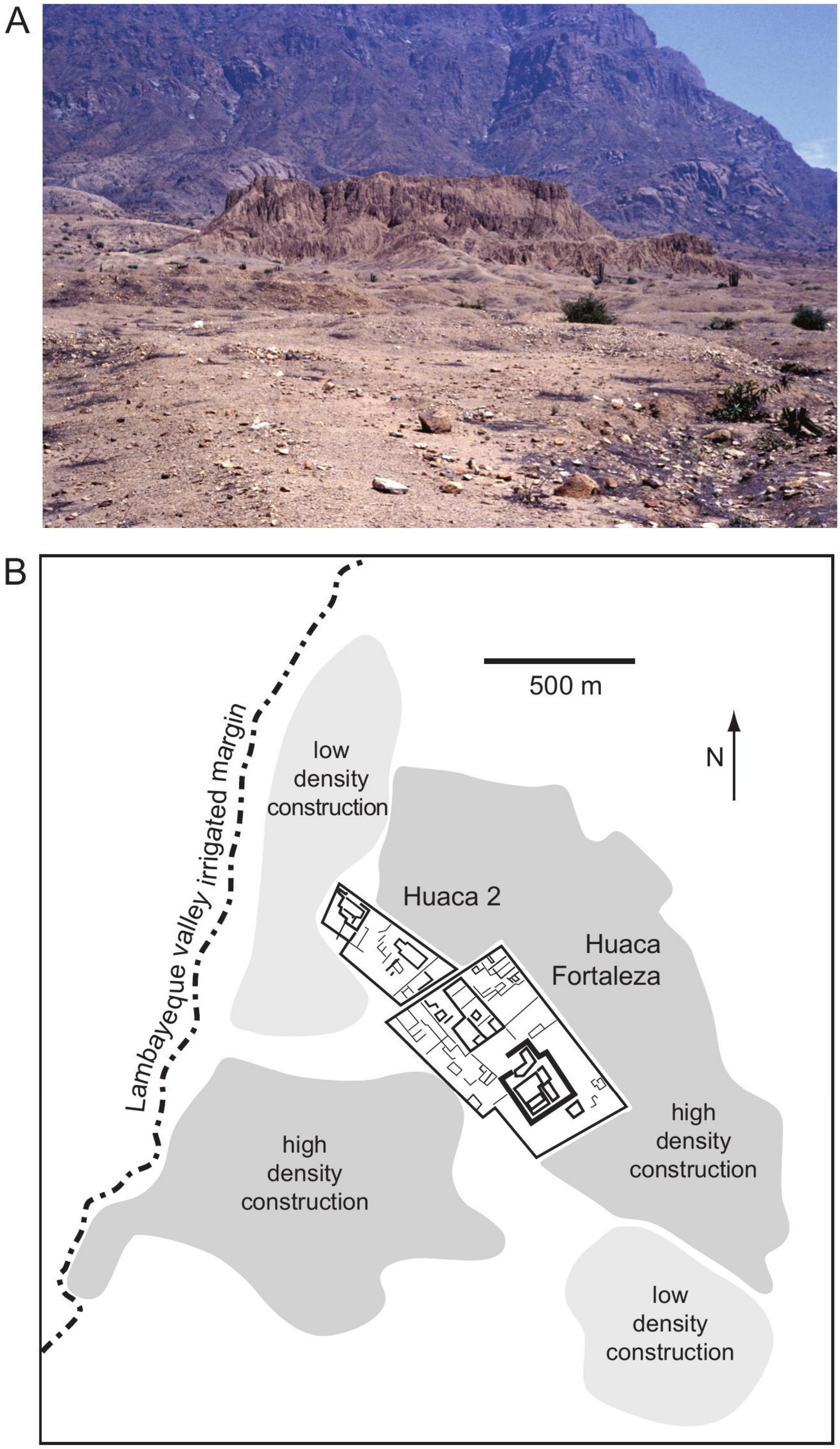

Figure 2. Pampa Grande site. (**A**) Photo of the Huaca Fortaleza, the largest mound at the site. (Photo by Daniel H. Sandweiss) (**B**) Schematic map of the Pampa Grande site. (Map adapted by Kirk A. Maasch from [24]: Figure 1).

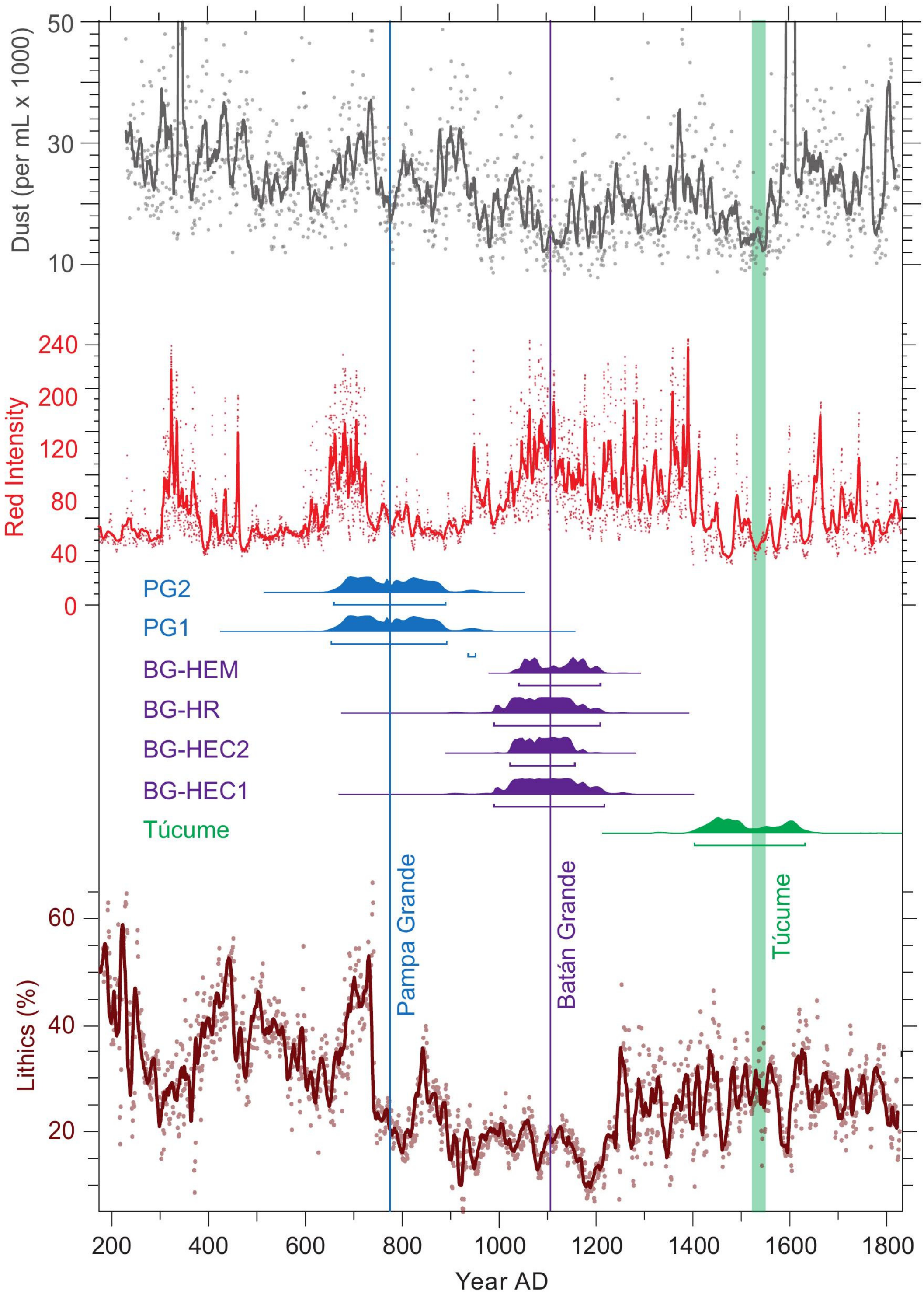

Figure 3. Dates of abandonment at Pampa Grande (blue) (from [1]), Batan Grande (purple) (from [2]), and Túcume (green) (from [3]). Brackets indicate confidence limits (95.4%) on dates. Dates for Pampa Grande and Batan Grande are on contexts closely associated with the burning and abandonment. The vertical blue and purple lines represent the average median date for these sites' abandonments. The date for Túcume is for the 60-year Inca period immediately preceding abandonment; the green bar represents the known historic age of abandonment as a result of the Spanish Conquest (1532-1547 AD). The dates were calibrated using OxCal 4.4 [22] with the SHCal20 curve [23]. El Niño proxy records based on: Quelccaya dust record [6] (gray), red intensity of lake sediments from Pallcacocha [7,25] (red), and lithic concentrations in marine core 106KL [4,5] (brown).

Table 1. Details of the radiocarbon dates related to the burning and abandonment of the sites of Pampa Grande, the Sicán Precinct at Batán Grande, and Túcume. The date for Túcume is for a context sometime in the Inca occupation, which lasted for approximately 60 years prior to the abandonment of the site; the date of abandonment of Túcume is known with precision from the historical record. The radiocarbon dates were calibrated using OxCal 4.4 [22] and the SHCal curve [23].

Site	Code on Figure 3	^{14}C Date	Error	95.4% cal AD Confidence Interval	Median cal AD Date	Lab #	Material	Context	Cultural Affiliation/Original Author Comments	Source
Pampa Grande	PG1	1300	60	656–953 cal AD	777	SMU-399	Charred cotton textile	Deer house floor	Moche V (Late Moche); end of occupation	[1]: Table 2, pp. 4–5; 2: appendix, pp. 372–377
Pampa Grande	PG2	1300	55	660–892 cal AD	775	SMU-644	Cotton textile	Floor of burnt platform mound	Moche V (Late Moche); end of occupation	[1]: Table 2, pp. 4–5; 2: appendix, pp. 372–377
Batán Grande-Huaca El Corte	BG-HEC1	985	65	992–1220 cal AD	1103	Beta-1802	Charcoal	Burnt roof	Middle Sicán	[2]: appendix, pp. 372–377
Batán Grande-Huaca El Corte	BG-HEC2	990	30	1025–1159 cal AD	1097	SMU-1622	Charcoal	Burnt roof	Middle Sicán	[2]: appendix, pp. 372–377
Batán Grande-Huaca Rodillona	BG-HR	1000	60	992–1211 cal AD	1095	Beta-13933	Charcoal	Partially burnt post on top of pyramid	Middle Sicán	[2]: appendix, pp. 372–377
Batán Grande-Huaca El Moscon	BG-HEM	950	30	1043–1212 cal AD	1128	SMU-1623	Charcoal	Burnt column on top of pyramid	Middle Sicán	[2]: appendix, pp. 372–377
Túcume	Huaca Larga	455	70	1406–1635 cal AD	1496	BGS-1604	Charcoal	Huaca Larga	Inca, near end of occupation	[3]: Table 1, p. 77

At about the same time that Pampa Grande was abandoned, construction began on mounds in the Sicán Precinct at Batán Grande [2], (Figure 4). Although Batán Grande had been occupied previously, this time marks the beginning of a new, post-Moche, regional culture, variously called Sicán or Lambayeque. The transition to Sicán marks a major cultural change in the long-term history of the Lambayeque Valley, with material culture patterns that are partly derived from but notably different from the Moche materials of the preceding ~750 years [2]. Early Sicán society (~750–900 AD) is less well-known, but Middle Sicán (~900–1100 AD) society has been studied intensively by Shimada and a multidisciplinary team since the late 1970s [1,2]. Middle Sicán has long been recognized as the source of many of the Peruvian gold artifacts in museums around the world. At its height during Middle Sicán, Batán Grande comprised eight large mounds. Based on dates from burning on several of the mounds, these structures were burned and abandoned around 1100 AD (Figure 3, middle, purple line; Table 1); although people continued to occupy the area, they no longer built monumental constructions there. As Shimada ([2]: 346) writes, "An extensive, intense conflagration took place within the Sicán Precinct near the time of its abandonment". Shimada ([2]: 365–366) offers evidence for flooding associated with the burning and abandonment of the Sicán Precinct at the end of Middle Sicán and notes the coincidence of flooding and burning at the abandonment both Pampa Grande and the Sicán Precinct at Batan Grande. However, at the time Shimada was writing. we did not know about the burning and abandonment of Túcume at the time of the Spanish Conquest (Figure 5).

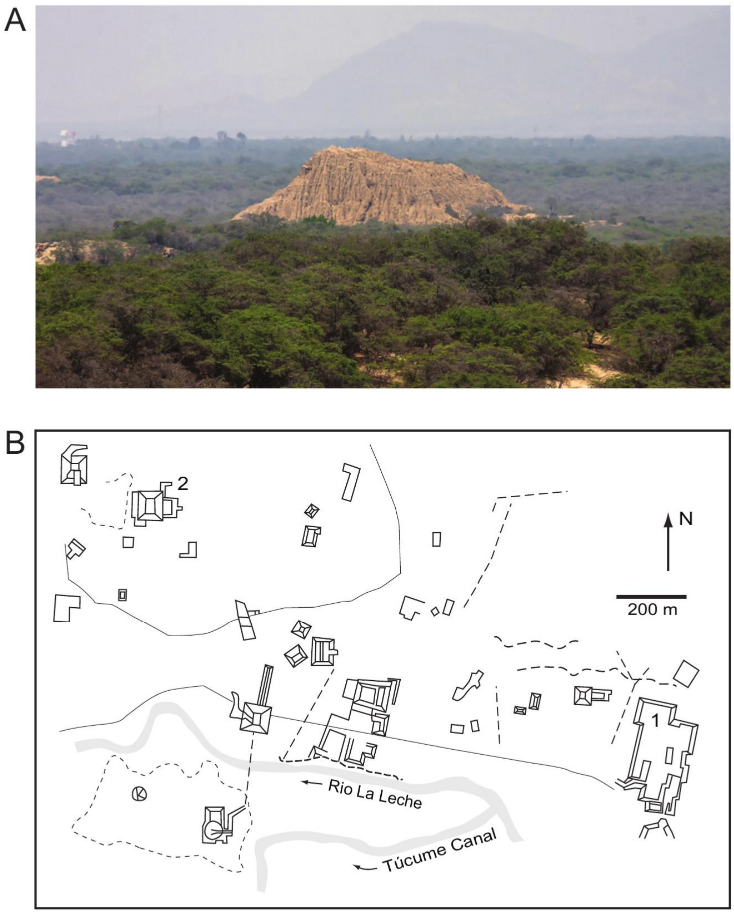

Figure 4. Batan Grande, Sicán Precinct. (**A**) Photo of the Huaca El Loro mound at Batan Grande. (Photo credit: https://commons.wikimedia.org/wiki/File:Huaca_El_Loro_(El_oro)_-_Vista_desde_el_Cerro_Las_Salinas.jpg (accessed on 22 May 2022). (**B**) Schematic map of the Sicán Precinct at the Batan Grande site. 1 = Huaca El Corte; 2 = Huaca Rodillona; Huaca El Moscon (also known as Huaca Colorada) is off the map to the south. (Map adapted by Kirk A. Maasch from [2]: Figure 5).

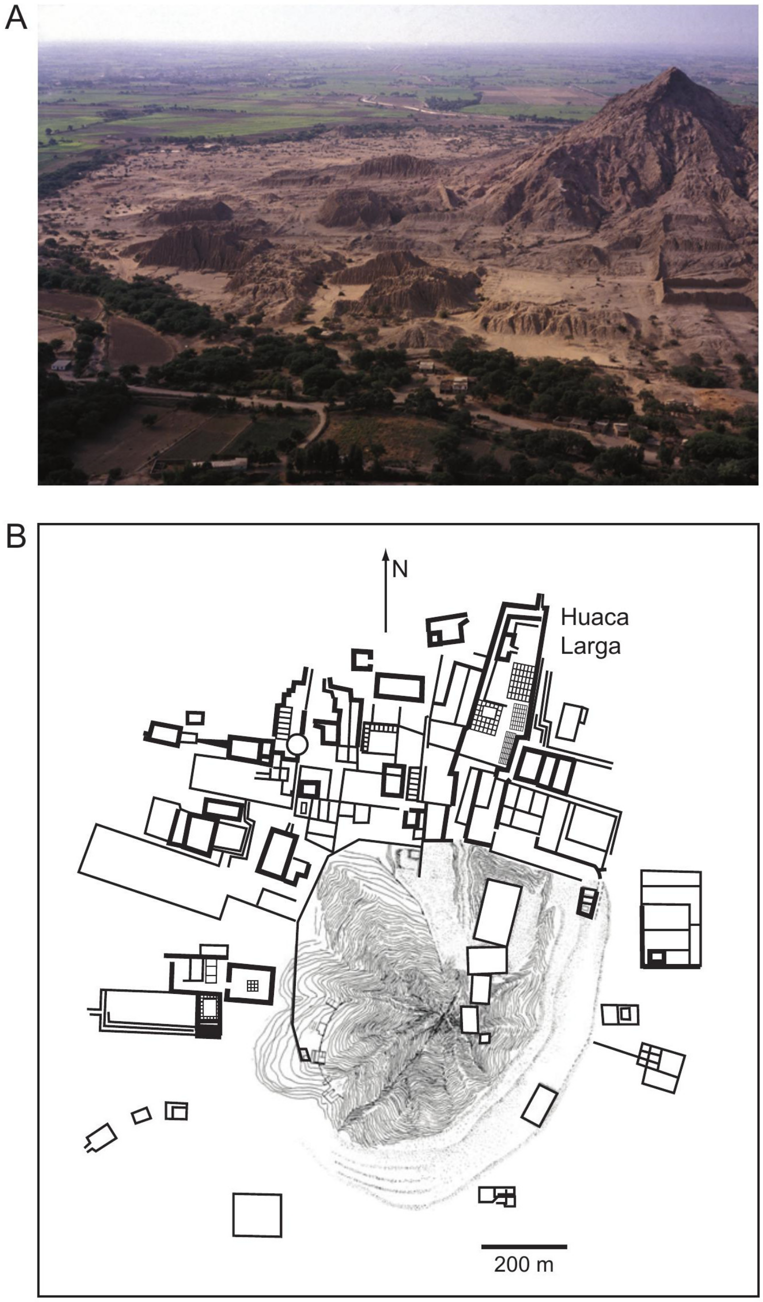

Figure 5. Túcume site. (**A**) Photo of the monumental sector at Túcume. (Photo by Daniel H. Sandweiss) (**B**) Schematic map of the Túcume site. (Map adapted by Kirk A. Maasch from [3]: Figure 33, based on [26]: 23).

Around 1100 AD, just as mound building and use ceased at Batán Grande, construction started at Túcume, some 10 km to the south [3], (Figure 5). Túcume was the largest of the multiple monumental centers in the Lambayeque Complex during the early second millennium AD and included thirteen major mounds and several dozen smaller structures covering over 200 ha. Originally founded by local people in the Late Sicán Period (~1100–1350 AD), the site was subsequently conquered by the Chimú Empire from the Moche Valley around 1350 AD, and then by the highland Inca Empire from Cuzco around 1470 AD. Both foreign powers made Túcume their regional administrative center. However, throughout this late pre-European period, Túcume and Lambayeque in general were largely inhabited by indigenous Sicán people, as evidenced by a strong, conservative tradition of utilitarian pottery forms at Túcume and other sites in the Lambayeque Complex [3,27]. In

1532 AD, the Spaniards conquered the Inca Empire. Within a few years and as a result of the disruptions caused by the Spanish Conquest, Túcume had been abandoned (Figure 3, middle, green bar; Table 1) and the Huaca Larga (the largest structure at the site, used by the Chimú as a temple and by the Chimú and Inca as the seat of their administration) had been filled in and burned (Figure 6). The response to the Spanish Conquest (abandonment and burning) is the same as the response to earlier crises in the Lambayeque Valley, including the disruption correlated with El Niño behavior at about 750 AD. The excellent preservation of textiles and other organic remains just below (prior to) and within the fill, and the presence of Early Colonial glass earrings in the fill, just prior to the burning, indicate that the abandonment and burning took place shortly after the Conquest ([3]: 96-101). Spanish soldier Pedro Cieza de León, considered one of the most reliable of the early chroniclers of Peru, passed by Túcume in 1547 AD and described the structures at the site as "ruined and demolished" ([28]: 200, Chapter 67). Thus, we have a narrow historical window for the abandonment of Túcume between 1532 AD and 1547 AD.

Figure 6. Evidence of post-Conquest burning in the Inka Stone Structure on the Huaca Larga at Túcume. The room had been filled prior to burning, with two pairs of Early Colonial glass bead earrings ([3]:97 and Figure 60). (Photo by Daniel H. Sandweiss).

2.2. El Niño in Northern Peru

There are multiple flavors of El Niño that influence the Peruvian coast [29]. The best known and most destructive is the canonical or Eastern Pacific (EP) El Niño, which warms coastal sea surface temperatures (SSTs), causes torrential rains from convective storms in this normally arid desert, brings diseases, and depresses near-shore biomass. The recently recognized Coastal El Niño (COA) is largely limited to northern Peru but has effects there that are similar if shorter lived compared to EP El Niño. Many studies have found evidence of individual pre-European EP/COA events and changes in EP/COA frequency (see Section 2.3 below). La Niña is the opposite of EP/COA in that it cools coastal SSTs and is associated with increased respiratory diseases [30]. There is no known pre-European proxy for La Niña events. Central Pacific (CP) El Niño (also called El Niño Modoki) does not significantly affect coastal SSTs; however, it does cause drought in the adjacent Andean highlands, which in turn attenuates flow to the coast from the rivers that originate in the Andes. For the irrigation-based societies of the last four millennia on the Peruvian desert coast, this must have caused significant hardship. There is no known proxy record for CP events older than about 400 years.

2.3. Climate Records

Wet and dry periods along the north coast of Peru are generally associated with EP/COA El Niño (henceforth El Niño) and have been identified using climate proxy records from the region [16,29]. Climate proxies extracted from the Quelccaya ice cap (13.9° S, 70.8° W) have been used as drought indicators [31,32]. The dating of the Quelccaya ice record is based on annual layer counting. Shimada et al. [17] noted that the onset of Moche V at around 600 AD coincided with a wet period that immediately followed a three-decade long drought; Etayo-Cadavid et al. [21]) identified alterations in El Niño activity in the preceding century. Rein et al. [5] analyzed a 20,000 year-long, high-resolution marine sediment record from the El Niño region of Peru (core 106KL from 80 km off Lima/Peru; 12.0° S, 77.7° W, 184 m). Estimates from 106KL for past sea surface temperatures, photosynthesis pigments, and lithic content serve as proxies for past El Niño variability and intensity. In particular, the lithic concentrations track changes in coastal zone precipitation and runoff, which are largely a function of El Niño presence and intensity. Rein et al.'s ([4]: 1–2) "chronology of the last 2500 years is based on 8 AMS ^{14}C dates and lead and caesium isotope profiles of the topmost sediments" and subject to additional uncertainties related to the estimate used for the marine reservoir.

Periods of extreme drought in coastal Peru occurred during the Medieval Warm Period (MWP, ca. 750–1250 AD) [4]. The continentally derived lithic concentrations at 106KL (Figure 3, bottom) were very low in the MWP, indicating the absence of strong flooding for about 500 years during this time. This marine record is consistent with a lack of terrestrial evidence for El Niño mega-floods [33,34], which do appear in records before and after the MWP. It is possible that this was a time when CP El Niño dominated ENSO dynamics. The timing of the abandonment of Pampa Grande (Figures 2 and 3) is coincident with the onset of this dry period. Batán Grande was abandoned near the beginning of a several decade minimum in the lithic concentrations at 106KL near the end of the MWP. In contrast, the abandonment and burning of Túcume does not coincide with any known drought conditions, but rather with the Spanish Conquest.

The Pallcacocha lake record (2.8° S, 79.2° W) [7,25] from the southern Ecuadorian Andes (Figure 3, top) is largely parallel with the Rein record [4, 5] for the last two millennia. The Pallcacocha age model is based on calibrated AMS dates, including four for the last 2400 years ([7]: 165) reported in Rodbell et al. ([35]: 517). In particular, an abrupt transition at 750 AD is one of the most prominent features of the Pallcacocha record over this period (Figure 3, blue line). Another abrupt transition occurs around 1100 AD (Figure 3, purple line). No significant transition is notable in early the 1500s (Figure 3, green bar).

3. Results

Core 106KL, Quelccaya, and Pallcacocha bracket the Lambayeque Valley geographically. All three records are temporally coincident at the critical periods of cultural transition and reflect similar climatic shifts. All three also show that the high intensity events that correlate with the abandonment of Pampa Grande and to a lesser extent Batan Grande were followed by relative climatic quiescence during the establishment of succeeding centers in Lambayeque (Batan Grande and Túcume).

On a larger regional scale, Haug et al. [36] suggested that shifts in the position of the ITCZ may be linked to changes in Pacific basin climatic variability. Their Cariaco Basin Ti record shows a rapid change to drier conditions near 750 AD that may be teleconnected to the abrupt change seen in Pallcacocha, Quelccaya, and core 106KL (Figure 3). Future research should investigate these correlations in greater detail.

Northern Peru remains susceptible to economic and cultural change from El Niño events, as evidenced in 1982–83, 1997–98, and 2017 (e.g., [37–39]). Not only does El Niño depress fisheries, destroy agricultural infrastructure, and threaten human health [40], but it also affects archaeological resources [41]. Once populations grew and came to rely on intensive fishing and agriculture during pre-European times, the negative effects of El Niño must have had serious consequences for ancient Peruvians. The first large magnitude

El Niño following the Spanish Conquest in 1532 AD occurred in 1578 AD and is instructive about the devastation such events wreak on traditional infrastructure [14], even accounting for intensive demographic and settlement pattern changes brought on by the Conquest [42] (Figure 7). An official Spanish inspection in 1580 AD includes extensive testimony from the Lambayeque Valley (Alcocer in [13,15]). Floods washed away agricultural fields and canals, destroyed public and private buildings, and killed farm animals such as chickens. Stagnant water led to epidemic disease. People were forced to seek refuge on high ground or to migrate to other parts of Peru; we tentatively identified a few instances in which this relocation strategy may have been employed in ancient Peru [11]. Plagues of insects and rodents seriously hampered efforts to restart agricultural production. One witness, a Spanish priest, told the inspector that "after the canals were fixed, the Indians hurried to plant and there came the plagues . . . such that any seed that grew a hand's width above the ground was eaten by crickets and locusts and some green worms and yellow ones and other black ones that were bred from the putrefaction of the earth because of the said rains . . . [After several plantings], when the fruit was ready to harvest there was such a multitude of mice that this witness didn't believe the Indians and went to some fields and saw mounds of mice like piles of sand . . . the mice were the size of medium rabbits . . . this witness counted a mound of them and there were 500 more or less . . . " [authors' translation] (Alcocer in [14]: 82).

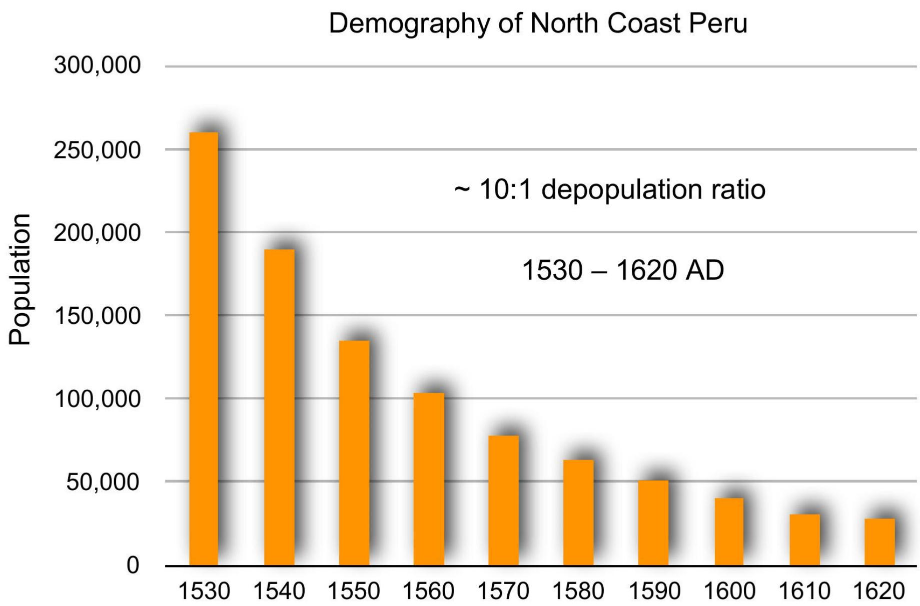

Figure 7. Depopulation on the north coast of Peru from the Spanish Conquest, 1532 AD to 1620 AD. (Figure prepared by Kirk A. Maasch from data in [42]).

Recent studies (particularly [9]) have demonstrated that indigenous inhabitants of the north coast of Peru developed resilient farming technologies to replace some of the production lost during major El Niño events; however, the above description and recent history show that such events are still significant stressors for coastal populations.

4. Discussion and Conclusions

For Andean peoples, the natural and supernatural were conflated—the physical world was seen as a manifestation of the spiritual realm. Bawden [43] wrote of the Moche who built Pampa Grande that mounds "possessed deep symbolic meaning . . . [and] articulated deep Andean structural belief pertaining to myth, cosmological balance, spirituality, and time". In northern Peru, the physical and spiritual impact of strong El Niño events apparently led to recurrent "crises of faith" [44].

Many scholars have noted an origin story first recorded by Cabello Valboa [45] in the late 16th century AD, in which dynastic founders came by sea and took over the Lambayeque Valley. The last ruler in this dynastic line sinned, rains and floods came, and the people seized the ruler and threw him in the ocean. There is much debate about whether there is a historical basis to this account, and if so, when Naymlap, the dynastic founder, arrived and when the dynasty ended (see, for instance, [2,27]). Regardless of the timing, if there is truth to the story, it may be an account of dynastic change precipitated by El Niño and a crisis of faith in leadership, as Donnan [27] suggested.

In Lambayeque, one expression of such crises of faith seems to have been the burning and abandonment of the mounds that had failed to maintain cosmological balance. Donnan ([27]: 269–271) suggests that the end of the Naymlap dynasty is associated with El Niño flooding around 1100 AD, while Shimada ([2]: 363–366) points to flooding around the end of both Moche V and Middle Sicán but is less certain if and where to place the Naymlap story. Our data from various paleoclimatic archives suggest that climatic factors contributed to the first and perhaps the second crisis; however, human factors precipitated the final and most disruptive calamity. We used the colonial period abandonment of Túcume, attributed to the Spanish Conquest, as a test to demonstrate that the archaeological signatures of crisis and abandonment are essentially identical.

Collation, correlation, and causation are difficult to disentangle in the archaeological record, particularly given the uncertainties of dating both archaeological and climatic phenomena [46]. We first look for major cultural shifts and then examine the paleoclimate record to see if large magnitude events or frequency shifts have a close temporal correlation with the cultural changes. In such cases, it is then incumbent on us and other archaeologists to seek data to test the hypothesis of causation. From another perspective, if cultural changes can happen in the absence of significant climatic change, then it is also possible that climatic change may occur in the absence of significant cultural change; however, that is a matter for a different paper.

We previously identified correlations between changes in El Niño frequency and cultural change during the early phases of civilization in Peru: at the origin of monument building around 5800 cal BP, at the end of the Late Preceramic Period ca. 3800–3600 cal BP, and at the end of the Initial Period temple tradition at 2850 cal BP [12,16,47,48]. The data presented here suggest a temporal correlation between cultural and climatic change at times during the later pre-European history of northern Peru and clearly show that other drivers can lead to similar cultural consequences: in the case of Túcume, there is no large magnitude event or frequency shift at the time of burning and abandonment and we know both the precise date (1532–1547 AD) and cause from the historic record. Nevertheless, the inhabitants of Túcume responded in the same way as their ancestors did when faced with earlier crises, including the changes in El Niño at about 750 AD. Archaeologists concerned with the relation between climatic and cultural change must evaluate each case with open minds and always consider equifinality. We applaud and support the growing recognition of human agency and resilience in the face of potentially devastating events; however, we also argue against throwing out all the Niños along with the bathwater.

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