Land, Labor, and Water of the Ancient Agricultural Pampa de Mocan, North Coast, Peru

A dissertation presented

by

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to

The Department of Anthropology

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Anthropology

Harvard University

Cambridge, Massachusetts

April 2018
Abstract

The Pampa de Mocan, located on the margins of the Chicama Valley on the north coast of Peru, is a superarid desert that was developed for agriculture between 900 BC-AD 1470. Current scholarship on the relationship between agriculture and complexity in arid regions operates under two assumptions: first, that desert environments impose limitations on smallholders; and second, that intensive, irrigation agriculture forces farmers to become sedentary. Excavation, survey and archaeobotanical data from the Pampa de Mocan challenge these assumptions by demonstrating a history of 1) ecological dynamism in the desert and 2) the practice of peripatetic irrigation agriculture. Ancient farmers of the Pampa de Mocan rotated around the Valley, basin, and even the greater region. This system of intensive agriculture without permanent settlement functioned as a risk-management strategy in an environment that frequently weathered unpredictable and destructive events related to El Niño Southern Oscillation (ENSO). This dissertation concludes that the farmers of Mocan organized their strategies around maximizing water, rather than the expansion of production over land. However, beginning soon after Spanish Conquest, the Chicama Valley underwent a forced resettlement program; the concentration of populations in newly-established urban centers instigated a socioeconomic shift toward private land rights and the maximization of available land. Since that time, the area has suffered widespread water shortages. In reaction to the scarcity of water today, the Peruvian State has enacted a regional irrigation program to expand agricultural production into desert areas, including the Pampa de Mocan. The abandonment of prehispanic concepts of water management in favor of a land-tenure economy re-arranged the relationship between land, labor, and water and catalyzed a self-reinforcing feedback loop of resource concentration, followed by redistribution that continues to shape the Chicama Valley and Peruvian state politics today.
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ACKNOWLEDGEMENTS

This work represents the confluence of many individual efforts, for which I am unendingly grateful. It turns out, a dissertation ‘takes a village’, and I feel very fortunate to have had mine.

My committee members deserve many thanks for countless hours of guidance, strategizing, and even visits to the field site (no easy feat!). Jason Ur and Rowan Flad provided non-Andean perspectives that challenged me to search for a broader significance for this research. Gary Urton has been a generous and careful listener, sounding board, and supporter over many years. Gary has always insisted that I hold my finished products to a high standard, and for that I am very grateful, and I hope I caught all the typos!

I met Luis Jaime Castillo Butters in 2009 as a field school student, and since then he has never failed to be an enthusiastic and warm teacher and mentor. Luis Jaime, along with the late Santiago Uceda, is at the center of a far-reaching legacy of PhDs and archaeologists working in Peru. One way or another, Luis Jaime has supported, advised, lent a truck, put in a good word, or provided a home to hundreds of students, and I am proud to be counted among them.

Very special thanks are owed to my advisor Jeffrey ‘Dr Q’ Quilter. Dr. Q is by far the best teacher I have ever known. He managed to show me how to think creatively, while keeping me focused on practical applications and methodologies. Most importantly, Jeff has taught me how to take joy in the evolution of one’s ideas—he is one of the rare professors who delights in seeing his contributions to the field challenged, and even changed, and he is often an active participant in the process. I may never endeavor to deserve the mentorship, guidance, and friendship he has given me over the past eleven years, so I’ll just say the next Cusqueña is on me.

Other faculty members at Harvard served as off-duty advisors, and I am very thankful for the counsel and encouragement they have offered, especially that of Richard Meadow, Ofer Bar-Yosef, and Bill Fash. Dan Sandweiss has also gone far above the call of duty to become a trusted advisor and friend. I wish to extend my sincere gratitude to my Dumbarton Oaks colleagues and friends. Joanne Pillsbury, Emily Jacobs, and Bridget Gazzo have long felt like family, and in the past two years Colin McEwan has
also become family. Daniel Boomhower and Bettina Smith have shown such understanding, patience, and support throughout the dissertation process, and I will never forget their kindness.

As a wide-eyed undergraduate, my first exploration of Peru was guided by the indomitable Michele Koons. Michele introduced me to several of the questions that I have approached in this dissertation; many of which are still burning. She also taught me how to be brave—and she is certainly one of the coolest archaeologists out there.

After almost 10 years of living and working in Peru, I continue to be surprised by the magnanimity and kindness I find in my colleagues. Santiago Uceda embodied this spirit: he was joyful and full of curiosity, open and generous, and, despite his incomparable achievements, never, ever arrogant. I miss him very much. Carlos Wester has been a constant supporter, and I thank him for introducing me to two of my favorite archaeologists: Luis Alberto Sánchez Saavedra and Jorge Wester. I am still not sure what Jorge did to his brother Carlos (lose a bet, maybe?) that led to his recommendation for a job with me in the middle of the desert, but I am grateful. I must also sincerely thank Ana Carito Tavera Medina, Raul ‘Papucho’ Berrocal, Segundo ‘Nayo’ Solano Chavez, and Neri Escobedo Alzugaray for withstanding the same hostile conditions. However, by the end of the field seasons, le han agarrado cariño a esa Pampa—or so they told me. Margarita and Elio Barriga and their daughters and grandchildren made Magdalena de Cao a second home for me, for which I am very thankful. I also wish to thank the Fundación Wiese, the entire El Brujo Archaeological Project, especially Regulo Franco, the Comisería in Magdalena de Cao, and Doris Bocanegra.

Luis Huaman Mesia and his team of brilliant students, Fiorella Villanueva, Claudia R. Morales, and Geraldine Borja, at the Universidad Cayetano Heredia have been patient and giving teachers since my first, chance visit to the Laboratory of Paleobotany and Palynology in 2014. I am so thankful for their instruction, collaboration, and friendships.

Solsire Cusicanqui Marsano became my family almost immediately after we met, and ever since, I have been leaning on her for professional and personal support as if she were my older sister (definitely older). I am eternally grateful to have you hermana.
So many friends have made these last seven (seven?!) years intellectually stimulating and lots of fun. Stephanie and Brian Tuttle have been constant pillars of strength and sources of comfort—even seeing me through my Generals Exam. Konstantina Karterouli and Maryum Jordan made life these last two years in Washington, D.C. an absolute joy. My thanks to Jess MacLellan (Dobereiner was right about us!), Luis Muro, and Ximena Chávez Balderas for your wonderful friendships.

At Harvard, I was very fortunate to be stuck in the ‘cattle-pen’ with some of the greatest people the world, and certainly Harvard, has ever produced. Yitzchak Jaffe, Max Price, and Jeff Dobereiner provided endless laughter, debate, giant cookies, and support. Special thanks are directed at Noa Corcoran-Tadd—my cohort-partner and dear friend. I am also very grateful to Bridget Alex, for the manicures, coffees, and always-sound advice.

I must express my sincere gratitude to my family. Much of the emotional labor of my dissertation program fell to them; they weathered it with equanimity and always offered love, comfort, and support. A lifetime of thanks are owed to my incredible mother. Who knows what she must have thought when I declared I was planning to spend the better half of a decade studying archaeology. Whatever it was, she did what I thought to be impossible: she hid it well. I also want to thank my Aunt and second-mom, Victoria, for picking up all the slack, all the time.

Finally, to my partner, Rodrigo, and his son, Matias, thank you for your patience and love. This dissertation, like all my accomplishments, would not be possible, or worthwhile without you. This brief tribute is pitifully lacking, but suffice it to say, I am very thankful to have you in my life.

The field work and analysis for this dissertation were generously funded by the National Science Foundation's Arctic Social Sciences Program (Award # 1152156); The National Science Foundation Graduate Research Fellowship; The David Rockefeller Center for Latin American Studies at Harvard University; and the Lefèbvre Fund of the Anthropology Department, Harvard University.
INTRODUCTION

The transition from hunter-gatherer subsistence to agriculture has long-been viewed as the most significant economic transformation in human history before the industrial revolution (Childe 1935, 1936). At the beginning of this transition, agriculture led to fundamental shifts in the organization of societies, forcing many formerly mobile groups to become sedentary (Kelly 1992, Winterhalder and Kennett 2006). Agriculture was ultimately linked to the emergence of ‘civilization’ (Childe 1950). In many cases, deserts formed the setting for the invention of farming. In extremely arid regions, complex irrigation systems were required to bring land under cultivation, and as system management became a specialized task, social hierarchies emerged, and the elite concentrated in urban centers, creating a socio-political core and, consequently, a periphery (Wallerstein 1974; Wittfogel 1957). The research that will be presented in this dissertation takes place in a presumed-peripheral area, however, it challenges the notion that complex irrigation results in sedentism or required the intervention of the state.

According to these models, early complex agriculture set society along a path that ultimately resulted in the agro-industrial world we know today. Recently, however, scholars have questioned the long-term viability of these farming practices, which have been linked to public health epidemics, global warming, and diminished water supplies (Manning 2004; Scott 2017). The maximization of productivity, the expansion of farmland, and the development of technologies capable of moving water vast distances for irrigation are pushing the environment to its limits. Today’s scholars and policy-makers argue that we have reached an impasse—the inevitable result of the march of technological progress—begging the question once posed by Jared Diamond (1987): is farming the biggest mistake society ever made?

Archaeology is uniquely suited to pursue these questions. It affords a diachronic analysis of the long-term effects of a given strategy, technology or subsistence choice. Moreover, the Peruvian desert provides a near-pristine record of agricultural landscape history. In now-uninhabited areas along the north coast, ancient features remain unmodified by modern cultivation and the extreme aridity allows for the preservation of irrigation canals, fields, and even field-furrows.
The north coast of Peru is one of the driest deserts on earth (Figure 1). The gently sloping alluvial plain that characterizes the region today formed throughout the Holocene as sea level rose and caused alluvial backfilling. The north coast consists of 13 deeply entrenched river valleys: rivers originate along the continental divide (3500-4000masl) and form deep V-shaped cuts that descend to the Pacific Ocean. These rivers provide the only perennial sources of water in the region. The eastern Pacific is typically characterized by high-pressure conditions, high sea levels, steady S-SE trade winds (~4m/s), and a shallow thermocline (the boundary between warm SSTs and colder, deeper water)—conditions which together strengthen the SE Pacific anticyclone along the Peruvian coast (Maasch 2008:43). Additionally, the cold, near-coast Humboldt Current and high sea levels limit evaporation and result in a high inversion layer (typically around 300masl). The combination of this anticyclone, the inversion layer and the rain shadow effect caused by the neighboring Andes mountains, all work to severely limit precipitation on the Peruvian north coast. In normal years, mean annual precipitation along the coast ranges from just 5mm to 40mm (Wells and Noller 1999:761). The Chicama Valley is one of the largest of the north coast Valleys, measuring approximately 1041km² below 400masl; and it has a total river drainage of 5822km² (ONERN 1973). Despite the extreme aridity, the Chicama has been the center of the Peruvian agricultural heartland for centuries, owed in large part to its dependence on the prehispanic system of irrigation canals.
The archaeology of irrigated landscapes on the north coast, and of the Chicama Valley in particular, has a far-reaching legacy. The monumentality of ancient irrigation features in the Chicama, in combination with numerous adobe pyramids, and the discovery of rich, elite tombs, inspired the development of pivotal theories regarding the emergence of ‘Irrigation Civilizations’ (Steward 1955). These same features, captured in aerial photographs beginning in the 1930s, led to the use of new research tools and innovative approaches to the study of the ancient landscape. Beginning in the 1940s with the Virú Valley Project, Gordon Willey (1953) and colleagues, aided in part by Rafael Larco Hoyle, a landowner and industrial farmer from the Chicama Valley, designed the first archaeological settlement survey to capture the extent and cultural implications of the anthropogenic coastal landscape. Paul Kosok (1965), drew upon his visit to the north coast and the analysis of black and white oblique and vertical aerial photographs to model the success of ancient agriculture against the productivity of 1960s sugar
farming in the same area. A 1970s project, known as the Programa Riego Antiguo (PRA), led by Michael E. Moseley, focused on prehispanic irrigation technology in the Moche and Chicama Valleys. The results of the PRA were referenced by the Peruvian state in their evaluation of the viability of today’s large-scale development project known today as the Proyecto Especial Chavimochic—a state sponsored initiative aimed at expanding agro-industry in the region.

The Chicama Valley, in particular, captures the image of modern agro-industry: tall, green fields of sugarcane are interrupted only by the smoke stacks of processing plants and the gray strip of asphalt of the Panamerican highway. Even the ancient huacas or adobe pyramids, a few of which continue to tower over the fields, are falling victim to an un-halting assault from tractors and backhoes (see Vining 2017). The Valley stands in stark contrast to surrounding deserts such as the Pampa de Mocan, which are characterized by dune fields and wind-eroded gravel surfaces, making the inner Valley seem all the more artificial. Over 90% of the valley floor is dedicated to cane production under the aegis of a single conglomerate: Grupo Gloria. The concentration of corporate wealth and the volume of production derived from the Chicama Valley have situated the area as one central to the economy of the Department of La Libertad, and consequently, the Peruvian State, with sugar exports totaling approximately 85,000 MT in 2016 (GAIN 2016). The degree of agricultural production in this Valley, an otherwise inhospitable setting for sugarcane farming, reflects the mastery of agro-industrial technologies over the environment. However, despite the apparent dominance of industry over nature, water shortages have plagued this area for decades. Even today, the most important issue in local elections in the Chicama Valley is the availability of water (especially related to poverty indices, such as drinking water). The Chicama River often does not reach the Pacific before being tapped dry by cane irrigation. This tension between local water needs and industrial water needs has spurred some of the most important and pervasive political movements in Peruvian history (Chapter 6). In reaction to water shortages, the Peruvian State is pushing forward with the multibillion-dollar inter-valley Proyecto Especial Chavimochic (Figure 2). The project draws water from the Santa River approximately 160km to the south, and carries it across the Chao, Virú, Moche and Chicama Valleys in an effort to expand arable land into the deserts bordering each valley. The
The Chavimochic Project is the crowning achievement of modern agro-industrial technology in Peru; yet, it has not been immune to the climatic forces that have punctuated this landscape for millennia. In 2017, the Project was halted due to extensive damage incurred during the ‘El Niño Costero’—a climatic phenomenon that results in widespread flooding on the coast (see Chapter 2). Moreover, the area
projected for new development overlaps with areas that were agriculturally productive in the prehispanic past: for example, in the Pampa de Mocan. How and when these areas were successfully cultivated, how they withstood climatic disaster, and why they eventually failed in prehispanic periods, are critical questions in the context of present-day development projects.

This dissertation reconstructs the history of human-environment dynamics and complex agriculture on the north coast of Peru through an intensive study of the desert area known as the Pampa de Mocan, located just outside the irrigated floodplain of the Chicama Valley. As a result, I have concluded that the formula for agrarian change that has long-been viewed as self-evident, namely, that agricultural systems apply labor and water to land, was fundamentally different during prehispanic times. This difference has far-reaching implications for our models of ancient agricultural societies, and the viability of modern-day irrigation practices. The shift in the arrangement of these variables was itself a historic event, occurring at a specific time (post-Conquest Peru) and place (the Chicama Valley), and it is this shift that has led to protracted environmental deterioration all along the Peruvian coast (Chapter 6).

This dissertation takes the following form: in Chapter 1, the history of modeling agrarian change in Peru and around the world are reviewed. Two assumptions have structured the understanding of this history, and the remaining chapters probe their validity. Chapter 2 is a detailed analysis of the ecology and potential for environmental dynamism of the Peruvian desert. The chapter concludes that those phenomena traditionally viewed as disruptions to the system, are crucial to the health and viability of desert soils. The remaining chapters focus on the archaeological history of landuse of the Pampa de Mocan.

The Pampa de Mocan presents archaeological evidence of ancient farming practices, preserved thanks to the presumed agricultural inutility of this desert landscape. Over the course of four field seasons, I conducted a complete pedestrian survey and collection of this area, carried out 18 excavations in field systems and architectural units, and analyzed a total of 26 sediment samples for the purpose of environmental reconstruction. A final complementary project was directed at research in local colonial
archives. Together, these data approach a detailed history of the land-use of the Chicama Valley as it pertains to irrigation, stretching from 900 BC to the present-day. My work in the Pampa de Mocan was aimed at addressing the following questions:

1) How did prehispanic agricultural systems withstand the challenging environmental setting of the north coast?

   a. How did they reach a level of expansion greater than that of modern-day agro-industrialists (Moseley et al. 1983 estimated that irrigated land of the Chimu exceeded modern development by 35-40%)?

   b. How did prehispanic farmers assess and adapt to risk posed by major El Niño flood events?

2) Why did the system fail?

   a. When and why were landscapes like the Pampa de Mocan abandoned?

   b. Why has modern industrial agriculture failed to achieve the same level of arable expansion?

Chapters 3 and 4 present the results of my research in the Pampa de Mocan, highlighting the history of land (agricultural fields), labor (settlement), and water (irrigation features). Chapter 5 reconstructs the environmental setting of these histories through the analysis paleobotanical records. In pursuit of these questions, my work in the Pampa de Mocan proposes a reassessment of two basic assumptions concerning agrarian change: 1) that arid environments impose limitations on agricultural strategies; and 2) that intensive, highly complex irrigation agriculture requires sedentism. Instead, the results from the Pampa de Mocan suggest that the north coast of Peru, although a desert setting, is environmentally diverse. Due in large part to the far-reaching impacts of El Niño Southern Oscillation (ENSO), this area evinces a history of environmental dynamism and features rich, well-drained soils. The nature of ancient agricultural features and settlement on this landscape point to peripatetic opportunistic farming based on the maximization of water, rather than land. Finally, in the Chapter 6, the abandonment processes of the Pampa de Mocan are linked to the present-day form and failures of the Chicama Valley.
The relationship between people and their landscape, especially as it is mitigated through the management of water and plants, can set society on an inescapable historical path. In the case of the Chicama Valley, the prehispanic understanding of this relationship was re-structured by a new social and economic system imposed after Conquest. This new arrangement trapped the Chicama Valley, like much of the rest of the world, in a positive feedback loop that will eventually collide with the limitations of the environment, namely, the availability of water.
CHAPTER 1: LAND, LABOR, AND WATER.

This chapter sets out the theoretical challenges for archaeology in arid regions, and, in particular, for north coast Peru. Here, I will review the standing models that, despite heavy and sustained critique directed at their neo-evolutionary frameworks, continue to pervade the archaeology of the north coast. I argue that the resilience of these models is related to a deep history of environmental determinism in Andean studies. Beyond the Andean region, similar or the same deterministic bias reinforces a seemingly inescapable premise: that agricultural productivity is measured against land. Meanwhile, as outlined in the following section, the culture history of the north coast of Peru, is one marked throughout by mobility and the exploitation of multiple resources—a history that does not easily conform to a neo-evolutionary trajectory of change.

Models of agrarian change.

“Social theory (e.g. Trigger 1998) maintains that present-day notions of property, equality and inequality, human relationships to nature, etc., are shaped, at least in part, by the social organization, technology, or food surpluses entailed in our dependence on agriculture” (Winterhalder and Kennett 2006:2).

The transition from hunting and gathering subsistence strategies to complex agriculture is viewed as the most important socio-economic shift in human history prior to the industrial revolution. This shift is no longer viewed as bimodal, but rather as a punctuated process involving the co-evolution of humans and domesticates, and the protracted and sometimes unexpected effects of resource management (See Zeder 2015). Still, hunting and gathering and agriculture are seen as occupying opposite poles of the same continuum, in part due to differential energy budgets for each set of practices. Behavioral ecology predicts that humans adjust their food production activities according to return rates, which can be influenced by the environmental, social, and demographic conditions of a given group (For a review: Winterhalder and Kennett 2006). While the dynamics of energy input and output are conditional, agriculture, especially complex irrigation agriculture, is linked to sedentism, and therefore permanent architecture, storage facilities, and labor and craft specialization—elements considered predictive of multi-tier hierarchical organization (Kelly 1992). Agriculture in the Andean region likely has its origins in
the tropical forest around 4000 BP (for review see: Piperno and Pearsall 1998); and while many of the early debates surrounding catalysts for the emergence of agriculture are echoed in discussions of later agricultural intensification, these will not be reviewed in depth here. Instead, the focus of this dissertation is on those periods after agriculture was well-established on the north coast. This dissertation argues that standing models, which depend on an environmentally-deterministic ethos, pervade archaeological studies on agriculture in arid regions. Specifically, fieldwork from the Pampa de Mocan was directed at testing the basic assumptions that underlie these models, especially regarding prehispanic water management. The validity of these assumptions has far-reaching effects for the study of agriculture and emergence of complex society in arid regions. In the following section, I will review the standing models for agricultural intensification and their application in the Andean region, beginning with a review of the archaeology and culture-history of the north coast and the Chicama Valley (Table 1).

The Chicama Valley boasts a rich history of archaeology; however, the current record does not achieve full chronological and spatial coverage. A long legacy of agro-industrial activities has obscured small and early sites, while making more substantial, later sites, difficult to access. Still, several pivotal discoveries have occurred in this Valley, some of which have added to the narrative of human history on the continent.

Table 1. Periods and cultures in the Chicama Valley.

<table>
<thead>
<tr>
<th>Period</th>
<th>Period Date Range (Rowe 1962; Quilter 1991)</th>
<th>Observed Culture in the Chicama Valley</th>
<th>Culture Date Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late Horizon</td>
<td>AD 1476-1534</td>
<td>Chimu-Inca</td>
<td>AD 1470-1532</td>
</tr>
<tr>
<td>Late Intermediate Period</td>
<td>AD 1000-1476</td>
<td>Chimu</td>
<td>AD 900-1470</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lambayeque</td>
<td>AD 900-1350</td>
</tr>
<tr>
<td>Middle Horizon</td>
<td>AD 600-1000</td>
<td>Moche and Chimu</td>
<td></td>
</tr>
<tr>
<td>Early Intermediate Period</td>
<td>200 BC-AD 600</td>
<td>Moche Gallinazo/Virú</td>
<td>AD 200-900</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 BC-AD 700</td>
</tr>
</tbody>
</table>
Early Horizon  
900-200 BC  
Initial Period  
1800 BC-900 BC  
Huaca Prieta  
4100-3500 calBP  

Cupisnique  
900-500 BC  

Preclassic Period  
3800-1500 BC (Terminal)  
Huaca Prieta  
4100-3500 calBP  

4500-3800 BC (Late)  
Huaca Prieta  
5300-4100 calBP  

8000-4500 BC (Middle)  
Huaca Prieta  
7500-5300 calBP  

~14,000-8000 BC (Early)  
Huaca Prieta  
14,500-7500 calBP  

Paiján  

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Human occupation of the South American continent likely began around 14,000 BP, with sites such as Monte Verde (Dillehay et al. 2008) and Fell’s Cave (Bird 1988) in the far south of Chile dating to 12,800 and 10,000 BP respectively, and the site of Huaca Prieta, located in the Chicama Valley dating as early as 14,500-13,300 BP¹ (Dillehay and Bonavia 2017). During this time, the Late-Pleistocene to Early Holocene transition was in full swing, resulting in scattered patches of environmental change: the overall warming trend was both protracted and uneven. On the coast, this meant the eventual extinction of megafauna and ultimately warmer, wetter conditions than those experienced today. While the north coast is presently characterized by desert conditions, some scholars propose that the area may have featured large mesic forests, frequent seasonal streams and springs, and perhaps extensive lomas (cloud-drip plant communities) (Dillehay et al. 2003:5; Rundel and Dillon1998; Rundel et al. 1991; Sandweiss 2003). The material record for this period generally supports these hypotheses.

Indeed, the earliest evidence of occupation on the north coast of Peru comes from the Huaca Prieta site. Huaca Prieta is a large mounded site, located on the edge of a Pleistocene-age terrace where the Pacific coast and the Chicama River delta meet. The 32m-high huaca is the result of thousands of years of intentional mound-building activities and accumulated midden and debris, giving the site its

¹ In a 2012 publication, this date range was derived from three radiocarbon samples all recovered from wood remains; the dates are attributed to pre-mound-building activities (Dillehay 2012: Table 1). In the project’s most recent publication, four samples within this date range were offered, a bean seed, wood charcoal, deer bone, and charred wood (see Dillehay and Bonavia 2017: Table 6.2)
signature dark-earth (*prieta*) color (Dillehay and Bonavia 2017; Dillehay et al. 2012). The site was first investigated by Junius Bird in the 1940s, who’s seminal work defined the Late Preceramic Period for coastal Peru (Quilter 1991). Tom D. Dillehay’s work at Huaca Prieta has since focused on the Early and Middle Preceramic occupations (see Table 1). The earliest phases of the site produced edge-trimmed pebble flakes, and shellfish and marine fauna remains. The first phase of mound-related activity (7500-6500 calBP) is related to hunting, gathering, and likely evidence of gardening activities (Dillehay and Bonavia 2017:88; Dillehay et al. 2012:62). Meanwhile, further inland in the Chicama Valley and the Moche Valley (Ossa 1976; Ossa and Moseley1972) contemporaneous groups were producing a distinctive stemmed lithic assemblage that included tools for plant-processing (Dillehay et al. 2003:6). The stone tool industry is known as the “Paiján Complex”, so-named because of the concentration of sites first identified in the Pampa de Paiján, just west of Cerro Tres Puntas outside of the Chicama Valley (Briceño Rosario 1999; Chauchat 1975, 1978; Chauchat et al. 2004; Chauchat et al. 1998; Pelegrin and Chauchat 1993). Paiján sites have also been found in the Quebrada Santa Maria near the modern Chicama town of Ascope. The sites are ephemeral camps and dating has been difficult due to wind-deflation, however, the culture likely endured between 10,000-8400 BP (Dillehay et al. 2003:6). Site strata suggest a high degree of mobility and a dependence on a variety of littoral resources; the PV22-13 site in the Quebrada Santa Maria presented deer, land-snail, and mollusk remains, while lizards were also a probably food source (Briceño Rosario 1999; Chauchat et al. 1998). However, around 7000 BP, when sea-level stabilized and ENSO climate patterns began to shift, the coastal area became much more arid, likely restricting littoral resources to isolated plant communities or along streams and river terraces.

Very few Middle and Late Preceramic Period sites are known on the north coast. The site of Ventarrón in Lambayeque, known for its elaborate polychrome mural painting of deer trapped in a net (~4000BP), is a notable exception (Meneses 2008; Wright et al. 2015). Likewise, the nature of inland occupation in the Chicama Valley after about 8300 BP is not well-known. Occupation along the coast at the site of Huaca Prieta persisted, but rising sea levels likely destroyed other early fishing sites. Junius Bird’s (1985) work at the Huaca Prieta began as part of the seminal 1946 “Virú Valley Project”, led by
Gordon Willey (1953). The Virú Valley Project was the first of its kind, investigating the long-term history of settlement over the entire area of the Virú Valley (rather than focusing on a single site). Bird’s work took place outside of the Virú Valley but was the first ever systematic excavation of a preceramic site in Peru and added to the understanding of this period across the region (Quilter 2014:85). Bird (1985) recovered evidence of gardening, and the management of industrial cultigens such as cotton and gourds. Moreover, he and his assistant Milica Dimitrijevic Skinner demonstrated the early application of iconography in weaving and on gourds, before the production of ceramics (Quilter 2014:86). Recent work by Grobman et al. (2012) on the Preceramic occupations at Huaca Prieta and the neighboring site of Paredones has pushed back the dates for early maize in the region to at least 4800–4500 calBP with a directly AMS-dated charred corn cob (see Grobman 2012: 1759, Table 1); however, the authors acknowledge that the crop was not a major food source before 4500–4200 calBP. Outside of the north coast, the Middle and Late Preceramic periods were phases of precocious economic and ritual activity. For example, in the Chillón and Súpe Valleys of the Central Coast, monumental stone constructions, complex burial practices, exotic goods and social stratification appear without dependence on farming or cultigens (Beresford-Jones et al. 2015; Engel 1966; Haas et al. 2004; Lanning 1963, 1967; Parsons 1970; Patterson and Lanning 1964; Quilter 1985, 1991; Quilter et al. 1991; Quilter and Stocker 1983; Solis 2006; Solis et al. 2001). V. Gordon Childe’s (1950) Neolithic and Urban Revolution theories were put to the test against these impressive, preceramic, and pre-agricultural sites. Michael E. Moseley (1975) offered an alternative model; he proposed that the rich marine resources of coastal Peru provided a caloric substitute for important cereals, and the need for cotton fishing nets motivated innovations in plant management. Later studies showed, however, that subsistence at these sites, while consisting in large part of marine resources, continued to be fundamentally ‘Broad-Spectrum’ (see Flannery 1969; Zeder 2012). Quilter et al. (1991) and Caramanica et al. (2017) found that occupants of the site of El Paraíso, just outside of Callao, Lima, depended heavily on lomas resources throughout all phases of the site.

The Initial Period witnessed the first widespread use of ceramics and the appearance of many new domesticated plants, indicating increased dependence on agriculture (see Towle 1961). In the Chicama
Valley, the Huaca Prieta is the only well-studied representative of this phase. Just south of the Chicama, two sites in the Moche Valley demonstrate continued monumental construction (Caballo Muerto) and intensified plant management alongside fishing activities (Gramalote) during this Period (Nesbitt 2012, 2016; Pozorski, S. 1979; Prieto 2015). Meanwhile, to the north of the Chicama Valley, archaeologist Carlos Elera (1998) recorded Initial Period occupation at the site of Puemape, with ceramic styles and funerary practices that continued into the next cultural phase: the Early Horizon. In fact, many Early Horizon components on the north coast appear in superposed strata of Initial Period sites. This is also true for the Caballo Muerto complex within the monumental sector known as the Huaca de los Reyes, and to some extent at the Huaca Prieta (and the nearby ‘Cupisnique Mound’) (see Dillehay and Bonavia 2017).

The most recognizable Early Horizon archaeological culture of the region is Cupisnique (also Chavinoid or Coastal Chavín), although the period overlaps with the ‘Salinar’ ceramic style. Today, scholars believe that Salinar is a continuation of Cupisnique, and indeed Salinar occupation has been found overtop Cupisnique strata. Well-known Cupisnique sites and styles have been identified in the Jequetepeque (known as Tembladera in the middle Valley) and Lambayeque Valleys (known as the Chongoyape style), but Cupisnique was ‘discovered’ and is widespread in and just outside of the Chicama Valley (see Larco Hoyle 1948; Toshihara 2002).

Cupisnique was first identified and named in 1934 by Rafael Larco Hoyle, a wealthy sugar plantation owner from the Chicama Valley. Larco Hoyle first explored his interest in the prehistory of the Valley through excavations on his properties in the inner Valley. He amassed an impressive collection of Moche-style fineware vessels and created a chronological seriation that is still used today (Hoyle 2001,1948). Larco Holey (1941) had been exploring the desert area of the Quebrada Cupisnique to the north of the Valley when he discovered a unique ceramic style characterized by dark paste, a polished finish, and incised decorative motifs. At the time, a similar discovery had been made in the Nepeña Valley far to the south, and for the investigators of both sites, there was a clear stylistic connection to ceramics from the central highland site of Chavin de Huantar, excavated by Julio C. Tello beginning in the 1940s (Burger 1992; Burger and van der Merwe 2008). Larco Hoyle (1941) was convinced of
Cupisnique chronological primacy, while Tello viewed the highlands as the center of this civilization. The stylistic similarities across vast distances, even beyond the north coast, including Kuntur Wasi in the north highlands, Pacopampa in Chota, Layzon in Cajamarca, Pallka in the mid-Casma Valley, and Huayurco in Jaén, supported the John H. Rowe (1962) interpretation of a Chavín cultural ‘horizon’, hence the period: Early Horizon. Recent isotopic studies by Weber (forthcoming), obsidian and cinnabar source work (Brown 2017; Contreras 2011), ceramic sourcing (Druc 2014), and the circulation of exotic goods during this Period have demonstrated that mobility was an important aspect of Early Horizon society. Chavín de Huantar was a significant node for this network of movement, perhaps the most important pilgrimage destination of the time (and even later periods), but not necessarily the origin of cultural diffusion. Archaeological work at sites such as Puemape (Elera 1998) and the Huaca de los Reyes (Nesbitt 2012), suggest that Cupisnique material pre-date the Janabarriu ceramic phase at Chavín. Moreover, at both sites, Cupisnique emerges as a continuation of the previous Initial Period phase; at Puemape, Elera (1998) notes the continuation of funerary practices, suggesting autochthonous development. While no previous studies have focused on Early Horizon agricultural systems, farming was clearly an important component of the Cupisnique economy. Puemape occupants subsisted on a mix of agricultural and foraged resources: Elera (1998:152-171) recovered gourds, and the extensive use of cotton, maize, avocado (identified through seeds), ají (chili pepper), pacay (Inga feullei), seaweeds, and of course marine resources such as fish and mollusks, birds, and sea lions. The subsistence practices from the Early Preceramic through the Early Horizon involved the exploitation of multiple ecozones. Agriculture, and even maize, was just one of many of many potential food resources (see Burger 1990; Tykot et al. 2006).

The Early Intermediate Period in the Chicama Valley and along the north coast is far better represented in the archaeological record than any of the preceding phases. Two ceramic styles of this period are relevant to the present discussion: Gallinazo wares and Moche-style ceramics. Gallinazo wares were first studied by William Bennett (1950) as part of the Virú Valley Project. Bennett and Larco Hoyle (1945) found that incised and appliques plainwares and negative-painting ceramics typically preceded
Moche ceramics in stratigraphic excavation. However, recent studies by Francois Millaire (2004, 2010) at the Huaca Santa Clara in Virú (10 BC-AD 670), Steve Bourget (2004) at the site of Huancaco, and Claude Chapdelaine (2004) have demonstrated that 1) the incised and appliques plainwares (also called “Castillo-decorated”) were part of a pan-north coast tradition that can be called ‘Gallinazo’, but do not represent a distinct socio-political entity or ethnicity; and 2) that the negative-painting wares were largely restricted to the Virú Valley and should therefore be considered a local variant, which maintains Larco Hoyle’s original name: Virú (Millaire 2009:8). Sites where the Gallinazo ceramic style predominates, such as the Huaca Santa Clara, are made up of multiple adobe platforms, and restricted residential areas with large agricultural storage structures, suggesting a high degree of social stratification in the past (Millaire 2009:9). Gallinazo wares are found throughout the Chicama Valley and tend to be common in the earlier phases of Moche sites. Meanwhile, ‘Moche’ describes a suite of ceramic styles, decoration and iconography; the most distinctive pottery form of the Moche, however, is the stirrup-spout vessel.

Rafael Larco Hoyle’s (1948, 2001) five-phase seriation of Moche stirrup-spout vessels continues to be used in the Chicama, Moche and Virú Valleys, while the northern Valleys of Jequetepeque and Lambayeque show evidence of a distinct stylistic evolution (Castillo Butters and Donnan 1994). The Chicama Valley, and the Pampas de Paiján and Mocan, are positioned between these two spheres, and recent work at the site of Licapa II demonstrates that the northern edge of the Chicama Valley was stylistically caught between the two, making relative dating based on Moche finewares difficult in this area (Koons 2015). As a result, Bridget Alex and Michele Koons (2014:1052) refined the absolute chronology of Moche ceramics to AD 200-900.

The Moche period also witnessed the construction of monumental adobe pyramids, called *huacas*. Huacas often existed in un-equal pairs, likely an allusion to an organizing principle of asymmetric dualism (see Kuzner 2001, Hill 2008). The most iconic huaca complex is the Huacas de Sol y la Luna, located in the Moche Valley. The decades-long archaeological project, led by Santiago Uceda, has produced a corpus of data on Moche rituals, human sacrifice, craft production, and daily life (Castillo Butters and Uceda 2008; Uceda 2010). The Chicama Valley has its own version of the Huaca de la Luna.
in the Huaca Cao Viejo. Located just to the north of the preceramic site Huaca Prieta, the Huaca Cao Viejo, like the Huaca de la Luna, features elaborate painted murals of ritual performance on its façade, restricted interior spaces, and most notably, an elite female burial—the Señora de Cao (Franco Jordan et al. 2003). The Chicama Valley features over 30 huacas (see: PRACH survey Leonard and Russell 1992); however, with the exception of Koons’ (2012, 2015) work, very few of them have been systematically excavated. Burials have been the source of most of the data regarding specific ritual practices, administrative roles, and the nature of Moche leadership. The discovery of the Tumbas Reales of the Lord of Sipán in the Lambayeque Valley and the site of San José de Moro in the Jequetepeque Valley have produced some of the most elaborate elite Moche burials to date. The Sacerdotes of San José de Moro were found among hundreds of lower-status burials. Many of these tombs show evidence of secondary and even tertiary burial practices: some occupants were removed in antiquity, and fardos (burial bundles) were missing bones. This phenomenon, known as ‘wandering bones’, suggests that bodies were being transported post-mortem with some frequency (see Nelson 1998).

The evidence of restricted ritual activity at huacas and data from other important cemeteries demonstrate that the Moche were organized around a strict hierarchical social structure (Castillo Butters and Quilter 2004). Human sacrifices and other burials provide evidence of combat, but there is very little evidence for a conquest state among the Moche. Quilter and Koons (2012) review the arguments for the status of the Moche as a state-level political organization. For the purposes of the present study, the categorization of Moche as set of socially-stratified polities will suffice.

The Moche were master farmers who developed sophisticated irrigation technologies. During this period, maize and maize beer or chicha became central to diet and ritual life. A deeper review of the relevant archaeological studies will be provided in the following sections. Still, despite the importance of complex agriculture at this time, the Moche continued to rely on a mixed-subsistence economy: ceramic depictions and the archaeological record demonstrate the practice of deer hunting, snail gathering, and fishing.
The Moche ceramic style and ritual regime came to an end sometime around AD 800-900. While some attribute this shift to a series of natural disasters caused by destructive El Niño floods (Moseley 1983, 1987; Nials et al. 1979), a transitional period, best understood at the sites of San José de Moro, Cerro Chepén and San Ildefonso in the Jequetepeque Valley, reflects a continuation of the Moche worldview, and domestic and even political practices, albeit with a clear change in ceramic style and organization of ritual space. The Moche components of the Huacas de Sol y la Luna and the Huaca Cao in the Chicama Valley were abandoned, and new settlements, with architecture that is referential to the earlier huacas, yet distinct in construction materials and methods, were established at sites such as Pampa Grande (Lambayeque) and Galindo (Moche Valley) (Bawden 1982; Shimada 1994). In the Jequetepeque Valley, instead of monumental adobe pyramids, the new architectural style was framed around expansive, orthogonal compounds placed on top of high coastal mountains or cerros (Swenson 2007). These compounds featured open plazas and small, interior rooms with restricted access. This same organization of space would continue into the Late Intermediate Period.

The Middle Horizon Period in the Chicama Valley is poorly understood. During this period on the central and south coasts, the expansive Wari and Tiwanaku highland polities established intrusive settlements, such as Castillo de Huarmey in the Huarmey Valley, and Cerro Baúl and Omo in the Moquegua Valley. However, the same is not true for the north. Wari settlements may have been established in the northern highlands (Yamobamba, El Palacio) (Watanabe 2001), but on the coast, Wari influence is marked through material exchange: the presence of Wari pottery, stylistic changes in local ceramics and the appearance of kaolin-paste wares, the raw material for which originates in the highland Cajamarca region (Castillo Butters 2000). The Chicama Valley has produced no such evidence to date. Instead, the Chicama seems to have experienced an early Late Intermediate Period as evidenced by the appearance of Lambayeque and Chimu cultures at this time.

Once again, the northern edge of the Chicama Valley marked a cultural boundary during the Late Intermediate Period. In the valleys to the north of the Pampa de Paiján, the language Muchik was recorded during colonial times, while to the south, Quignam was spoken. Several origin stories related to
this period were recorded in colonial times and feature a foreign lord as the protagonist, arriving to north coast shores on a balsa raft (typical of long-distance sea travel). Around the area of Trujillo, this figure was called Tacaynamo, while in the northern Valley of Lambayeque, the figure was known as Ñyamlap. The cultural assemblage of the Lambayeque culture (also called Sicán) featured large, truncated adobe pyramids with central ramps, black-ware ceramics commonly depicting a figure known as the ‘Huaca Rey’, and elite burials with elaborate copper and gold death masks. While most Lambayeque sites and material are concentrated in the northern Valleys, recent studies further south at the Huacas de Sol y la Luna and the Huaca Cao Viejo have presented evidence of Lambayeque pilgrimage activities; and in the Pampa de Mocan, right on the edge of this cultural sphere, Lambayeque ceramics were collected.

It has long been argued that the Lambayeque were conquered sometime around AD 1350 by the Chimu (Cordy-Collins et al. 1990; Rowe 1948). The Chimu are viewed as an expansive state whose territory ranged from Manchan in the Casma Valley (Moore 1981) to Tucume in the Lambayeque Valley (Portocarrero 1994). The Chimu trade network, however, reached at least as far as Ecuador, as evidenced by the vast quantities of imported *Spondylus princeps*, a thorny oyster with a distinct orange-pink color that lives in the warm coastal waters off of Ecuador (see Pillsbury 1996). Just beyond the Pampas de Huanchaco and Esperanza to the south of the Chicama Valley was the capital of the Chimu: Chan Chan.

Chan Chan is a sprawling royal complex, made up of 10 burial and administrative compounds or *ciudadelas* and an attached lower-status population area; the entire complex totals over 20km² (Moseley and Day 1982). The ciudadelas likely reflect a practice of split-inheritance, as it appears that each compound corresponded to a different ruler. Chan Chan is essentially the type-site for Chimu ‘administrative’ architecture, and the extent of Chimu control has been measured in large part by identifying architectural similarities between those compounds built in the regional hinterland and the ciudadelas themselves. The favorite construction material of the Chimu was adobe and poured adobe or *tapia*; the elasticity of tapia allowed for modeled and sculpted designs of sea birds and creatures in textile-like patterns to adorn the walls (Pillsbury 2009). Archaeologists of the pivotal 1970s Chan Chan Moche Valley project identified an architectural unit whose prevalence in the royal compounds have lead to their
use as a symbol of Chimu state authority: the *audiencia* (Keatinge and Conrad 1983; Moore and Mackey 2008: 786; Moseley and Day 1982;). Audiencias are small, U-shaped multi-purpose rooms with *banquetas* or built benches and niches cut into the walls. Scholars have attributed them to accounting spaces, elite living quarters, or royal audience rooms. The inclusion of an audiencia in Chimu architecture outside of Chan Chan is seen as indicative of the state’s administrative seat, supporting the interpretations of these sites as Chan Chan outposts (Keatinge and Conrad 1983; Mackey 1987; Pillsbury and Leonard 2004; Pozorski 1987). However, recent studies suggest the nature of Chimu political expansion was not necessarily militaristic (see Cutright 2014). Instead, it appears the state was waging a ‘culture war’ by disseminating Chimu products and offering political gifts to local leaders.

Historical sources suggest that political organization on the coast was centered on local lords, or *caciques*. ‘Caciques’, a Taino word, and ‘*curacas*’, possibly derived from Quechua, were terms used by Spanish chroniclers to describe ‘chiefs’ who extracted labor from an attached population in exchange for luxury goods such as textiles or corn beer (*chicha*) (Bray 2008:530; Cordy-Collins 1990; Moore and Mackey 2008; Netherly 1977). Chimu territorial expansion was predicated on the ability to provide these goods, and by extension, produce the necessary raw products: maize and cotton.

Scholars of the Chan Chan Moche Valley Project pointed to monumental irrigation works as evidence of state-controlled agricultural production, and this conclusion has had far-reaching influence on the interpretation of Chimu canals in areas outside the capital (Moseley 1983). To highlight just one of these impressive works, the La Cumbre or Inter-valley irrigation canal tapped water from the neighboring Chicama Valley with the purpose of delivering it over 54km away to fields outside of the Chimu capital. Heated debates have centered on the ultimate success of this canal; however, it has become a symbol of Chimu political and economic hegemony (Farrington 1983; Moseley 1983; Ortloff et al. 1982). The underlying argument states that centrally-controlled expansive agriculture was necessary to feed a growing conquest population (see also Watson 1979). Consequently, the presence of monumental irrigation branches that reach out to the desert, much like the audiencia, has long been treated as a stand-in for the presence of the Chimu state.
The Late Intermediate Period was a time of economic ‘globalization’ in terms of trade networks and long-distance contact (see Jaffe 2017; Jennings 2011). Not only were exotic goods being circulated around the broader Andean region, but plainware Chimu ceramics and low-status burials appeared almost everywhere in the northern Andes and northern and central coasts at this time. However, by AD 1470, the Chimu had been conquered by the highland-based Inca empire (Rowe 1948). Just a few decades before, at the coastal site of Huanchaquito, over 43 children and 74 camelids were sacrificed (Prieto 2014; see also Benson and Cook 2001, Hill 2000). Such acts suggest that the Chimu organization was undergoing turmoil—political, economic, or perhaps disaster (ENSO)-induced (see Prieto 2014)—making it particularly vulnerable to Inca invasion.

While Spanish chronicler sources record a hostile-takeover, there is no evidence of a subsequent Inca occupation at Chan Chan. Instead, the nature of Inca conquest seems to have been centered on the economy of the north coast and specialized crafts. Rather than carry out large-scale political re-organization, the Inca likely governed and directed ceramic, textile, and precious metal craft production through the already-existing political framework (Costin 2011; Hayashida 1999; Mackey 2010). While fineware ceramics were produced for the Inca, a local variant that blends elements of both styles emerged known as ‘Chimu-Inca’. However, once again, the archaeological evidence for this political shift is not evenly distributed across the northern valleys. While Chimu-Inca material is common in the Jequetepeque, Lambayeque, and even Moche Valleys, the Chicama, possibly due to the paucity of investigations directed at this period, presents very few examples of Chimu-Inca material. The Pampa de Mocan project recorded only three fragmentary examples.

The culture history of the north coast of Peru appears to conform to a linear progression from hunter-gatherer subsistence to complex irrigation agriculture; and from small, mobile societies to hierarchical, expansive polities or states. The combination of an arid desert environment, rich archaeological record, monumental centers, and expansive irrigation systems have made the north coast a fertile testing ground for models of agrarian change and state-formation (Boserup 1965; Steward 1955; Wittfogel 1957). The next section will provide an in-depth review of this legacy.
**Review of standing models.**

“The Boserupian idea of a continuum from extensive to intensive agriculture that has been assumed to map the cultural evolutionary stages as progress through bands to tribes and chiefdoms to state, is often recast as a continuum of political organization from simple to complex” (Erickson 2006:336).

Two of the most influential contributions to the study of social and agricultural change continue to be Ester Boserup’s (1965) *Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure* and Karl Wittfogel’s “Hydraulic Hypothesis” (1957). Together, these two works complement each other. Boserup’s work focused on smallholder behavior at the level of the individual farmstead, while Wittfogel was interested in collective system dynamics, specifically water management bureaucracy.

Boserup (1965) argued for an agro-behavioral continuum, which ultimately mapped on to evolutionary models of sociopolitical and technological development. On one end was shifting cultivation, which required little technological input and operated under usufruct land rights. On the other end, was intensive agriculture, which resulted in technological innovation and personal property rights. The ‘Law of Least Effort’ was a central postulate of Boserupian agrarian change. The Law held that smallholders would not exert greater energy over production than that required to meet basic needs; they would not create surplus or accumulate capital except when directed by political leaders or bureaucracy (Chayanov 1986 [1966]). In other words, change in behavior among smallholders, in the absence of a governing body, was attributed to outside forces, such as the restriction of available land and population pressure. Shifting cultivators, having no external limits on arable land, would simply acquired more land or felled more forest to increase production and meet population demands. Meanwhile, argued Boserup, where arable land was circumscribed, smallholders adapted by intensifying production in already-existing fields, for example, through the application of new technologies such as irrigation and drainage canals, fertilizers, or fire-clearance methods. Boserup’s theory directly challenged the long-standing Malthusian (Malthus 1976 [1798]) hypothesis, which argued that population was limited by available food supply. Instead, *The Conditions of Agricultural Growth* reversed the argument, contending that ‘necessity is the mother of invention’: where population pressure exceeded the available land, farmers innovated to
increase field production. Two important socio-economic concepts would emerge from the process of intensification: land ownership and class-based division of labor.

Boserup argued that as smallholders invested labor and technology in their fields, fallows would grow shorter, and exclusive rights to the worked-parcels of land would emerge. Netting (1993) tested this aspect of the hypothesis, and found multiple ethnographic case studies where individual land tenure and property rights appeared as population pressure increased and land availability decreased:

“...The practice of intensive agriculture, both correlates with and eventually requires private property rights...The higher the long-term subsistence and/or market value of such intensively used resources, the more likely that they will be subject to detailed rules of ownership, exchange, and inheritance” (Netting 1993:172).

At the same time, as technologies became more sophisticated, the aggregate labor per unit of land increased, which would require group-level cooperation, specialized labor, and ultimately, class-based divisions of labor.

When applied to the past, these models proposed that the early stages of agricultural intensification led to systems of land-tenure and labor division (Boserup 1965); while, the later stages, featuring complex irrigation infrastructure, required high-level management and ultimately a hydraulic state (Wittfogel 1957). Wittfogel’s (1957) Hydraulic Empire hypothesis argued that, in arid environmental settings where available water was spatially restricted, states emerged to oversee and direct the maintenance and operation of large-scale irrigation:

“If irrigation farming depends on the effective handling of a major supply of water, the distinctive quality of water—its tendency to gather in bulk—becomes institutionally decisive. A large quantity of water can be channeled and kept within bounds only by the use of mass labor; and this mass labor must be coordinated, disciplined and led.” (Wittfogel 1957:18).

Both Boserup’s and Wittfogel’s theories were structured around gradual, linear change resulting from technological progress. For Boserup, the catalyst of technological change was population pressure, while Wittfogel pointed to labor requirements of complex irrigation technology as a central cause for the emergence of hierarchical society. For both Boserup and Wittfogel, technological advancement and sociopolitical complexity were linked variables along the same agro-behavioral curve. Crucially, both scholars required that available land be a limited resource in order to catalyze either intensification
(Boserup) or organizational hierarchy (Wittfogel), making the arid north coast of Peru an appropriate setting for the application of these theories.

Julian Steward (1955) applied the Hydraulic Hypothesis to coastal Peru, where precipitation in normal (non-ENSO) years is minimal and deeply-entrenched rivers provide the only permanent, year-round source of freshwater. Early complex societies on the Peruvian coast were characterized by Steward (1955) as “Irrigation Civilizations” both for the technological prowess reflected in the irrigation technology, and for the interdependence of past states and canal system functionality. Steward’s assessment was further supported by aerial photography, which began in Peru in the 1930s (Denevan 1993; Science 1930) and continued with the establishment of the Servicio Aerofotográfico Nacional del Perú in 1942. The photographs captured the extent and monumental nature of the ancient canal and water transport systems and showed that they reached well-beyond the limits of modern agriculture (Kosok 1965). The images of industrial-level productivity in the prehispanic past, evoked an admiration for, and expectation of, high-levels of socio-political complexity during those periods:

“In the coastal desert valleys of Peru, irrigation has always been the sine qua non of agricultural production. Without it, life would be impossible. It is true at present—it was true in the past! What are some of the implications of an irrigation agriculture? In such an economy, as contrasted with one that depends on entirely on rainfall, man exerts considerable control over one of the basic natural productive forces, i.e. water…At the same time, the building, cleaning, repairing and defense of a network of irrigation canals imposes on the tribe or community a greater need for collective work and thought than is required in communities dependent merely on rainfall agriculture” (Kosok 1965:9-11).

While these models provide an elegant and explanatory structure for social change by mapping agricultural production onto technological innovation and increasing class divisions, they rarely bear out when tested against the ethnographic or archaeological record. As a result, a rich literature of ‘intensification debates’ has emerged (see Hunt 1994; Lourandos and Ross 1994; Mitchell 1973; Morrison 1994; Price 1994), and scholars have aimed their critique at three areas of weakness: 1) the models’ underlying assumptions; 2) causal directionality; and finally, 3) the conceptual premise.

The Law of Least Effort is a critical underlying assumption for Boserup’s model for intensification: smallholders would not create surplus without pressure from an outside force, such as the state. Brookfield (1984:21) credits Marshall Sahlins with the early application of this Law to social
theory. Using the example of irrigation agriculture in Hawaii, Sahlin (1972) argued that surplus was pursued and manipulated by the ambitious few, who used their control of goods or services to create an imbalance in social relations and gain ‘chieflly’ status. Seminal works by Brookfield (1984, 2001) and Netting (1993) successfully challenged this long-standing view by demonstrating that smallholders often create surplus, anticipate future risk, participate in the market and establish forms of capital. For example, smallholders often ‘bank labor’ in the form of landesque capital (Blaikie and Brookfield 1987; Kirch 1994), which Blaikie and Brookfield (1987:9) define as, “any investment in land with an anticipated life beyond that of the present crop or crop cycle”. They create earthworks such as terraces, dams, or irrigation canals and benefit from even the unintentional consequences of farming and settlement, such as anthropogenic soils (see Neves et al. 2004). These investments would be classified as technologies of intensification by Boserup. However, unlike Boserup’s (1965) technologies, landesque capital creates surplus by alleviating the future need for labor and improving production for the future—making an individual farmstead more sustainable. Meanwhile, Boserup’s concept of intensification technology cannot ‘bank’ labor, rather it ties the smallholder into an increasingly labor-expensive scenario, requiring more and more man-power and higher degrees of specialization leading to the emergence of class-based labor divisions.

A second body of critique has focused on testing the causal link between irrigation and political complexity. Wittfogel’s Hydraulic Hypothesis holds that the maintenance requirements of irrigation works led to the hierarchical control of labor. The labor-demanding and diverse tasks involved in maintaining system functionality, including canal cleaning, repairs, managing erosion, and of course water distribution, necessitated a bureaucratic elite. Robert McC. Adams’ (1981) project on Mesopotamian irrigated landscapes demonstrated that socio-political complexity preceded large-scale irrigation (see also Adams 2005[1966]; Jacobsen and Adams 1958). Since Adams’ work, scholars have gone even further, testing whether there was any relationship between major irrigation works and socio-political complexity (see also Marston 2011). Ethnographies on southeast Asian irrigation systems by Barth (1993), Lansing (1991), and Leach (1961) demonstrated that extensive systems were operated at the
farmstead level or through timed religious rituals, and that cooperation was not always necessary or desirable to smallholders connected by a common irrigation system. Robert Hunt’s (1988) publication definitively argued that canal systems, even in the arid southwest United States, could operate at a level of small-scale organization. Multiple energetics studies have also demonstrated that smallholders can construct and maintain extensive irrigation systems at the local-level (raised fields: Erickson 1999, 2006, 1988; terracing: Kolb 1997; Treacy 1989; Treacy and Denevan 1994) with Mabry and Cleveland (1996) arguing that local-level systems were in fact more efficient than centrally-managed ones. Millon et al. (1962) argued that there was no connection between degree of sociopolitical centralization and the size or extent of irrigation systems in central Mexico. Finally, Erickson’s (1988, 1999, 2006) investigations in the Titicaca Basin expanded the argument that there is little or no connection between labor-intensive, complex raised field systems and bureaucratic organization. Instead, he suggested, rather than using the ‘form’ or apparent uniformity of irrigation works as an indicator of intensification, labor requirements or sociopolitical complexity, archaeologists would be better served by relying on the ethnographic record for references to labor-requirements.

Case studies in the Andes: low-level organization of complex agrarian systems. The Andes have been the site of extensive ethnographic and ethnohistoric scholarship focused on campesino or smallholder farming practices. These studies have provided important contributions to Boserup-Wittfogelian debates, by arguing that complex irrigation is not a threshold phenomenon: both complex irrigation systems and small-scale farming can be carried out simultaneously and result in a combination of communal and hierarchical approaches to labor division. For example, Gose (1994) recorded both communal and private land rights practiced by two distinct social classes among the Huquira farmers in Apurimac: those who divided labor symmetrically (ayni) and those who provided beer in exchange for labor (mink’a). Similarly, in the Colca Valley, Guillet (1992) observed that smallholders balanced communal water management with individual rights over land and were willing to sacrifice immediate gains for future economic and environmental stability. Treacy’s (1989) work in Coporaque demonstrated that the vast terraced slopes of the surrounding Colca Valley were maintained and constructed by local,
non-specialists; meanwhile, Zimmerer (1993) argued that a combination of social conditions and market forces fueled the construction of expansive drained ridged fields in Colquepata, Paucartambo. Ethnologies of highland Andean farming communities have also shed light on ritual, mythological, and moral aspects of agricultural practices; many of these substantiated through the symbolic meaning of water (Valderrama and Escalante 1988). Rituals tied to the quotidian use of water and canal maintenance reify dualistic and complementary relationships at a kinship-, community-, and even a supra-community-level (see Gelles 1995, 2000; Gose 1994; Mayer 2002; Mitchell 1978). Paerregaard (1994) described daily ‘pagos’ or ritual offerings at the level of the individual farmer in Tapay as scheduled in order to attend to the maintenance requirements of the greater irrigation system, resulting in moments of centralization, “Ceremonies progress along the system advancing toward the same geographical location on Seprigina Mountain where the critical rituals of the separate groups are celebrated at the same time. Different irrigation groups thereby come together, unifying an otherwise decentralized system” (Guillet and Mitchell 1994:9). Enrique Mayer’s (2002) work with the highland community of Tangor, led him to conclude that for these campesinos, the social expectations of reciprocity surrounding agriculture and irrigation essentially constitute an Andean morality.

Ethnohistoric work by Tom Zuidema (1964) points to the central role of water in an Andean cosmovision that had origins in prehispanic times. Zuidema’s (1964) study argued that the Cusco ceque system (sacred places linked along vectors organized radially around the Inca capital) was related to the surrounding environment. Water sources, such as springs or rivers, and irrigation canals fit spatially into the dual moieties of Hanan and Hurin Cusco (see also Zuidema 1986). In concordance with Zuidema’s ethnohistoric work, Sherbondy (1982) demonstrated that the circulation and flow of water was crucial to Inca origin myths and gave order to the sacred landscape. Water was the “Sangre del nevado” (Valderrama and Escalante 1988:206); its kinetic properties, the flow of water, provided a life force to stones, architecture, fields, mountains and people (see Cummins and Manheim 2011). Finally, the
agricultural cycle, and the seasonal abundance of water, likely structured the Inca ritual calendar
(Zuidema 2010).

Moving beyond critique.

“The Wittfogel model, like Elvis, refuses to die. And like the impersonators of Elvis Presley who earn their keep by rocking
around the clock, Karl Wittfogel’s ‘hydraulic hypothesis (Wittfogel 1938; 1957) continues to be repackaged in a variety of guises
that assign a unique causal role to irrigation in the development of socio-political complexity” (Butzer 1996:200).

The systematic testing and critique of the Boserup/Wittfogel framework has resulted in a body of work
that successfully challenged the Law of Least Effort, and the primacy of water-management bureaucracy,
and questioned the causal relationship between state-level political organization and irrigation systems.
Still, however, complex irrigation, and its proxy metrics, important cereal cultigens, territorial expansion,
labor division, conquest, emergence of intermediate elite, political economy, or agrarian collapse (see
Clement and Moseley 1991; Downey 2014; Erickson 1999; Farrington 1977; Farrington and Park 1978;
2010; Williams 2002) continue to ‘stand in’ for ‘degree’ of sociopolitical complexity. Although multi-
valent investigations measuring multiple variables are the new standard of practice, and the term
“hydraulic hypothesis” or “irrigation civilization” has essentially dropped out of the vernacular,
disentangling monumental canal systems from socio-political complexity, even just for the purpose of
hypothesis testing, continues to prove difficult:

“As it applies to intensification of agriculture, the political economy approach has been labeled the neo-
Wittfogelian Perspective (Erickson 1993; Stanish 1994). Although they may deny that the organizational
demands of intensive agriculture (large-scale irrigation in Wittfogel’s original model) caused state
formation and centralized despotic government, some archaeologists assume that the intensification process
and resultant large-scale intensive agriculture would require elite involvement and management (e.g. Earle
(Erickson 2006:336).

2 The dynamics of agricultural production, community, and water have been viewed as a microcosm of the greater Andean
cosmovision. The weaknesses of the structuralist approach have been argued at length:
Starn, Orin, Olivia Harris, David Nugent, Stephen Nugent, Benjamin S. Orlove, S. P. Reyna and Gavin Smith
1994 Rethinking the Politics of Anthropology: The Case of the Andes [and Comments and Reply]. Current
Despite the well-argued critique of these models, including challenges from Andean case-studies, the correlation between increasingly complex irrigation systems and increasingly hierarchical sociopolitical organization continues to frame archaeological investigations on the north coast of Peru. The framework itself is problematic: without reworking intrinsic assumptions, future studies risk simply ‘repackaging’ the original Boserup/Wittfogel models. The resilience of this framework in the scholarship of this region has to do with a long tradition of environmental essentialism in the Andes.

*Environmental Essentialism in the Andes.*

The broadly-defined environmental properties of the north coast, and the long-standing tradition in the Andes of mapping behavior on to environmental zones, make for an elegant, but over-simplified model of ancient smallholder practices. Beginning with early bio-geographical maps, the representation of Andean ecology emphasizes the diversity of types of environmental zones, classified in part by the contemporary land-use of the area, which, while not necessarily problematic in phytogeographical studies, can be applied uncritically to the past. In 1938, Javier Pulgar Vidal published *Las ocho regiones naturales del Perú* with eight ecological zones determined based on elevation and local agricultural practices and labeled with Quechua terms (Zimmerer 2011). For example, the *chala* or coastal zone is located below 500 masl, and the word “chala” itself refers to maize. For Vidal, subsistence practice in each zone was an important variable for defining the ecological divisions themselves; however, for archaeologists, the inclusion of modern-day production data create a problematic tautology by tying ‘natural’ environmental zones to modern land-use practices, and by extension, to legacies of past land-use and environment. This has had far-reaching consequences: for instance, the ‘land-use’ variable was central to the heavily cited reports (including this dissertation!) of the Oficina Nacional de Evaluación de Recursos Naturales del Perú (ONERN), which focused on or two valley systems as geographic units. ONERN’s 1973 study of the Chicama Valley resulted in the identification of six ‘life zones’, but only one, ‘Premontane Desert’ identified below 400 masl³. This zone was further divided into eight areas, based largely on modern land-

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³ The most influential study of tropical ecosystems, which was later adopted by ONERN, is Holdridge’s (1967) ‘life zone’ system. The life zone system strove to be applicable to any area in the world, and therefore based on *objective* measurements.
use: four classes of intensive agriculture; two classes of permanent agriculture; marginal and useless soils (Watson 1979: Map 1[Compiled from ONERNO 1973]). Under this rubric, the Pampa de Mocan is classified as agriculturally ‘useless’.

Moreover, the seminal ethnohistoric work of John Murra (1956, 1972) proposed that the distribution of natural resources across the Andean region structured economic activities across space in both the colonial and prehispanic periods. Murra (1972) based his findings on a 1562 Visita from the highland region of Huanuco. There, smallholder communities were distributed across the distinct eco-zones of the Andes. These ecological pisos, he argued, constituted niches of agro-pastoral products, and linked-communities cooperated to exchange complementary goods. The ‘vertical archipelago’ model of Andean complementarity essentially maps community location and agricultural practice on to environmental zones.

The elision of land-use practice and environmental-zone has perpetuated the idea that there ought to be distinct agricultural histories across the highlands and the coast. The highland region is recognized as consisting of great diversity even within ecological pisos (see Zimmerer 1995). Similarly, irrigation techniques respond to the peculiarities of slope, topography, water source and crop choice in a given area. Farmers located on mountain slopes take advantage of small springs or runoff, and those located in highland valley bottoms rely on rivers and irrigation canals (Guillet and Mitchell 1994). Many highland communities utilize still-water systems for irrigation, through the construction of reservoirs or drained, sunken, or raised fields in lake margins or reclaimed wetlands (Balée and Erickson 2006; Erickson 1993; Erickson 1988; Guillet and Mitchell 1994; Valdéz 2006). Terraces and other landscape modifications such as dams are constructed to prevent erosion, improve water retention and even create microclimates by redirecting cold air flow (Guillet 1987). Finally, in the high Andean puna region (4200-5000 masl), transhumant pastoralists maintain and expand native grassland through the controlled flooding and

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Holdridge defined the environmental conditions of an area or zone based principally on four factors: biotemperature, precipitation, potential evapotranspiration ratio, and elevation – subsistence practices were intentionally excluded from calculations. Critically, these life zones were considered divisible, and by adding more area-specific data, they could be qualified further to even describe land-use – these are called “associations” (A.E. Lugo et al. 1999:1027).
irrigation of existing wetlands, known as *bofedales* (Browman 1987; Stanish et al. 2010; Verzijl and Quispe 2013; Vining 2011). Meanwhile, the same ecological and technological diversity is not attributed to the coast. For example, Gose (1993:482) states,

> “Here a sharp dichotomy exists between coastal and highland situations. The coastal situation is close to the classic preconditions of the Wittfogel hypothesis: a climate with virtually no rainfall and large populations dependent on an intensively irrigated agriculture involving extensive canal systems…In the highlands themselves, local control of irrigation also prevailed but against a significantly different natural background. Here irrigation has primarily supplemented natural rainfall to extend the growing season of maize…Because this need to control water was not a compelling natural necessity, we should understand [“almost obsessive concern for the ritual control of water” (Gose 1993:482)] at least in part as a human invention”.

The environmental differences in the highlands versus the coast are considered extremely pertinent to the very divergent histories of socio-political formations: the coast, due to its extreme aridity, requires dependence on irrigation and therefore state-controlled canal systems, whereas the diversity of highland environments means irrigation technology can be used to supplement growing seasons. The result in the highlands is irrigated farming and pastoral practices operating at both the local and the regional scale, inherent to myth, ritual and social relations; while ancient coastal irrigation is viewed as existing along a linear trajectory from simple to complex. Consequently, neo-Wittfogelian models continue to frame much of the scholarship of pre-Hispanic coastal agriculture.

*Archaeology of irrigation on the north coast.*

The 1970s and 80s witnessed important contributions to the study of ancient irrigation agriculture on the north coast; however, these works are also characterized by a strict adherence to a Boserupian/Wittfogelian framework. James Lee Nolan’s (1980) thesis on the Late Mochica, Lambayeque, and Chimu canal systems on the inter-valley area between the Lambayeque and Zaña Valleys made the argument that canal construction responds to sociopolitical centralization and secularization. Michael E. Moseley and Kent C. Day’s (1982) synthesis of their multi-year project on the Chimu capital of Chan Chan and the surrounding areas pointed to monumental irrigation works as evidence of Chimu sociopolitical hegemony: canal systems and even an inter-valley canal (Farrington 1983; Ortloff 1982) were built to feed the coffers of the Chimu state by carrying water to the fields around the capital walls.
Meanwhile, Herbert Eling (1987) and Richard Watson’s (1979) work in the Jequetepueque Valley and Chicama Valley, respectively, were focused on irrigation networks that reached the marginal areas of the Valleys: the now-desert *pampas* or plains located at a great distance from the central water source, the river. The development of these inhospitable areas was only possible thanks to a high-level of sociopolitical organization and the influx of substantial labor resources. Both authors concluded that expansion into these landscapes were Chimu state initiatives. Watson’s (1979) work focused specifically on the Pampa de Mocan, where he concluded that Chimu development of this area was motivated by a growing need for cotton and maize. As the conquest state expanded, fine cloth and chicha were required for political rituals of gift exchange and reciprocity.

More recent studies on north coast irrigation systems complicate the irrigation system—management bureaucracy correlation. For example, Brian Billman’s (2002) compilation of settlement surveys in the lower Moche Valley refutes the Wittfogelian claim that irrigation management led to the emergence of a bureaucratic class. Rather, he argues that irrigation expansion, and by extension territorial expansion, created conflicts among neighboring polities and opportunistic elites took advantage of the scenario. Billman’s (2002) article, although it provides nuance and greater historical precision, ultimately adheres to a linear trajectory of irrigation expansion tied to sociopolitical complexity. Other recent publications acknowledge the multidimensionality of political centralization across the coast by including variables such as elite ritual, language, imperial signaling, and urbanization in their calculus (Castillo Butters et al. 2012; Earle and Jennings 2012; Heggarty and Beresford-Jones 2010; Jennings 2010; Londoño et al. 2017; Schreiber 2001, 1987; Swenson 2007; Williams 2002). Several investigations have focused on a single landscape or canal branch system as the subject of detailed analysis, taking a historical ecology approach to the study prehispanic irrigation (Barnard and Dooley 2017; Beresford-Jones 2009; Eling Jr. 1987; Hayashida 2006; Huckleberry et al. 2012; Nolan 1980; Nordt et al. 2004; Watson 1979). The Pampa de Chaparri, for example, located in the Lambayeque Valley, featured continuous agricultural activity from the Middle and Late Sicán Period (AD 900-1375) through Chimu and Inca (AD 1375-1532) occupation (Hayashida 2006). An inter-valley canal system, including feeder
and drainage features, walled fields (Téllez and Hayashida 2004), and evidence of nitrogen inputs through manure or fertilizer (Nordt et al. 2004) point to long-term intensification of the landscape. Hayashida (2006) documents a shift in architecture and practices at the onset of Chimú and Inca imperial administration; she concludes that while local-level management prevailed for centuries, intensified agricultural landscapes were attractive to expansive states, making them vulnerable to conquest.

**Theoretical reframing: human ecodynamics.**

In thinking about what theoretical approach best structures archaeological landscape data, historical ecology seems an obvious ally. Rather than modeling short-term responses as aimed at returning to system equilibrium, the historical ecology approach recognizes sustained change (Balée 2006; Balée and Erickson 2006). However, historical ecology organizes this change along a gradualist, linear framework, which can lead to a ‘tyranny of monuments’ problem (Sutton 1989)—a bias toward major events or political figures as causes for significant breaks from the norm, for example, a major flood event seen as triggering sociopolitical reorganization. Instead, Karl S. Zimmerer (1994) describes a ‘new ecology’ that has moved away from the idea that ‘nature seeks equilibrium’, instead, favoring non-linear processes:

“The once-abiding belief in a balance of nature is deeply questioned and, in many quarters, is now rejected outright. Instead, a large number of cornerstone ecological processes are described as nonequilibrium dynamics, long-term shifts, and historical conditionalities such as path dependencies and trajectories” (Zimmerer 2000:3566).

Complexity theory offers an approach for archaeology “which acknowledges the crucial importance of different temporalities and scale-dependent dynamics in the emergence of societal structure” (McGlade 2006:83). This may seem like a subtle divergence from the historical ecology framework, but it carries with it an important implication: by stepping away from a linear model, causality can be distributed across temporalities and scales of events—opening the way for ancient landscape histories to converge with modern, industrial irrigation projects (see Chapter 6).

According to complexity theory, “normal conditions” should not have primacy; rather, humans are constantly problem solving and their collective effort occasionally constitutes a significant break from preceding phases. Both incremental and systematic change can result in unintended consequences on
landscape and social systems, occasionally leading to ‘emergent’ or self-organized dynamics. McGlade (2006:81) defines ‘self-organization’ as, “the ability of uncoordinated, ‘bottom-up’ dynamics to generate coherent structure”. These efforts are not to be organized as evolutionarily forward or backward. Instead, this perspective argues that any ‘natural selection’ we may perceive in a population history, should be viewed as learning: “that is, the ability to continuously adapt to the co-changing, and at times unexpected and dramatically altered conditions” (Allen 1994). Complexity theory, which has a useful partner in Path Dependence Theory (Mahoney 2000; Pierson 2000), assumes that aberrances are the norm: in other words, humans are continuously responding to potential micro-disasters such as over-salinization, erosion, riverbank overflow, canal breaches, channel meandering, seasonal blooming, flood waters, and climate change. When an extreme event occurs, for example, a massive flood, continuous ‘background noise’ responses emerge as a unified program of ‘disaster response’. In this way, complexity theory differs from co-evolutionary theories: for example, while niche-construction implies simultaneous co-adaptation at similar or the same time-scale, complexity theory states that what occasionally appears as a coherent phase-change, is more likely a temporary overlap of multiple co-existing trajectories, categorized as ‘environmental’, ‘social’, ‘technological’—a kind of “spontaneous order” (Sugden 1989). Crucially, these trajectories can proceed at vastly different timescales, making the millennia-scale increase in ENSO frequency relevant to the decadal-scale process of salinization, and the century-scale socio-political processes that result in hierarchical organization.

Interpretations.

In the review of standing models presented in this chapter, two intrinsic assumptions were highlighted and identified as potentially responsible for the resilience of the Boserup/Wittfogelian framework in north coast archaeology: 1) that arid environments impose limitations on agricultural strategies; and 2) that intensive, highly complex irrigation agriculture requires sedentism. In the following Chapter, I will evaluate the first of these two postulates. The arid desert is viewed as ecologically static, and as a result, models that control for variables such as water availability have led researchers to assume a set of
limitations for agriculture. These limitations are often so restrictive that they pre-empt the possibility for historical particularism; consequently, scholars continue to rely on linear, gradualist frameworks to explain socio-agrarian change. In the following chapter, I will directly address the viability of the environmental determinism fundamental to standing models. I offer a detailed review of the environmental setting of the north coast and the Chicama Valley and will demonstrate the potential of ecological dynamism in this region. I will focus on one aspect of local climate: El Niño Southern Oscillation (ENSO). This phenomenon is largely viewed as a system perturbation, but I will argue it is central to the ecological life cycle of north coast valleys, and therefore, can be viewed as an agricultural resource rather than a disruption.
CHAPTER 2. DIVERSITY IN THE DESERT

In the previous chapter, I highlighted the inherent environmental determinism that underlies popular models of agrarian change in anthropology and archaeology. The north coast of Peru is viewed as a type-site for these models, in part because of the environmental extremes seen as governing social and economic life. The arid desert coast is viewed either as existing in stasis (Farrington 1983; Ortloff et al. 1982; Pozorski and Pozorski 1982), or as experiencing moments of punctuated change followed by a return to system equilibrium (Moseley 1987; Shimada 1994). Consequently, much of coastal scholarship attributes sociopolitical change to disaster response; and as Wells and Noller (1999) argue, little attention has been paid to gradual landscape change and coevolution with society. One of the most visceral impacts on both landscape and society on the north coast is El Niño. El Niño Southern Oscillation or ENSO describes a climatic phenomenon that arises from perturbations in normal sea surface temperatures and winds over the Pacific Ocean. ENSO has two extreme phases: El Niño, which results in heavy rains on the Peruvian coast, and La Niña, which reduces precipitation on the coast. Interannual variability of this phenomenon makes predicting these events and detecting them in past extremely difficult. The timing, extent and intensity of El Niño events have played a crucial role in both landscape formation and the development of societies, especially as they pertain to agriculture.

This chapter explores the environmental conditions of north coast Peru, and evaluates the limitations posed to ancient agriculturalists. First, I will review the desert land forms encountered on north coast—rather than being a homogenous, flat landscape, the desert topography is diverse, and integrally connected to El Niño. I will explore the relationship between ENSO and land formation, soil composition, water sources, and vegetation on the north coast and argue that, rather than being punctuated interruptions to the natural system, this phenomenon is in fact intertwined with the ecology of the region. Finally, I will address the relationship between ENSO and human occupation and question the disaster-research framework that has come to define discussions of ENSO in Peru. This dissertation proposes a complexity-theory approach to an understanding of El Niño and human-environment dynamics, which
involves multiple temporalities, scales of intensity, and expressions of response. This perspective allows El Niño to be counted as a possible resource for intensive agriculture.

*Desert land forms.*

The north coast desert is not an internally-homogenous ecological unit. While the area is classified as an arid desert overall, there exists great diversity of soils, climate, seasonal water availability, topography, and vegetation communities within even a single valley. The entire coast measures 2,200km long and is made up of intrusive volcanic and sedimentary rocks, including sandstone and limestone. The north coast (Tumbes—Trujillo) consists of 13 entrenched river valleys formed from the Paleozoic to Cretaceous western Andes (Gilboa 1971; Hosmer 1959:40). The valleys are bounded by igneous intrusions of granite, granodiorite and diorite—the coastal ‘cerros’ or hills. Each valley consists of alluvial fans, piedmont plains and east-west transverse rivers. In the inner valley along the river floodplain, typical riverine vegetation is present. South of 8°, lomas plant communities form on the flanks of cerros in winter months; in the northern latitudes, *Prosopis* forests and mangroves (*pantanos*) are part of the local ecology. Finally, *humedales* or wetlands continue to be found all along the coast. Coastal soils belong to one of four general groups (adapted from Gilboa 1969:17):

1) Alluvial soils: depth varies between 5 and 20m⁴. Salinization is a problem only in the lower sections of the alluvial cones (fans).

2) Desertic lithosol: rock and gravelly soils of igneous and sedimentary origin, located along the lower flanks of the Andes.

3) Desertic regosol: soils covering large plains (tablazos) composed of unconsolidated Quaternary marine sediments and eolian deposits. Gypsum and calcareous accumulations and hard saline crusts are present. Sand and dunes cover large swaths of area.

4) Desertic red and grumusol (black clays).

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⁴ The original publication lists these depths as “5 and 20km” (Gilboa 1969:17). These depths could not be corroborated with other publications therefore, the kilometer unit is likely an error.
The desert sedimentary plains or plateaus that surround and separate the river valleys are known as “pampas” (Quechua for ‘plains’) on the coast. Pampas are distinct from river valleys both in geological form and structure (Hosmer 1959). On the north coast, pampas are located near the fall zone of the western Andean flanks, i.e. where the mountain rock meets and begins to be buried by piedmont sediments; these plains are inclined in the direction of the Pacific Ocean. Piedmont sediments are typically made up of hard, crystalline rocks, often covered in eolic deposits, shales, siltstones, and feldspathic sandstone (Hosmer 1959:90). The pampas surrounding the Chicama Valley, including the Pampa de Paiján and the Pampa de Mocan, share this characterization. Gilboa (1971, 1969:78) describes the northwestern corner of the Chicama as covered in cemented gravels typical of an old delta. Meanwhile, further inland near the Pampa de Mocan, eolic deposits are covered in gyspic ryzoliths (crystallized and hardened rootlets) and active dunes encroach on Pleistocene-era ridge and swale topography. The north coast pampas are areas of both new and very old depositional formations, reflecting desert dynamism: sediments are undergoing near constant chemical and physical breakdown, through both gravitational and transport erosion. As a result, El Niño flooding on these landscapes can have spectacular effects, both above and below the surface

Understanding ENSO.

Fishermen from Peru and Ecuador gave the name “El Niño” to the abnormally warm summer current that appeared off the coast around Christmas time (Carranza 1891; Philander 1991). Warmer waters resulted in lower yields of fish and occasionally rainfall. Every decade or so, however, the warm current persisted through May or June and heavy rainfall caused destructive flood events on the coast—this phenomenon is now known as an El Niño event. These events are part of a much broader pattern of oceanic-atmospheric dynamics, which have both local and global effects.

El Niño Southern Oscillation (ENSO) is a continuum of shifting pressure cells between the western Pacific (Australia) and the central (Tahiti) and eastern Pacific. In normal years, the eastern Pacific is characterized by high-pressure conditions, high sea levels and trade winds, and a shallow
thermocline (the boundary between warm SSTs and colder, deeper water), causing dry conditions on the Peruvian coast (Maasch 2008:43). Sea level pressure (SLP) is tied to a multitude of climate and weather variables, including sea level, sea surface temperature (SST), wind direction and precipitation. ENSO has two extremes that affect SLP and consequently local climate on the north coast: La Niña corresponds to cooler-than-normal conditions and El Niño to warmer-than-normal—essentially an inversion of normal conditions. During El Niño events, low SLP accompanied by warmer SSTs, rising air and lower sea level result in wet conditions in the western Pacific.

Climate scientists do not fully understand the causes for the El Niño phenomenon, however they have consistently observed the co-occurrence of several anomalies in pressure systems (SLP), currents, and sea surface temperature (SST). During an El Niño, SLP in the eastern Pacific lowers, causing trade winds to weaken and the thermocline to deepen (the cold Humboldt Current is subverted downward). A deeper thermocline results in diminished upwelling and an increase of 5°C or more in SSTs along the coast of Peru and Ecuador. During the 1998 El Niño event, river flood discharge in Piura was recorded at 4300m³/s, sea level rose 23-30cm, and SST rose 6-8 degrees (Wells and Noller 1999:761). The most recent El Niño event, the so-called El Niño Costero of 2017, recorded SSTs over 4°C greater than normal along the north coast of Peru. Of course, this directly affects the ocean animal and plant life, often resulting in mass death events up and down the trophic chain, from plankton and mollusks to dolphins and sea lions (Ortlieb and Macharé 1993; see also Craig 1992). Strong El Niño conditions can have global affects (teleconnections): warm currents can reach the California coast and impact regions from the Gulf of Alaska to Central America to the southeastern United States (Caviedes 1984; Maasch 2008; Quinn 1993:48-54), with some studies identifying incredibly sensitive correlations between the sea level in the Gulf of Panama and SST in Puerto Chicama, Peru (Glynn 1988:313). Across the broader Andean region, precipitation in neighboring countries such as Paraguay, Brazil, and Chile increases, while the Peruvian altiplano suffers from rainfall deficits (Caviedes 1984; Quinn 1987; Tapley and Waylen 1990). However, the most recognizable results of strong El Niño conditions are extreme rain and flood events that manifest along the coasts of Peru and Ecuador.
The history of ENSO on the Peruvian coast: variability in timing, scale, and location. In 1578, the citizens of Lambayeque described the destruction caused by a massive flood event,

“A terrible downpour fell in this town of Lambayeque that it seemed that jars of water were pouring out and that after the following days until March 3 of that year it rained every day a little or a lot and that the said third of March it rained another downpour as the first and then every day going forward until the fifth or sixth of April it did not stop raining ... and for the other part of said town that is towards Tucuma from the ditches that were broken and destroyed came another river with a large flow never before seen... [F.218r.]; the fields were made pools of water [F.219v.]; and came the plagues that are usually said of Egypt in such a way that in there being any seed a handful of earth was eaten by crickets and locusts and some green and yellow worms and others that were black that grew from the putrefaction of the earth because of the said rains and which he saw in this town of Lambayeque” (Huertas Vallejos 1987:40-42[F.221r.]) [Translation by the author].

El Niño events are notoriously difficult to predict: they vary in their location and intensity, and the frequency of events has changed over time (Fontugne et al. 1999; Glynn 1988:314; Moy et al. 2002). For example, the south coast rarely experiences El Niño events; instead, heavy rainfall is typically concentrated on the north coast, from Piura to the Virú Valley, where orographic characteristics and proximity to the Equator, encourage more intense precipitation (Beresford-Jones et al. 2009:22-23; Magilligan et al. 2008:15; Waylen and Caviedes 1986). Moreover, even within the sub-region of the north coast, rainfall is not experienced evenly across the region over the course of an event (Waylen and Caviedes 1986). Multiple accounts of El Niños through time describe the remarkable circumscription of some events, with rainfall and flooding occurring in one valley and sunny skies prevailing in the neighboring valley (Figure 3). The variability of ENSO effects across the region creates challenges for archaeologists and other scientists attempting to detect ENSO in the past (Placzek et al. 2001).

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5 The original Spanish quotation is: “Callo un aguacero tan terrible en este pueblo de Lambayeque que parecia que se derramaba cantaros de agua y que despues los dias siguentes haste tres de marzo del dicho año llovio todos los dias poco o mucho y que el dicho dia tres de marzo llovio otro aguacero como el que tienen dicho primero y de alli adelante todos los dias hasta a cino o seys de abril no dejo de llover...y por la otra parte del dicho pueblo que esta hacia Tucuma de las acequias que se quebraron y destruyeron venia otro rio muy caudaloso toda cosa no vista...[F.218r.]; las chacaras quedaron hechas picinas de agua [F.219v.]; y vino las plagas que suelen decir que Egipto de tal manera que en estando qualquier semilla un palmo de la tierra la comian los grillos y langostas y unos gusanos verdes y amarillos y otros negros que se criaban de la putrefacción de la tierra a causa de las dichas lluvias y que vio en este pueblo de Lambayeque [F.221r.]”

6 Waylen and Caviedes (1986:153) find that the amount of basin area located on the coastal plain, as opposed to in higher altitudes (>1000m), can be correlated to the amount of flooding that a given valley experiences.
Studies drawing from sedimentary lake, marine, and glacial cores (Moy et al. 2002; Rein 2007; Rein et al. 2005; Rodbell et al. 1999; Thompson et al. 1984; Thompson et al. 1985), isotopic analyses of marine shell (Carré et al. 2005; Carré et al. 2014), foraminifera (Koutavas and Joanides 2012) and corals (Cobb et al., 2003; Cobb et al. 2013), geological (Wells 1987, 1990), and malacological (DeVries et al., 1997; Devries and Wells 1990; Sandweiss 1996; Sandweiss et al. 1996; Sandweiss et al. 2001) data point to two major transitions in Holocene ENSO activity. It is generally accepted that ENSO activity on the central and north coasts (Lurín to Chira Valleys) was suppressed between 9000 and 5800 calBP, followed by increasing frequency, peaking at 3200 calBP and then reaching modern conditions by 3000 calBP. Both the locale and the type of material used to date and measure ENSO events must be taken into account at the moment of interpretation. For example, not every ENSO results in a rain event and not every rain event is the result of an El Niño (see Magilligan et al. 2008: Figure 3; Ortlieb 2000). Therefore, chronologies that rely solely on evidence for sheet flow or those chronologies derived from locations that could be affected by Atlantic precipitation systems must be buttressed with corroborating data.

Glacial core data, such as those collected from Quelccaya and Huascarán, can be successfully applied at the local- or site-scale as broad, paleoenvironmental trends, rather than as chronologies of ENSO events (Thompson et al. 1984:52; Thompson et al. 1995). Dust records and O isotopes from these records indicate that the Andes experienced dry periods (possibly related to ENSO conditions on the coast) between AD 1720-1860; 1250-1310, and 570-610 (Thompson et al. 1985). Similar debates
surround both the use of thermally-anomalous molluscan assemblages (TAMA) (see Devries and Wells 1990; DeVries et al. 1997; Rollins et al. 1986; Sandweiss et al. 1996) and beach ridge stratigraphy (DeVries 1987; Ortlieb et al. 1995), questioning whether these data points can stand alone in the reconstruction of El Niño-event histories. Complete correspondence between those events identified through secondary effects, for example, dust accumulation in a distant glacial core, and ‘primary’ evidence at a local or site-scale, such as a flood layer over top archaeological site, has not been successfully attempted. However, despite discrepancies in timing and spatial scale, changes in event frequency and longer-term climate trends have been identified.

**Quaternary evidence for ENSO.** During the Pliocene (4.5-3.0 Mya) the eastern Pacific experienced near-constant El Niño-like conditions, including warmer waters, but more importantly, less differentiation between western and eastern-Pacific climate systems (Ravelo et al. 2006). Such differentiation, or ‘see-saw’ oscillation between the western and eastern Pacific systems is crucial to the existence of El Niño. Strong evidence for El Niño flood events has been identified in lake cores from Ecuador and dated to at least 15,000 years ago (Rodbell et al. 1999). Additionally, Lisa Wells (1987) identified a minimum of 21 events in flood deposits along the north coast of Peru. In southern Peru, Fontugne et al. (1999) identified sedimentary evidence for El Niño dating to 8980 calBP.; and in a complementary study, isotopic analysis of *Mesodesma donacium* shells from the preceramic site Quebrada de los Burros date an early ENSO to 8900 calBP (Carré et al. 2005:44).

**ENSO acceleration over time.** Since 1525, strong events have occurred on the Peruvian coast as frequently as every 6-7 years and as infrequently as every 14-20 years (Garcia-Herrera et al. 2007; Ortlieb 2000; Quinn and Neal 1987:14455) (See Appendix A), but this has not been the case through time. As outlined above, studies have shown that ENSO activity on the central and north coasts between 9000-5800 BP was suppressed but later increased peaking at 3200 BP before reaching modern-day conditions at 3000 BP (Carré et al. 2014; Moy et al. 2002; Sandweiss et al. 2001). Rodbell et al. (1999) examined 9.2m lacustrine sedimentary cores from the Laguna Pallcacoicha in coastal Ecuador spanning
15,000 years. This study demonstrated that event intervals averaged at least 15 years apart 15,000 years ago; by 7000 calBP events occurred every 10 to 20 years, and finally beginning around 5000 calBP, event frequency accelerated to its present state, which is every 2 to 8.5 years (Rodbell et al. 1999:519). Using strictly alluvial records, Wells (1990:1137) reported a mean frequency of 1 event every 1000 years in the last 7000 years. Using marine fauna, with a particular focus on molluscan remains, Daniel H. Sandweiss (Rollins et al. 1986; Sandweiss et al. 1996; Sandweiss et al. 1999; Sandweiss et al. 2001; Sandweiss 2003; Sandweiss et al. 2004) has proposed that waters along the Peruvian coast cooled around 5800 cal BP, leading to increased richness in coastal fisheries (see also Huckleberry and Billman 2003; Thompson et al. 1995; it should be noted that Carré et al. 2014:10450 contradicts this). By 5000 BP, sea level stabilized and ENSO events increased until 3200 BP (see Beresford-Jones et al. 2015 for a summary). It is this time (between 7000-5000 and 3200 BP), at a point of sea level stabilization, cooler sea temperatures and overall increased ENSO frequency, which marks the onset of the modern coastal environment. In other words, early agriculturalists were reckoning with a changing ENSO regime (3200-3000 BP).

**ENSO and the development of the north coast landscape.**

El Niño floodwaters play a central role in floodplain development on the north coast. Manners et al.’s (2007:235) work in the middle and upper Mocquegua River Valley demonstrated that river channels widened by 30% after an El Niño event in 1946, causing the loss of 19ha of land and increased entrenchment of the main river channel. Manners et al.’s 2007 study is consistent with the response of rivers to discharge surges in other arid environments, where channels are recorded moving up to 3.2km laterally and up to 6m in depth through incision after major flood events (Graf 1983; Huckleberry et al. 2012). Consequently, terraces of varying height and age surround the increasingly entrenched river (see also Hudson 2004). However, in the years after the Mocquegua 1946 event, sediments were continuously deposited along the new channel terraces, resulting in the slow recovery of land. The stratigraphy of older terraces along the Mocquegua river show near-continuous deposition of alluvium at a rate of 3mm/year.
(245 cm since AD 1230) (Magilligan 2008:20). Consequently, Manners et al. (2007:243) conclude that 80% of the Moquegua Valley is younger than 550 $^{14}$C years.

In summary, El Niño flooding causes river channels to widen and, therefore, leads to the immediate loss of arable land near the narrow valley neck; however, the floodwaters transport that sediment and deposit it onto fan terraces and aggrading river terraces. In other words, rather than being ‘lost’ outright, sediment is mobilized, remaining in the system. Floodwaters transport sediments in the immediate aftermath, but, in the longer-term, the same vegetation encouraged by the influx of water works to slow down erosion (Tote et al. 2011). This sediment load made mobile by El Niño flooding has extenuating consequences for the landscape, including the pampas surrounding the floodplain.

Aquifers of the north coast: Groundwater and ENSO. As described above, both the western Andean flanks and the coastal mountain range are made up of near-impermeable igneous rock. In those areas where either the coastal mountain range or near-shore coastal uplift slows groundwater flow to the Pacific, subterranean aquifers are formed close to the surface (5-20 m). In the Chicama Valley, Gilboa (1969) identified three important aquifers: a large aquifer in the area of the Cartavio hacienda in the lower valley, a “saline swamp” just to the west of Paiján, and a projected aquifer in the area of the Pampa de Mocan—the piedmont nestled between both the western flanks and the coastal mountain range. Today these aquifers make up a significant portion of the Chicama Valley water supply. Gilboa (1969:79) reported over 550 wells in the area, which are exploited at a rate of 175 mcm/year. Over 80% of the Chicama wells are less than 30 m deep (Gilboa 1969:79). Together, these data point to an expansive and important aquifer supply in the Chicama Valley, therefore, the question of recharge is particularly salient. While Gilboa (1969) argues that the majority of aquifer recharge occurs through river and irrigation seepage, Taltassee (1973) points out the significant difference across river and groundwater temperature and chemistry. These differences suggest that the river supply and groundwater supply originate from different sources; Taltassee (1973:109) suggests groundwater recharge through geological faults. Magilligan et al. (2008:26-27) go a step further and use isotopic composition from groundwater samples to argue that groundwater supplies are ultimately controlled by ENSO patterning. The authors
hypothesize that ancient springs were recharged after El Niño flood events in the prehispanic past, playing a crucial role in the maintenance of groundwater levels. In the Mocquegua Valley, Tiwanaku canals were located near such springs, which were then tapped to carry water to marginal areas on the edges of the floodplain. These canals date to around AD 730—coincident with a significant El Niño flood event (Magilligan et al. 2008:28). El Niño serves a vital role in aquifer recharge, and therefore, would have allowed for agricultural expansion beyond the valley-bottom floodplain in the prehispanic past.

**ENSO and the arid landscape.** Above the surface, El Niño floods have an enormous impact on the sediment load both in the floodplain and in the pampas. As described above, the immediate effects of flooding in the floodplain include extensive land-loss; however, land is recovered in the longer-term (~30 years). Meanwhile, beyond the floodplain, the desert pampas are directly affected by the mobilized sediment load. Two variables contribute to this process: 1) sediment transport and 2) plant growth (Tote et al. 2011:1777). Londoño et al.’s (2012) study of the Ilo dune fields in southern Peru concludes that periods of influx of eolian deposition are preceded by ‘hydrologic excess’ in nearby floodplains (Londoño et al. 2012:12-13). In other words, El Niño floodwaters carry sediments from the eroded land surfaces of the upper and middle river valley to the river delta and coastal beach ridges (Wells 1988:176). There, trade winds pick up the loose sediments and transport them to the pampas where they add to the active dune fields and desert pans—also known as ‘peri-desert loess’ or more commonly, ‘soil dust’ (Goudie and Middleton 2006; Noller 1993; Pye and Tsoar 2009:143). The influx of dust in north coast deserts enriches the soil content, adding higher percentages of both silt and clay than expected for hyperarid sediments (Noller 1993:133-157; see also Mächtle and Eitel 2013). Ultimately, ENSO contributes to the topography and formation of these desert or pampa areas, and crucially to the enrichment of sediments—adding loess inclusions to the otherwise largely gravel, sand, and sandstone soils. In the pampas, with the influx of ENSO-related water, these soils support blooming events that have far-reaching consequences for the landscape and the ecosystem.
ENSO-related blooming events. The arid and semi-arid areas surrounding the valley floodplains encompass a diversity of vegetation communities, including lomas, or fog-drip communities, and xerophytic plant communities. In lomas areas, Dillon (2005:132) reports the effects of El Niño Southern Oscillation (ENSO) on both Tillandsia and Solanaceae, and determines that Solanaceae population increases during ENSO years, while Tillandsia dominates in non-ENSO years. In fact, in one case, Dillon (2005:141) observed the cultivation of Solanum tuberosum (potato) in lomas during ENSO years, suggesting that the species’ presence in these formations may be attributed to human activity. Dillon et al. (2011) and Manrique, Ferrari, and Pezzi (2010) have observed that ENSO has an overall positive effect on the extension, density (Beresford-Jones et al. 2015; Muenchow et al. 2013), and diversity (Dillon 2005; Muenchow et al. 2013) of lomas plant species. Moreover, there is a higher degree of plant diversity, overall, with the Solanaceae, Asteraceae, and Brassicaceae families exhibiting the greatest species diversity (Dillon and Rundel 1990; Muenchow et al. 2013). ENSO, therefore, bolsters lomas plant communities and the history of their geographic distribution and endemic plant life has close ties to the history of ENSO frequency.

Outside of the lomas environments, the arid and semi-arid deserts or pampas undergo spectacular transformations in the aftermath of El Niño flooding. During the 1982/1983 and 1997/1998 ENSO events on the north coast, the annual streamflow was 5.4 times higher than average and rainfall was up to 25 times the norm (Holmgren et al. 2006:88; Tote et al. 2011:1785). This influx of water into desert environments resulted in explosive blooming events with staggered appearances of first, herbaceous ground cover, followed by shrubs, and finally trees (Richter and Ise 2005:143-144). The typical (non-ENSO) vegetative community in Peruvian deserts was recorded in the in the Sechura Desert in the far north of Peru:

Desert areas: <5% plant cover. Prominent members: Galvezia limensis, Encelia canescens, Alternanthera halimifolia, Maytenus octogona and Haageocereus pacalaensis. Sporadic associates: Prosopis pallida and Capparis scabrida.
Semi-desert areas: between 5-25% plant cover. Trees (1-5%) include *Prosopis pallida*, *Capparis scabrida* and *C. avicennifolia*. Shrubs: *Encelia caescens*. Prostrate subshrubs: *Tiquilia paronychioides* (Richter and Ise 2005:143-144).

During the El Niño rainfall in March 1997/1998, plant cover consisting of largely herbs and grasses increased to 100 +/- 20% in just three months (Richter and Ise 2005: 143-144). Arid ecosystems are capable of responding quickly to pulses in precipitation due to seed banks that have built up over time—Holmgren et al. (2001, 2006) argue that annual species survive the long interims between flood events by producing a large amount of seeds (Holmgren 2001:89; 2006:88). However, the boom in propagation of grasses quickly declines: by October 1998 almost all of the fast-growing grasses had perished (Richter and Ise 20015:144). In contrast, tree and shrub growth can persist for much longer and therefore continue to affect the water and sediment supply to the floodplain. Richter and Ise (2005:144) report an increase in tree cover in the Sechura Desert from 1.75% in 1997 to 7.5% in 2004. Woodland restoration impacts both the drainage system and environment, affecting vegetation cover and the growth of companion species, erosive processes and groundwater levels, which in turn have significant consequences for human occupation (see Beresford-Jones 2009).

Coevolution: ENSO, landscape, and society on the north coast.

The coastal environment of Peru was largely established by around 8000-6000 BP (Thompson et al. 1995; Wells 1988:163-172). Hyperaridity on the coast has been the norm since the Quaternary: the Andean rain-shadow, the Humboldt current, and the South Pacific anticyclone (southern oscillation) reached their present conditions by at least the Pleistocene. Finally, Wells (1988) and Wells and Noller (1999) find no evidence for significant tectonic uplift on the north coast during the Holocene (see Moseley 1983 for contrasting theory). Therefore, while some early preceramic sites located along the coastline have been affected by eustatic sea level change and related fluvial aggradation, those landscape changes that have taken place since 5000 BP are the result of human impact and/or significant sediment transport, which, on

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7 As mentioned earlier, eustatic change largely ceased by 7500/5000 BP, although there is evidence that sea level dropped by about 1m around 3500BP and then returned to modern levels soon-thereafter (see Wells 1988:162).
the arid north coast, can only be attributed to El Niño. It stands to reason, therefore, that human-ENSO dynamics form an important contribution to the cultural and landscape histories of the north coast.

Society and El Niño. Discussion surrounding human societies and El Niño in coastal Perú is often couched in “hazard research” (Bawden and Reycraft 2000). El Niño as a disaster is easily observed today and has been identified in the historic and prehistoric past. For example, two “mega-Niño” events dated to 500 BC and AD 1100 were identified by Nials et al. (1979) through geoarchaeological work in the Moche Valley. Based on analysis of historic flood deposits, Nials et al. (1979) estimated the AD1100 event to have been 2-4 times more powerful than the infamous 1925 event (see also Chang Huayanca 2014). Such an event would have affected settlements and entire irrigation systems, possibly triggering societal collapse, and even entering in to local mythology.

Moseley (1983) and others (Clement and Moseley 1991; Craig 1986; Keefer et al. 2003; Satterlee et al. 2000; Shimada 1994) have argued that the convergence of environmental stressors, such as prolonged drought, tectonic uplift, and earthquakes with El Niño events around AD 600 and AD 1100 led to a rupture in both the Moche and Chimu cultural systems. Specifically, according to these studies, the failure of canal systems in the face of tectonic uplift was a socio-political tipping point. Clement and Moseley (1991) dated the patterns of canal abandonment to approximately AD 1100—similar abandonment was observed in the Moquegua/Osmore Drainage and the Moche Valley at this time (Satterlee et al 2000; Keefer and Moseley 2008; Moseley 1983). However, Wells (1987;1990; Wells and Noller 1999) has argued that there is no evidence on the north coast of tectonic uplift that would have rendered these canals systems obsolete. Instead, she points to lateral main-channel movement and channel incision caused by El Niño flooding as a more likely cause of canal abandonment. Meanwhile, Keefer, Moseley and deFrance (2003) present evidence that the massive debris flow caused by El Niño sheet floods directly affected preceramic settlement at the Quebrada Tacahuay, forcing occupants to move.

While archaeological evidence demonstrates the direct impact of ENSO on canal systems and settlement patterns; secondary effects, such as disease, food and water shortages, were equally disruptive to society and possibly inspired mass human sacrifice (see Kiracofe and Marr 2008; Zhou et al. 2002;
Prieto 2014). However, other studies demonstrate that life simply moved on after major events. Uceda’s (1993) excavations in the urban sector at the Huaca de Luna revealed a major flood layer, followed immediately by an occupation layer. Moore (1990) reported a similar pattern in the Chimu sites of Quebrada Sta. Catalina and Manchan. Finally, Huckleberry, Hayashida and Johnson (2012), have shown that despite repeated flood events, the Racarumi canal system was quickly repaired and functioning soon after. The human response to these challenges has been recorded in several ethnographic case studies: in Peru and across the globe, humans have invented ways to both predict events and take advantage of excess water.

Avoiding disaster. Risk management is perhaps the fundamental principle of smallholder agricultural strategy (Netting 1993), and when facing the effects of ENSO, agriculturalists across the globe and Peru have developed ways to cope with damage to canals, debris flow, erosion, and even food supply. For example, Rajindra K. Puri’s (2007) work with farmers in Borneo observed that despite the effects of ENSO, farmers rarely suffered crop failure or shortage. Specifically, farmers planted a mixture of perennials and annuals alongside drought-tolerant species and staggered their plantings across the landscape (Puri 2007). Terry Stocker (described in Quilter 1983:552), in the course of conducting fieldwork at the Preclassic site of El Paraíso on the Central Coast of Peru, spoke to local fishermen who could predict El Niño based on migratory patterns of fish reacting to the warming currents in the months preceding an event. Both ethnographic and archaeological studies record flood-discharge mitigation technology, including check-dams, but also systems of diversion canals (Brooks et al. 2005). Wells and Noller (1999:756) recorded this practice during and after the 1982-1983 El Niño event in the Casma Valley:

“In 1985, we observed the remains of modern ‘abandoned’ canals adjacent to the Sechin branch of the Río Casma. These canals had been dug by backhoes or other heavy equipment in attempts to reclaim land during the 1983 El Niño. Local farmers, displaced from their farmland by flooding, attempted to harness the flood discharge into these canals. The canals were abandoned, due to the recession of the floodwaters, before any agricultural land was actually reclaimed”.

Similarly, in the far north region of Piura, Víctor Eguiguren reports in March 1824:
“In various places in the province of Piura I have recognized traces of the admirable hard work of the ancient inhabitants of these regions. In the Solsol estate there are two canals to irrigate the two banks of the Río Seco creek. The one on the right is perfectly preserved and very little would be spent on restoring it; but there are no branches to cultivate the lands that would be eventually irrigated, when heavy rains fall in the Shilagua mountain range” (Hocquengham 1998:312) [Translation by the author].

These few historical references reflect a long-standing practice of implementing construction features in anticipation of floodwaters—what Dillehay and Kolata (2004:4329) refer to for the Early and Late Intermediate Periods (AD 500-1500) on the north coast as “defensive infrastructure” (see also Brooks et al. 2005). However, ethnographic accounts of smallholder behavior in the aftermath of the 1998 El Niño event in the Chicama Valley suggests that risk management strategies involved not only re-directing water flow, but also relocating the fields themselves. Cesar Galvéz (2011) observed that local farmers moved their ruined fields in the inner valley to the desert margins where they used the temporary water sources, i.e. rejuvenated springs and water table, to continue growing their crops (Galvéz Mora and Runcio 2011). Galvéz reported that farmers secured harvests for up to 4 years after the 1998 event. In other words, there are several potential strategies that aid in managing the effects of ENSO in its various forms. Moreover, desert plant and animal response to increased ENSO moisture creates the conditions for a refuge of productivity when areas in the inner valley or floodplain experience environmental stress.


This past spring, February-April 2017, witnessed the most devastating El Niño event in recent memory, resulting in 158 flood-related deaths and 1,372,260 people displaced or otherwise affected. In the Chicama Valley the rains and floods brought urban and rural life and modern infrastructure, including highways, bridges, and irrigation systems to a standstill. However, just outside the irrigated valley in the typically-arid Pampa de Mocan, a veritable oasis emerged in the months after the El Niño floods, and the presence of archaeological remains in the area suggest that prehistoric inhabitants predicted and took

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8 Original quote in Spanish: “En diversos lugares de la provincial de Piura he reconocido huellas de la admirable laboriosidad de los antiguos pobladores de estas regiones. En la hacienda de Solsol hay dos canales para regar las dos márgenes de la quebrada Río Seco. El de la derecha se conserva perfectamente y se gastaría muy poco en restablecerlo; pero no hay brazos para cultivar las tierras que se regarían eventualmente, cuando caen fuertes lluvias en la cordillera de Shilagua.”
advantage of this effect (see Chapter 3). In June and July 2017, my team of biologists from the Universidad Peruana Cayetano Heredia and I conducted an intensive survey and collection of the plants that appeared as a result of the El Niño waters in the Pampa de Mocan. The result of the project is an herbarium collection of over 45 unique plant species, approximately 70% of which appeared in the aftermath of the 2017 El Niño event (Table 2). El Niño-bloom plants included wild tomatoes, flowering herbs, gourds, and legumes, along with sturdy shrubs and young trees such as Capparis (also known as caper bush) and Prosopis (or carob tree in the United States). Additionally, the seed bank blooming event attracted new insects, and consequently expanded the trophic chain. We observed desert lizards (likely Dicrodon guttulatum), foxes (Pseudalopex sechurae), the Peruvian crested swift (Microlophus occipitalis), burrowing owls (Athene cunicularia nanodes), and the migrating peregrine falcon (Falco peregrinus) (Figure 4) (Richter and Ise 2005:143-144). It is easy to imagine the presence of additional primary consumers, such as rodents and white-tailed deer, and more secondary predators, including hawks or large felines during other large events.
Figure 4. Examples of animals that appear in the post-ENSO conditions in the Pampa de Mocan: a) Dicrodon (lizard); b) *Athene cunicularia nanodes* (burrowing owl); c.) *Falco peregrinus* (Peregrine Falcon). 07-2017. Photos by the author.

Table 2. Families and species identified and collected in July 2017. Several Poaceae species were collected but are not included here because they are still undergoing identification to the species level. Identification completed by Roxana Tornero, UPCH.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaranthaceae</td>
<td><em>Althernanthera halimifolia</em></td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td><em>Alternanthera peruviana</em></td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td><em>Amaranthus haughtii</em></td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td><em>Atriplex rotundifolia</em></td>
</tr>
<tr>
<td>Apocynaceae</td>
<td><em>Matelea aliciae</em></td>
</tr>
<tr>
<td>Asteraceae</td>
<td><em>Encelia canescens</em></td>
</tr>
<tr>
<td>Asteraceae</td>
<td><em>Isocarpha microcephala</em></td>
</tr>
<tr>
<td>Boraginaceae</td>
<td><em>Heliotropium angiospermum</em></td>
</tr>
<tr>
<td>Boraginaceae</td>
<td><em>Tiquilia dichotoma</em></td>
</tr>
<tr>
<td>Boraginaceae</td>
<td><em>Tiquilia paronychioides</em></td>
</tr>
<tr>
<td>Bromeliaceae</td>
<td><em>Vriesea cereicola</em></td>
</tr>
</tbody>
</table>
Table 2. (Continued)

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capparaceae</td>
<td><em>Capparicordis crotonoides</em></td>
</tr>
<tr>
<td>Capparaceae</td>
<td><em>Capparis avicennifolia</em></td>
</tr>
<tr>
<td>Capparaceae</td>
<td><em>Capparis scabrida</em></td>
</tr>
<tr>
<td>Cucurbitaceae</td>
<td><em>Luffa operculata</em></td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td><em>Chamaesyce serpens</em></td>
</tr>
<tr>
<td>Leguminosae</td>
<td><em>Dolichos purpureus</em></td>
</tr>
<tr>
<td>Leguminosae</td>
<td><em>Hoffmannseggia viscosa</em></td>
</tr>
<tr>
<td>Leguminosae</td>
<td><em>Macroptilium lathyroides</em></td>
</tr>
<tr>
<td>Loranthaceae</td>
<td><em>Psittacanthus chanduyensis</em></td>
</tr>
<tr>
<td>Martyniaceae</td>
<td><em>Proboscidea altheifolia</em></td>
</tr>
<tr>
<td>Nyctaginaceae</td>
<td><em>Allionia incarnata</em></td>
</tr>
<tr>
<td>Nyctaginaceae</td>
<td><em>Boerhavia verbenaceae</em></td>
</tr>
<tr>
<td>Nyctaginaceae</td>
<td><em>Commicarpus tuberosus</em></td>
</tr>
<tr>
<td>Nyctaginaceae</td>
<td><em>Cryptocarpus pyriformis</em></td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis dombeyi</em></td>
</tr>
<tr>
<td>Plantaginaceae</td>
<td><em>Galvezia fruticosa</em></td>
</tr>
<tr>
<td>Plantaginaceae</td>
<td><em>Scoparia dulcis</em></td>
</tr>
<tr>
<td>Polygalaceae</td>
<td><em>Monnina herbacea</em></td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Exodeconus postratus</em></td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Lycopersicon pimpinellifolium</em></td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Nicotiana glutinosa</em></td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Nicotiana plumbaginifolia</em></td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Solanum sp.</em></td>
</tr>
<tr>
<td>Verbenaceae</td>
<td><em>Lantana svensonii</em></td>
</tr>
<tr>
<td>Zygophyllaceae</td>
<td><em>Tribulus longipetalus</em></td>
</tr>
</tbody>
</table>
The Pampa de Mocan features densely concentrated archaeological surface remains including a vast irrigation system (see Chapters 3 and 4). The system included both opportunistic technologies, such as check-dams to divert or capture floodwaters dating to around 900 BC, and planned, large-scale infrastructure, such as aqueducts and irrigation canals dating to AD 1460. The vegetation of the 2017 ENSO event clustered in patterns along the irrigation features, suggesting differential moisture retention across the landscape (Figure 5). Although data are still undergoing analysis, the clear preference of herbs and grasses—the ‘first responders’ to water influx—for ancient irrigation canals demonstrates the long-term effects that these anthropogenic modifications have on the landscape. Moreover, if humans were able to predict these patterns of water retention, risk strategies likely adapted in kind. My team and I observed a clear example of this kind of adaptive behavior along the Ascope Aqueduct, a monumental prehispanic canal system. The adobe-built aqueduct follows the topography of the nearby Andean foothills, but in a few areas, the aqueduct acts as a dam to a natural ravine. In these areas, identified by geologist Gary Huckleberry in 2014-2015, excess water from the 2017 El Niño rainfall collected and was captured in the alluvial fill that has accumulated behind the aqueduct wall over centuries of flood events. Today, much like in 1998 (Galvéz and Runcio 2011) local farmers have tapped the near-surface moisture and have planted bean, squash and cornfields (Figure 6).
Figure 5. New, post-ENSO Poaceae growth follows the meandering channel of an ancient canal in the Pampa de Mocan. Photo by the author.

Figure 6. Image of an opportunistic corn-bean-squash field located behind the ancient adobe construction known as the Ascope Aqueduct. 07-2017. Photo by the author.
**Interpretations.**

“The environmental limitations of life in this harsh desert landscape have long colored the interpretation of the archaeological history… The resulting view is often of a nearly static desert landscape impacted exclusively by intermittent catastrophic events, either earthquakes or El Niño flooding” (Wells 2001:121).

Discussion of El Niño and its effects is often couched in terms of hazard research, catastrophism, or collapse. Warm El Niño currents lead to mass deaths in fisheries, and floodwaters cause extensive erosion, breach irrigation infrastructure, and perhaps most destructive for local smallholders, flood agricultural fields. Secondary effects include diseases, rodents, insects, and food and water shortages.

However, ENSO has ‘positive’ effects on the landscape as well. Floodwaters and erosional processes are integral to the formation of soils in the floodplain and flushing out salts; the sediment load that eventually settles in the sandy pampas around the valleys is rich in loess and clays. Settlement patterns suggest that ancient inhabitants understood the dynamics of the floodplain, preferring older, more stable surfaces, such as alluvial fans, old dunes, coastal deposits, or the ancient floodplain; only 14% of sites in the Casma Valley were located on erosional surfaces (Wells 1987:121). ENSO floodwaters rejuvenate subterranean aquifers, reactivating local springs. Perhaps most spectacularly, El Niño germinates an entire ecosystem in a matter of months in the desert: herbaceous plants emerge first from extensive seed banks, followed by shrubs and woody species. Woodlands can be particularly resilient once established and lead to long-term changes to the water regime. Moreover, the ethnographic record makes clear that local farmers have developed innovative responses to ‘la abundancia’ or excess water flow from El Niño floods. These range from the construction of diversion canals and check dams, to opportunistic fields. Flexibility and mobility are key to mitigating the risk posed by El Niño events: north coast smallholders practiced risk management, but also risk ‘aprovechamiento’—today and in the past, they have developed ways to make ENSO cycles agriculturally productive.

In recent years, the field of environmental archaeology has moved away from a systems-based, or neo-evolutionary approach often critiqued as ‘environmental determinism’ (see Erickson 1999), where ‘disaster’ has only transitory effects on ‘normal’ conditions. Michael Moseley (1987) applied the term ‘punctuated equilibrium’ to this dynamic: where disaster triggers an adaptive response, whether social,
technological or political, which attenuates the disruption caused to the normal system. Instead, the historical ecology framework begins with the assumption that disaster and society are intertwined—“’nature’ is embedded within human systems” (Hakansson and Widgren 2014:12; Balée 2006; Balée and Erickson 2006). In other words, disaster can be defined by the damage relative to typical social response—human behavior, subsistence, settlements and norms determine those conditions. Humans then make choices in response to those disasters, entering into a feedback loop of adjustments with a positive slope; rather than short-term response aimed at returning to system equilibrium, the historical ecology approach recognizes sustained change (Balée 2006; Balée and Erickson 2006). These changes are reflected in features on the landscape—for example, in the form of landesque capital, defined by Blaikie and Brookfield (1987:9) as “any investment in land with an anticipated life well beyond that of the present crop or crop cycle” (emphasis added).

The following chapter outlines the evidence from fossil fields of the Pampa de Mocan. Archaeological data from the Pampa de Mocan suggest that El Niño and the sporadic or seasonal appearance of water, was a driver of agricultural development.
CHAPTER 3: IRRIGATION AND THE PAMPA DE MOCAN.

Chapter 1 of this dissertation detailed those underlying assumptions that give early, neo-evolutionary models of agrarian change in arid regions their resilience: arid environments are assumed to impose limitations on arable land. Furthermore, in river valleys, the source of water is considered centralized and circumscribed. The desert north coast of Peru adds another variable to the environmental milieu: periodic El Niño flood events. However, the Chapter 2 discussion of the environmental and topographic diversity of the north coast, and the integral role of ENSO in local ecology, challenges these assumptions. In the present Chapter, I evaluate the archaeological evidence of farming in the Pampa de Mocan under a new rubric that views arable land as an unlimited resource. I justify this assessment through the careful outline of the seasonality of this area and the potential for alternative water sources. Next, the role of irrigation on local climate and soil will be described, with particular emphasis on the signatures of irrigation in ancient soils. The final sections of this Chapter are dedicated to the archaeological data that reflect the ancient irrigation practices in the Pampa de Mocan, beginning in the Early Horizon (900-500 BC) and continuing until the Late Intermediate Period (AD 900-1470). This Chapter concludes that the farming history of Mocan reflects behavior that centered on water management and water maximization, rather than the maximization of land. Opportunism, rather than territorial expansion, makes up the connective tissue of the history of the Pampa de Mocan.

Seasonality.

The Chicama River experiences seasons of relative water abundance and scarcity (Tables 3 and 4). During the months of May-Sept, the maximum monthly river discharge average is just 21m³/sec; meanwhile, between December and April, the volume increases to more than 200m³/sec (see Table 3). In other words, despite perennial flow, the volume of river flow is not held constant all year round. Kosok (1965) suggested that ancient farmers likely prepared landscapes with embankments or even canals in anticipation of high-volume-flow months.

<table>
<thead>
<tr>
<th>River</th>
<th>Total Catchment Area (m²)</th>
<th>Years of measurements</th>
<th>Flow (thousand m³/year)</th>
<th>Duration of max flood</th>
<th>Month of Max Flow</th>
<th>Month of Min Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicama</td>
<td>5806.0</td>
<td>1911-1960</td>
<td>982,260</td>
<td>Jan-May</td>
<td>March</td>
<td>August</td>
</tr>
</tbody>
</table>

Table 4. Chicama River monthly discharge. Adapted from ONERN 1973.

<table>
<thead>
<tr>
<th>Month</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
</tr>
</thead>
<tbody>
<tr>
<td>m³/second</td>
<td>17.38</td>
<td>11.01</td>
<td>7.97</td>
<td>10.25</td>
<td>12.88</td>
<td>17.45</td>
</tr>
<tr>
<td>Month</td>
<td>December</td>
<td>January</td>
<td>February</td>
<td>March</td>
<td>April</td>
<td>May</td>
</tr>
<tr>
<td>m³/second</td>
<td>44.27</td>
<td>93.26</td>
<td>157.1</td>
<td>469.84</td>
<td>244.77</td>
<td>61.48</td>
</tr>
</tbody>
</table>

Other water sources.

The main and permanent water source of the Chicama Valley is the Chicama River, with a total watershed of 5806m² (ONERN1973). The Pampa de Mocan is located approximately 30km north of the River, and has no active water sources; however, there is ample evidence that suggests the existence of ephemeral streams, springs, a possible lagoon, and a high-water table in the area in the past. According to Hecker and Hecker’s (1990) deductions based on Ubbelohde-Doering’s 1950s (1959) notes, a small lake or lagoon used to form in the area near Cerro Tres Puntas after periodic El Niño rains. Chauchat et al. (1998) confirmed evidence of a small ancient lake and identified a second possible lagoon on the northern flank of Cerro Colorado. Chauchat et al. (1998) also identified several springs in the heights of Quebradas Santa Maria and Cuculicote. Springs and evidence of ancient spring-fed agriculture have been observed in other areas of the north coast and recorded in colonial documents (Clement and Moseley 1991; Netherly 1981; Sabogal Wiesse 1974). Indeed, springs and ephemeral streams were an important water source up to and including the colonial period; however, such features were likely very sensitive to changes in the irrigation regime and no longer exist today. Meanwhile, Gilboa (1969; 1971) and Taltasse’s (1973) work on aquifers in the Chicama Valley demonstrate the importance of phreatic water sources for agriculture in
the recent past (see Chapter 2). Gilboa (1969) reports the existence of an aquifer in the area of the Pampa de Mocan, which would have been recharged by irrigation seepage in the past or El Niño flood events in the past and today. Indeed, NDIR imagery of the area of Mocan captured during the aftermath of the 2017 Coastal El Niño, depicts an area of high reflectivity, possibly due to a near-surface aquifer (Figure 7). Ancient water-table farming is well-known in the lower-valleys across the north coast (Knapp 1982; Parsons 1968; Rodbell et al. 1999; Smith 1979; West 1979).
Figure 7. Images of the Pampa de Mocan (polygon outlined). In the left Sentinel 2 Band 8 NIR Image just before the 2017 ENSO, no anomaly is visible, while in the right Sentinel Image the anomaly is visible as an orange area in the middle of the polygon. Figure provided by Benjamin Vining.
Finally, reservoir farming is common across the north coast today. Modern still-water irrigation systems were first established in the 1950s with government-sponsored projects, including the well-known Tinajones reservoir in the Lambayeque Valley. In the highland Andes, similar constructions are used as back-up systems during extended dry seasons. Ancient reservoirs have been alluded to by several scholars (Eling Jr. 1987; Sabogal-Wiesse 1974), though few have been identified in the archaeological record. Watson (1979) points out that the area of Cerro La Laguna near the Ascope Aqueduct forms a small lake. This lake is actually a permanent reservoir that collects irrigation runoff from both abandoned and active upslope irrigation seepage. The reservoir expands and contracts during wet and dry seasons; however, any evidence of diversion canals that may have carried water from the reservoir to ancient fields has been long-destroyed by erosion. During the recent coastal El Niño event, the Cerro La Laguna reservoir reached over 20ha in area and likely over 2m deep in the center (Figure 8); a resource that almost certainly would have been exploited to water nearby lands in the Pampa de Mocan in the prehispanic past.

![Figure 8. Cerro La Laguna reservoir after the 2017 ENSO event. The reservoir forms between Cerro La Laguna and the ancient adobe construction known as the Ascope Aqueduct. Left Photo Credit: Jeffrey Quilter; Right: Photo by the author.](image)

Irrigation and local climate.

Irrigation itself can have a significant effect on local climate and may work to ameliorate what are otherwise harsh desert conditions. Lobell et al. (2009) and Wen and Jin (2012) studied the effects of irrigation on near surface temperature across many regions and found an overall cooling effect over cropland of up to 3.2°C (see also Kueppers et al. 2007). Moreover, over irrigated areas in India, an
increase in dense cloud cover was recorded; and in the SE United States, irrigation was linked to a 20% increase in precipitation (Lobell et al. 2009). Weberbauer (1945) in 1911 argued that the topography of the Chicama Valley was not conducive to the formation of dense clouds (the coastal mountains in the Valley are located too far inland), and for this reason, no lomas plant communities were present in the Chicama. However, today, the Chicama Valley does experience dense cloud cover in the summer months, and the extent of the cloud cover is likely related to active irrigation canals in the area (see Figure 9). As a result, the north coast valleys, including the Chicama Valley, experience mild temperatures with some humidity (Table 5), and, compared to typical desert climates, conditions are amenable to agriculture.

Table 5. Climate and weather averages in the Chicama Valley. Adapted from ONERN 1973.

<table>
<thead>
<tr>
<th>Locality in the Chicama Valley</th>
<th>Mean Temp C</th>
<th>Min Temp C</th>
<th>Max Temp C</th>
<th>Mean Rel. Humidity %</th>
<th>Evaporation (mm/year)</th>
<th># of Hours of sun/year</th>
<th>Rain mm/year</th>
<th># of years of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casa Grande</td>
<td>21.0</td>
<td>15.6</td>
<td>26.3</td>
<td>77.3</td>
<td>840.0</td>
<td>2142</td>
<td>15.7</td>
<td>19-26</td>
</tr>
<tr>
<td>Cartavio</td>
<td>20.4</td>
<td>16.7</td>
<td>24.0</td>
<td>78.3</td>
<td>1620.0</td>
<td>2195</td>
<td>10.2</td>
<td>10-17</td>
</tr>
</tbody>
</table>
Irrigation and soils.

Despite the extreme aridity, desert soils in this region are quite rich:

“The pampas, with their very fertile soil, represent excellent areas for agricultural expansion. But the necessary irrigation networks would pose complex problems of a technical character (for example, siting of diversion dams, length and alignment of feeder canals), and would involve investment beyond all proportion to the amount of water transported and to the areas brought under cultivation” (Taltasse 1973:109).
Soil types differ within river valleys on the north coast. Soils located in the river delta areas and in the lower valleys tend to be fine-textured and densely packed, trapping salts on the surface (see also Jacobsen and Adams 1958). Meanwhile, coarse-grained, loose parent materials, like those found in the upper valleys, valleys margins, and quebradas, have low water-holding capacities and low nitrogen content. Irrigation has both physical and chemical impacts on the soil and it affects desert soils and river delta soils differently. In general, irrigation results in an increase in biotic activity and, consequently, organic matter, also known as Soil Organic Matter (SOM) (Huckleberry 1992:238-239). When SOM is high, water-logging causes a gleying effect, resulting in a grey color (Holliday 2004:336). However, in desert soils where natural drainage is better than in near-river soils, SOM will oxidize and result in a porous topsoil (Holliday 2004:336). Permeability affects both the chemical and physical impacts of irrigation on soil.

Depending on the soil permeability, irrigation may result in an increase in soil pH. In soils that are poorly-drained, salts dissolved in irrigation water evaporate through capillaries toward the surface—a process known as salinization. Salinization is a destructive process and has been attributed to agrarian collapse in the Nile Delta, Tigris-Euphrates, and even Huang-Ho Valleys across time (Artzy and Hillel 1988; Harris 1960; Jacobsen and Adams 1958). Moreover, salinization can occur in different areas within a single valley system. In coastal Peru, in the La Leche Valley, Nordt et al. (2004) reported that over 50% of soils downstream of the river suffered high percentages of salinity, while those located in the mid- and upper valleys, with loose gravel content, enjoyed better drainage qualities. While some evidence of salt accumulation, such as shattered clasts and stone-splitting (salt-wedging), exists even in the mid- and upper valleys (including in the Pampa de Mocan), the salinity of desert soils on the north coast is low overall, even compared to the south coast (Noller 1993:201). This is likely due to the frequency of El Niño events throughout the Quaternary, which essentially flushed out the salts in this region (Noller 1993:158). Soil pH is largely related to salt content and, consequently, north coast desert soil pH tends to be mild, ranging from 5.2 to 8.8 with a mean of 7.7 (Noller 1993:168).
Physical changes to soil are closely related to sedimentation. Silts and clays suspended in irrigation water deposit on the surface of the given field, accumulating at rates of at least 0.5-2.0mm per year (Noller 1993:240). According to Huckleberry (1992), it is this effect that leaves a lasting signature of irrigation activity through time. However, despite ample evidence of irrigation infrastructure in both the Salt River Valley in Arizona and the Pampa de Mocan, there is a paucity of evidence for corresponding irrigated soils. In part due to the lack of visible soil horizons, Thomas Pozorski (1987:116) argued that the Pampa de Mocan was never developed agriculturally; rather, he hypothesized that the many field systems and trunk canals were constructed in anticipation of irrigation waters that never arrived. My observations of the Pampa de Mocan contradict this hypothesis, and I refer to the Salt River Valley Hohokam case study as an appropriate analogy to address the lack of visible irrigated-soil horizons in the Pampa de Mocan and other arid landscapes.

Soils and irrigation in the Pampa de Mocan.

The area of interest of the present study is the Pampa de Mocan. The Pampa de Mocan is located in the Department of La Libertad on the north coast of Peru, approximately 60km north of the Department capital, Trujillo, and on the southern edge of the Paijan Desert. The Pampa de Mocan, a general term for the areas of the Pampas de Huatunero and El Inca, and the Playa Mocan, makes up a total of approximately 5800ha of the right margin of the middle Chicama Valley (Figure 10). The present study is concerned with just under one third of the entire area, a 1707ha polygon in the northeastern extreme of the Valley margin. Watson (1979:208) reported that soil in this portion of the Pampa de Mocan (here on referred to as the Pampa de Mocan) was classified as regosols, or unconsolidated materials, originating from relatively recent erosional or alluvial formations, and lacking horizons—undeveloped and low in organic matter. However, studies show that these soil conditions can be partly mitigated through the deposition of fine sediments from irrigation (Strawhacker 2013). For example, natural quebrada soils in the area of the Pampa de Mocan are gravelly and highly permeable, allowing for good drainage. Repeated application of silt suspended in irrigation water would increase the silt and clay content of these soils,
resulting in increased water holding capacities and chemical reactivity related to enhanced fertility (see Hesse and Baade 2009 for a south coast example). Perhaps the best analogy in terms of environmental setting for the Pampa de Mocan in the archaeological record is that of the Salt River Valley in Arizona and its Hohokam occupation.

Figure 10. Area of the Pampa de Mocan and project universe.

The arid area of the Salt River Valley was irrigated intensively by the Hohokam over several centuries (AD 850-1450), however, surface analysis reveals an apparent lack of suitable soil (Huckleberry 1992; Masse 1981). Huckleberry’s (1992) work in the Salt River Valley provides a possible explanation as to why ‘cumulative irrigation’ was not sufficient to leave a lasting physical signature,

“This hypothesis implies a highly transitory irrigation strategy in which canals and field areas were shifted frequently...Transitory irrigation strategies may have been necessary to adapt to two environmental constraints: flooding and soil salinization. Salt River flooding and main channel lateral migration (Graf 1983; Nials and others 1989) was a high frequency event, and such processes favor the repeated abandonment and construction of canal headgates. The other environmental constraint is water-logging” (Huckleberry 1992:244).
Similar to Huckleberry’s (1992) findings, the Pampa de Mocan presents evidence of sediments formed when runoff flow is cut off by trunk canals, resulting in pooling on the upslope banks of the canals. Bankwash sediments, which accumulate on the banks of canals during dredging and cleaning, are also observed. Moreover, pockets of preserved soils are scattered across the Pampa, and these areas present oxidization patterns that imply flood-irrigation. Evidence from excavation and natural cuts across the Pampa de Mocan suggests that organic matter formed through irrigation resulting in darkened epipedons and greater "tilth" favorable for agriculture (Figure 11).

![Tilth, Oxidation related to SOM, Sterile deltic parent material](image)

Figure 11. Example of tilth formation in the Pampa de Mocan. Photo by the author.

The fields of the Pampa de Mocan.

While the Pampa de Paiján (just north of the Pampa de Mocan) was a site of early Holocene occupation (see Chapter 1; Chauchat et al. 1998) the desert marks a long-standing boundary between northern and southern political spheres for later complex societies such as the Moche (Early Intermediate Period) and Chimu (Late Intermediate) archaeological cultures (Castillo Butters and Donnan 1994; Chauchat et al.)
 Evidence of long-term occupation and agricultural development in the Pampa de Mocan questions the validity of this boundary.

Based on observations of aerial photographs, Richard Watson (1979) identified seven large intake canals that terminated in Mocan and attributed them to Chimu state construction (AD 1100-1460). Following the dominant model, Watson hypothesized that the Mocan irrigation project reflected the Chimu state’s need to feed a growing conquest population. Mocan was permanently abandoned shortly before Spanish conquest (see Chapter 6) leaving a near-pristine record of a prehispanic agricultural landscape, complete with trunk, intake, feeder and drainage canals, wells, and field systems. The fieldwork for my project took place over the course of two field seasons, Proyecto Arqueo-ambiental del Valley Chicama (Resolución N°361-2014-DGPA-VMPCIC/MC) and Proyecto Arqueo-ambiental de la Pampa de Mocan (Resolución N°124-2016/DGPA/VMPCIC/MC), one laboratory season between 2014-2015, and one botanical collection season (SERFOR Resolución N°226-2017-SERFOR/DGGSPFFS).

Methodology: recording archaeological remnants of farming and settlement. The archaeological fieldwork conducted over the 2014-2016 seasons will be described in the following sections and in Chapter 4. The data presented here will center on features related to irrigation and agricultural fields; the methods applied to record these features were designed to address the form of irrigation application and the sequence of use-lives or chronology both at the level of the landscape and within individual field and canal systems. Those data collected during these projects that are related to settlement will be presented in Chapter 4.

Description of field methods. In 2013, my team of 10 students and local professionals carried out a preliminary reconnaissance project across the 5800ha of entire the Pampa de Mocan. The goals of this initial, informal project, called the Chicama Valley Landuse Survey (CVLS), were to narrow-in on an area for intensive study, and conduct geological test pit excavations (see Chapter 5) aimed at better understanding the nature of the strata across the different landforms (wind-swept plains, alluvial platforms, dunes, arroyos, etc.). As a result of this preliminary study, I selected a 1707ha area on the
northeastern edge of the Pampa, where irrigation features were best-preserved. The following season, my co-director Luis Alberto Sanchéz Saavedra and I led a team of four Peruvian and American students and four local professionals in a systematic survey across this 1707ha area. This project, Proyecto Arqueoambiental del Valley Chicama (PAAVC), was a complete-coverage pedestrian survey with a 25% collection rate of ceramic material. The PAAVC survey was designed to 1) locate and record irrigation infrastructure and the extent of farmed areas, 2) record all sites, and 3) collect a sample of surface ceramic material. These data were aimed at two questions: how was farming in this desert landscape carried out? And, what was the historical sequence of farming in the area? Originally, survey was planned in uniform linear transects within cuadrants (1km² each) established during the CVLS project. However, it soon became clear that the topography of the area prevented a linear-transect survey design: the incised ravines, steep, aggraded alluvial platforms, and dunes posed a significant challenge to walking in straight lines. Therefore, the entire survey universe was divided by land-form type and linear transects were laid out within each section (Figure 12).
The survey results reflect two, overlapping spatial designations: cuadrants, which are the original 1km² divisions of the CVLS project (for example, 5C), topo-area or sector (i.e. CsC = Campos de Cultivo), the waypoint number, and if there was a site present, the unique site number (Figure 13).
Sites were defined by the presence of stone, adobe, *tapia* (poured adobe), or mixed-material architecture or the dense concentration of lithic tools, flakes, cores or other lithic production by-products. Concentrations of sherd scatter were not considered sites due to the clear, intentional use of ceramic fragments in agricultural fields (see Dunnell 1992). Therefore, ‘site’ strictly refers to activity spaces delimited by architectural remnants; sites, like field systems, are designated with their quadrant number (5C), waypoint (205), sector (CsC4), and unique number (2) (see Appendix C). If several sites were found in close proximity to one another and hypothesized to be related, they were further designated as a ‘Complejo’ and given the label C plus the corresponding series number (C6), followed by a backslash (/) and the unique site number (2). In other words, the site 5C-WPT205-CsC4-C6/2 could be located in the southern-middle area of the survey universe (5C), at waypoint 205 (692493 E; 9159169 N), related to the flat, wind-swept plain area of CsC4 (where a concentration of agricultural field systems were
identified), and is the second structure (/2) of the 6th-identified related group of sites (C or Complejo 6) (Figure 14):

Figure 14. Example of site-coding system.

This system was devised as a practical matter to create unique identifiers for both non-site features and sites and simultaneously place them in space in real time; this helped my team members both move around the landscape and to one another efficiently while carrying out the project.

Mapping and creating identifiers for non-site features was a significant challenge. Features such as canals crossed multiple quadrants, though they rarely cross-cut sectors (Figure 15). Meanwhile, field systems were irregular and therefore difficult to map in a time-efficient manner; additionally, creating unique identifiers was problematic both because no typology of fields existed at the time and because the relationship between field systems was difficult to discern on the ground. Our solution was to use
waypoints (WPTs) for all non-site features. Waypoints provided a neutral identifier, which freed me from having to apply an on-the-ground-typology. Most irrigation features were assigned multiple waypoints because they occupied multiple quadrants; as a result, the features appeared as an alignment of points when the data were uploaded to the spatial program.

Field systems were treated with a three-part process. First, each system was given a unique waypoint, and like irrigation features, some field systems were given multiple waypoints if they occupied more than one quadrant. After recording the identifying-waypoint, the team member would turn on the tracking tool on their handheld GPS unit and walk the edges of the field. Finally, the team member would sketch a 3x3m ‘sample patch’ of each field to record furrow width, shape, and depth relative to the ridge. Canals, and other non-site features, such as roads, geoglyphs or walls were designated with a unique waypoint number and later given new identifiers: trunk canals were labeled A-H; roads were labeled H

Figure 15. Trunk and feeder canals identified in the Pampa de Mocan. These features cross-cut quadrants. Photo by the author.
(with a number, 1-3) and walls were M. Field systems and geoglyphs maintained their original waypoint number as their identifiers (Appendix D). Therefore, field system labels have three parts (4C-197-CsC3), while sites have four-parts: (5C-205-CsC4-C6/2).

Ceramic material was collected at a 25% rate. Ceramics served as a relative dating tool for field systems and sites. Therefore, each ceramic collection was affiliated with a field system, site, or feature waypoint or given unique waypoints. In the course of walking transects within quadrants, each team member placed a waypoint on a field system, irrigation feature, non-irrigation feature, or site. The member then placed a stake as close to the waypoint as possible and using a measured string, walked a 5m radius around each waypoint to collect every fourth sherd (Figure 16) (see Appendix E). Each individual sherd was given a unique number (i.e. Fc01).

Figure 16. Ceramic collection across the Pampa de Mocan. Circle size reflects number of ceramics collected within a 5m radius around the given waypoint.

In addition to survey and surface collection, a second formal season called the Proyecto Arqueo-ambiental de la Pampa de Mocan (PAAPM) was dedicated to excavation. 18 excavation units were placed within the same 1707ha polygon. The excavation units were placed in fields (CC), sites (R), and features
thought to be related to water storage (P) (Figure 17). Field excavations (total 8 units) measured 2x1m, units placed in architecture (R) (total of 7 units) were 1x1m, and P-units (total of 3) measured 3x3m. Originally, only six of each unit-type were planned, however, several planned units were eliminated based on new erosion or modern-disturbance and new units were added to replace them. For example, CC4 and CC6 were planned excavations targeting specific field types; these units were eliminated due to modern-day interference from squatting land surveyors.

Finally, in 2016 and 2017, two drone missions, a total of five flights, were carried out by Luis Jaime Castillo Butters over selected areas of the Pampa de Mocan. The imagery captured landforms, the effects of the most recent El Niño event, and confirmed the extent and location of canals, field systems, and sites (Figure 18).
This chapter will look closely at the 8 excavations centered on agricultural fields, or the ‘CC’ units (Figure 19). Excavations were aimed at understanding the duration of use of these fields, the formation of soils where present, and the confirmation of field “type”, which was determined by the manner of irrigation-water application (see below). Therefore, the units reflect a variety of field types and chronological affiliation. Relative chronology of the fields was determined based on surface ceramics and geological signatures (degree of desert varnish, desert pavement, salt-wedging). Additionally, soil samples were extracted from each layer of the excavation profile for paleobotanical analysis.

Paleobotanical analysis, specifically microbotanical analysis of phytoliths, starch and diatoms, served to identify the cultigens grown on each field, along with any other environmental indicators. The following is a description of the history of use of the canals and field systems, with supporting data from phytolith, starch and diatom results.
Figure 19. CC excavation units in relation to their units and trunk canals. Each field system was assigned a waypoint number and its relative chronology determined by surface ceramics.

*Topography of the Pampa de Mocan.* As described previously, the Pampa de Mocan consists of essentially four types of landforms: piedmont aprons, the bajada or windswept-alluvial platforms, dry stream beds or channels (arroyos or quebradas), and dunes (Figure 20). Agricultural fields and features have survived best in the bajada, although many are visible extending out from beneath some of the dunes. Meanwhile, occupational sites exist on all three landforms (no sites were recorded in the dry channels). The only features visible on the arroyos are several aqueduct-like raised canals that crossed narrow stretches of the dry stream beds.
Figure 20. Selection of different landforms found across the Pampa de Mocan: a) dune fields; b) downcut dry ravines; c) piedmont flanks; d) wind-swept bajada with visible field features (S-shaped and straight furrows). Photos by the author.

The alluvial platforms across the Pampa de Mocan differ in age. The oldest surfaces present evidence of advanced desert varnish, deflation and/or desert pavement (Figure 21). Newer surfaces also exhibit deflation; however, pockets of remaining tilth are still visible (see Figure 11).
Field-System Types and Irrigation Strategies.

The field systems across the Pampa de Mocan, rather than indicating a uniform program of state-directed production, reflect the dynamism and diversity inherent in the ecology and landscape. Irrigation strategies are made visible in the form of fields and canals themselves; the following section will elucidate this link between field system type, irrigation strategy, and water availability.

Field systems are categorized around the manner of application of irrigation water. Irrigation in the Pampa de Mocan includes both surface-flooding and subsurface-flooding technologies. Surface flooding systems can involve irrigation through channeling river flow, capturing runoff or floodwaters, or ‘harvesting’ water from dammed reservoirs. Once the water reaches a prepared field, the system can be further broken down into either border-strip flooding, at times called low terraces; check-flooding, also known on the coast as ‘posas’ (see Hatch 1974); and furrow irrigation. Finally, raised fields are typically found in areas of standing water, seasonal inundation, or high-water table. In the case of raised fields, ridges are built up above the surface in order to prevent water-logging of plant roots.
Subsurface irrigation has also been identified across the coast, most notably at the site of Chan Chan, where sunken gardens or *mahamaes* were closely studied near the fishing villages of Chilca (Knapp 1982). Such fields were located in areas of ‘backmarsh’ where the water table could be reached through excavation. No sunken fields were identified in the Pampa de Mocan, although wells located in the lower bajadas of the Pampa indicate the use of the water-table.

The most obvious features of the Mocan landscape, however, are the eight monumental trunk canals (A-H), their branches, and modifications that terminate in this 1707ha area. While the point of origin of several of these canals has been obscured over time, several of the trunk canals (A-C) appear to have connected to the greater Ascope Canal System (ACS), best known for its iconic Ascope Aqueduct, (Figure 22) at some point during their use-lives.

![Figure 22. Projected path of the Ascope Canal System and the Intervalley Canal System (La Cumbre).](image)
The Ascope Canal System. The ACS appears to constitute one monumental irrigation branch, originating at an intake in the narrow neck of the Valley—conforming to a Wittfogelian ideal of concentrated economic and, therefore, political power. A recent study by Huckleberry, Caramanica and Quilter (2017) has shown, however, that the Ascope Aqueduct, a massive structure measuring approximately 30m in height, is the final instantiation of a multi-phase canal system. There had been many Ascope Canal Systems prior to and during the construction of the ultimate Aqueduct, likely dating as early as the Early Intermediate Period, with each construction responding to the breach or loss of a bocatoma or intake along the Chicama River bank. Across the river, on the southern side of the Chicama, the contemporaneous La Cumbre or Intervalley Canal is similar to the Ascope System in its monumentality and extension. When seasonal volume and flow of the Chicama is accounted for, Huckleberry et al. (2017) found that these systems could not have served the entire connected irrigation network at the same time. In other words, the Pampa de Mocan trunk canals that definitively connected to the ACS represent multiple phases of construction and adjustment to main channel migration and damaged intakes over time; and moreover, because of the competition presented by the La Cumbre system, it is unlikely that these canals irrigated the Mocan lands all-year round. Rather, Huckleberry et al. (2017) propose a rotating system of irrigation similar to the ‘transitory’ system postulated by Huckleberry (1992) for the Salt River Valley. Finally, an important component of the ACS is the laguna located upslope of the Ascope Aqueduct, which may have served as a reservoir during times of water shortage (see Figure 8).

Organization of discussion. The following discussion is organized around relative chronology and the eight trunk canals (A-H), however it must be noted that each of these canals was modified significantly, in some cases forming additional trunk branches (a1, a2, c1, c2, etc.) (Figure 23). The numbering of the trunk canals reflects their position along the slope, with A being the highest. Finally, the canals themselves had several distinct use lives, sometimes in isolated segments of the channel. Due to the ad hoc nature of use of these channels, they were deemed unreliable proxies for establishing a
chronology; instead, chronology is tied to ceramic sherd scatter on related field systems rather than on the trunk canals themselves. No attempt to date the trunk canals through OSL or radiocarbon was carried out by this project.

Figure 23. Total of eight trunk canals identified in the Pampa de Mocan and their branch canals. Canals B and C are considered separate based on closer investigation upstream.

Other features of agricultural activity are visible on the land surfaces across the Pampa de Mocan, including field furrows. Due to their varied and distinctive forms, some scholars have postulated a chronological or functional relationship for each furrow form. However, closer examination and ethnographic observations suggest that there is no one-to-one relationship between furrow dimensions or form and crop choice or time period. Instead, slope and desirable levels of water-pooling are primary in furrow choice. James Kus (1972) compiled a detailed thesis on ancient furrow types and field systems identified on the Pampas in the southern border of the Chicama Valley near the Quebrada del Oso site. There he argued that furrow width had a significant relationship to field-system type in only one case, that
of E-shaped furrows. Similarly, he argued that the classic serpentine-shape furrow, once iconic of prehispanic coastal agriculture (Kosok 1965:107), is most closely related to slope, occurring when slope is 3.1% or higher. The serpentine furrows were likely constructed to slow down water flow and prevent erosion. The present study, therefore, does not discuss furrow width or slope at great length. The analytical value of furrow form in the Mocan case study is as a metric of water abundance and as reflective of the manner of irrigation-water application. Concurrently, plant life, including crop choice, are related to water abundance and management. My work in the Pampa de Mocan recorded the same field furrow ‘types’ first identified at the Quebrada del Oso site by Kus (1972), including his types 1-6:

**Type 1:** Straight Furrow (Kus 1972:162): Average furrow width .62m, but a range of .36-.87m in width; Average slope 2.5%; Furrow direction is typically aligned parallel to slope. Modern equivalent is used for maize, beans, camote, and yuca. Tomato and aji are also planted in straight furrows but at much wider intervals. Other vegetables are also found in straight furrows, but at much narrower intervals.

**Type 2:** Interrupted Straight Furrow (Kus 1972:171): Similar to Type 1 except that every 4-6m a ridge blocks water flow and creates pooling; Average width of furrow .62m; Average slope 2.3%; Typically, furrows are aligned across the slope (rather than parallel) (Kus 1972: Figure 3). No modern equivalent.

**Type 3:** E-Type (Closed Type) (Kus 1972:174): Furrows formed in the shape of an ‘E’; Water pools in dead-end furrows with no outlet for each E; Typical alignment is across the slope; Average slope 2.5%; Mean width of furrows was .99m—there is a significant relationship between furrow width and this Type (Kus 1972:Figure 4). It should be noted that Zak (1984:54) reported that E-shaped swales in the Casma Valley were much wider than those near Quebrada del Oso. No modern equivalent.

**Type 4:** Serpentine furrows (Kus 1972:177): Furrows formed in the shape of an ‘S’; Unlike Type 3 ‘E’-shaped furrows, these typically have an outlet allowing for drainage (rather than water-pooling); Average furrow width was 0.8m; Average slope was 3.1%. The relationship between
slope and field type in this case is statistically significant (Kus 1972: Figure 5). No modern equivalent, but farmers report that this shape would help to slow water flow.

**Type 5:** Piled Stones: Two varieties:

First, there is Field Type 1 with Stone Piles: These are fields of mostly straight furrows overlain by stone piles with successive piles of stones spaced at one- or two-meter intervals throughout the normal Type 1 field.

Second, is the No-Furrow Stone Piles: The upper and lower ends of each field feature inlet and outlet channels; Stone piles are placed evenly in a ‘checkerboard’ pattern; Space between piles averages 1.67m; Average furrow width was .83m; Average slope was 2.7% (Kus 1972: Figure 6). No modern equivalent (See also Fish 2000; Homburg and Sandor 2011; Lightfoot 1996).

**Type 6:** ‘E-Serpentine’ (Kus 1972:181): A combination of the ‘E’-shaped furrows with inlet and outlet channels to prevent excessive pooling; Average furrow width was 1.02m; Average slope was 2.4% (Kus 1972: Figure 7).

In addition to these six field “Types”, the Pampa de Mocan adds the following (Figure 24):

**Raised Fields**, *sangrias* or *campos de camellones*, also known as *chiñampas* in Mexico (not to be confused with sunken fields, known as *mahamaes* or *campos undidos*). Raised fields are constructed globally to reclaim water-logged areas, low-lying marshlands or swamps, and lake or coastal margins. Raised fields are defined by Denevan (1974:24) as, “any prepared land involving the transfer and elevation of soil above the natural surface of the earth in order to improve cultivating conditions and can include mounds or ridges.” In the Andean region, raised fields, or *campos de camellones* (Valdés 2006), are best known in the highland region of Mojos de Llanos, Bolivia (Whitney 2014), Lake Titicaca Basin (Erickson 1993; 1988; Kolata 1993; Stanish 1994), and a rare coastal example in the Casma Valley (Moore 1988; Pozorski 1983; Zak 1984). Just beyond the core Andean region, raised fields have been identified in Rio San Jorge, Colombia (Parsons and Bowen 1966), Guayas Basin, Ecuador (Parsons 1969), Guayanas (Grenand 1981),
Llanos de Orinoco, Venezuela (Zucchi and Denevan 1979), Sabana de Bogota (West 1959), and Cayambe, Ecuador (Knapp 1991).

**Embankment Fields.** Embankment fields are defined here as a level area of cultivation bordered by a dike, ditch, bund, or low mound, which aids in the capture of runoff flow and debris (essentially, flooding a bordered field).

**Border-strip irrigation.** Watson (1979:143) described this type of field system as long, wide strips of land bordered by low walls. The strips run parallel to the slope. These fields are irrigated through a ditch at the top of the field and are more common in areas of low slope (0.1%-1.0%).

**Check-flooding or Posas.** In this system, fields are divided into small, cell-units (*posas*) with mounded borders (*bordos*). There is only one irrigation ditch at the top of the field and one ‘posa’ or unit is inundated at a time. Robert Hatch (1974) conducted an ethnographic study of modern farmers in the town of Motupe, Lambayeque Valley; there, these fields were used to grow mostly maize.

**Lithic Mulch fields.** Lithic mulch agriculture (LMA) has been described by Lightfoot (1996) as a strategy for arid-land agriculture to increase moisture in a given field while reducing the possibility of wind-erosion. Lithic mulching involves the application of pebbles or small rock fragments to the field and thus leaves a distinct surface signature. According to Lightfoot, LMA is known historically in the Negev, the Mediterranean, Atacama, northwest Argentina, New Mexico, New Zealand, the Canary Islands, and China. Typically, a borrow pit, a pit dug for the extraction of desired rock material, is found in close proximity to the field.

**Intra-canal fields.** These are fields excavated into the beds of abandoned trunk canals, with inlet ditches capturing pooled buildup on the upslope side of the trunk canal and an outlet channel leading from the field to the downslope side of the trunk canal.
Figure 24 displays all the field systems that could be confidently identified by the project; blank spaces represent areas where no field systems were recorded, however this should not be interpreted as evidence of absence. As described previously, the variety of landforms and surfaces across the project area have weathered multiple geomorphic processes to differing degrees. Moreover, especially in the southeastern and southwestern corners of the polygon, modern interference has had a significant impact on preservation. The survey and excavation projects studied over 235ha of fields in detail and projected that approximately 746ha of the area within our research polygon was under cultivation at some point during this landscape’s history. These myriad field systems are scattered across the alluvial platforms of Pampa de Mocan and several dip under the sand dunes encroaching from the northwest into the Pampa de Paiján. Many of them are related to the trunk canals (A-H) described above, however others are
apparently vestiges of now-extinct water sources. The following is a description of the systems recorded in the Pampa de Mocan.

A note on chronology. Canals and field features are notoriously difficult to directly date, therefore this study has relied entirely on relative dating methods, namely diagnostic ceramic material. The field systems across the Pampa de Mocan are covered in ceramic sherd scatter, perhaps deposited there through manuring with household middens or used as a type of ‘lithic mulch’ (Wilkinson 2003; Lightfoot 1996). There exists the problematic possibility of translocation of materials through water transport, especially given this area was intensely irrigated and experienced many strong flood events. However, surviving field systems are located on high ground unaffected by major floods. Moreover, fields systems exhibited very shallow time depth. Over the 235ha of field systems studied in detail, no field exhibited more than one archaeological-culture ceramic type. Indeed, the combination of shallow use-lives and discrete ceramic types indicates that fields were used over relatively short time-periods and never cross-culturally reused.

The eight large trunk canals may seem to be a tempting chronological tool, however, this project explicitly avoided relying on these canals as a source of relative chronology. Any reference in the following sections to the age or sequence of these trunk canals is derived from the dating of those fields definitively connected through distribution and feeder canals. Similarly, those sites lacking a concentration of diagnostic ceramics or architectural elements were roughly dated based on their proximity and orientation to related field systems. Excavations produced twelve radiocarbon samples from reliable contexts, however these are currently awaiting analysis. Therefore, the bulk of the chronological assertions made in this chapter are derived from ceramic data collected in the fields themselves—not on any evaluation of the construction date of the trunk canals or the sites. The earliest evidence of agricultural activity on the Pampa de Mocan dates to the Early Horizon, as evidenced by the presence of Cupisnique ceramics and scattered settlements.
A note on paleoethnobotany. Paleoethnobotanical data from sediment samples collected in excavation of fields or geological test pits across the Pampa de Mocan will be presented over the course of this and the following chapters. The present chapter emphasizes the phytolith and starch data extracted from a selection of field-types. Each sediment sample was divided for phytolith and starch analysis, and processed following guidelines published by Horrocks (2005). Phytoliths are silica bodies formed in the cells of growing plants, especially epidermal cells, but also hair cells and hair bases. These inorganic bodies are deposited into the archaeological record after plant decay and are often found in burned or charred contexts. Under normal depositional conditions, phytoliths reflect the plants that were physically present in a given context (Feng et al. 2017). Starch grains are food reserve granules typically located in the storage organs of plants, such as seeds, rhizomes, roots, tubers, fruits, and corms. Starch grains can also present morphologies when they have undergone processing for food preparation (see Piperno 2006 for an overall review of phytolith and starch grains). The decomposition of starch grains is accelerated by enzyme activity, such as that in the upper humus layer of soils (Haslam 2004). Neither phytolith nor starch concentrations were high enough to warrant abundance-data analysis, therefore, presence-absence data are presented here.

Pollen, meanwhile, can derive from a number sources. Pollen rain describes the natural dispersal of pollen grains in the open environment, particularly from anemophilous (air born pollen) species; consequently, in many archaeological contexts and especially in semi-closed or roofed structures, pollen rain deposition is at least partially obstructed. However, pollen can also be dispersed through animal or insect transport (zoophilous) or the movement of water (hydrophilous) (See Faegri 1989; Traverse 2007). Pollen samples were also processed and analyzed from several different contexts across the Pampa de Mocan. These results are interpreted as a record of ‘background’ plant life over time. Together, pollen and phytolith data provide information on in situ plants (phytoliths and starch) and living plants in the nearby environment (pollen) (see Pearsall 2015). Additionally, comparing phytolith with pollen records allows the researcher to check for inconsistencies across results. Pollen data will be highlighted in Chapter 5.
Early Horizon agriculture.

Unlike in later periods, there is little evidence that Early Horizon occupation depended on a river-based irrigation system: instead, small-scale canals tapped water from ephemeral streams, including those activated by El Niño flood events. Such canal technology would be consistent with preceramic irrigation canals recorded on the south side of the Nanchoc River (Dillehay et al. 2005). Moreover, the archaeological culture was named by Larco Hoyle (2001[1934] T1:21) after the Quebrada Cupisnique, where he observed evidence of former ‘avenues of water’. Carlos Elera (1998:39) contends that during particularly wet summers in the adjacent highlands, water flowed like a river through the Quebrada Cupisnique. Two exemplary cases of Cupisnique farming technology were revealed in the excavations CC7 and CC2. CC2 was placed a ridged or raised field system. The entire complex measures a total of 0.84ha and is located on a small alluvial embankment between two quebradas or arroyos. A long canal (0.2km) runs alongside these fields, and likely functioned as a drainage canal. As described above, this type of field is formed by excavating the sediment from furrows and piling it up on either side creating artificially raised ridges or camellones, which serve to prevent water logging. This field type is typically a response to excess or standing water (Denevan 2001). The presence of a prominent drainage canal indicates there was a substantial amount of excess water at the time of field construction.

The entire area covered in ridged fields in the Pampa de Mocan totals 11.46ha (Figure 25). This field type is concentrated in the area immediately downslope of Canal D, between D and F, although a 4.1ha field was identified along a dry water channel near Canal A. Excavation at CC2 confirmed that these features were raised fields (see Erickson 1988 for further description of ridged field profile varieties). The ridges of CC2 have a largely consistent width of 1-1.74m ridge to ridge, while their length responded to the narrowing of the alluvial surface, ranging from 9-27m long. The natural sediment is

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10 Canal width (an average of 4m berm-to-berm) has likely been affected by later flooding.
comprised of large pebble (4-64mm) and cobble (64-256mm) inclusions, which are present in both the base of the canal and in the fill of the swales or ridges; the natural sediment was excavated out to form the canal and piled on its borders to form the ridge (the furrow is the depression formed by excavation). However, in the case of these fields, even larger cobbles and boulders (>256mm) were apparently ‘mined’ from nearby CC1 and used to raise the ridges even higher—CC1 was essentially a ‘borrow pit’, similar to those identified near LMA fields (Lightfoot 1996:207). The rock inclusions would have allowed for rapid drainage and aeration.

Three excavation levels were tested for phytolith and starch remains. The level corresponding to the ridges, N2-CA, produced the greatest diversity of taxa, including *Zea mays*. The phytoliths recovered from this field point to very moist or wet conditions, especially the subfamily Bambusoideae (likely the species *Chusquea* a forest-dwelling grass), a trichome form indicative of shrubs, and the presence of

Figure 25. Raised field systems across the area of Mocan and inset photograph of ground-view of raised field CC2. Long stone mounds are 'ridges'. Photo by the author.
diatoms (single-cell algae). Starch analysis confirmed evidence of *Phaesolus vulgaris* and spores, which are produced by moisture-loving ferns and mosses (see Zak 1984 for a report on pollen recovered from LIP raised fields located in the Casma Valley and Whitney et al. 2014 for a paleobotanical comparison in the Amazon).

CC7 was located adjacent to a very poorly preserved canal, possibly a trunk canal (Canal E). This field system would be classified as Type 1 for its straight furrows (.37m in width), however, unlike a typical straight-furrow field, they are laid out in a manner perpendicular to the slope. The canal itself has suffered multiple flood events and erosive processes, therefore, neither the intake nor the trajectory could be determined. While the canal alignment is parallel to the other main trunk canals in the area and measures an impressive 6.26m in width, we were unable to determine its water source, or whether it eventually linked up to the Chicama River, nearly 30km to the south. It is possible that Cupisnique intake canals tapped embanked reservoirs or a nearby quebrada channel. Cupisnique-period windbreaks were identified on one side of the canal and a spiral geoglyph and ancient road just to the northwest of the field itself. Both geoglyphs and Cupisnique sites, which largely consist of circular house pits or windbreaks, frequently appear near associated fields.

CC7 and CC2 were identified as Early Horizon based on associated ceramics and the geomorphological properties of field surfaces. Cupisnique-period fields exhibit advanced desert pavement and desert varnish, processes that require thousands of years of exposure in arid environments. Moreover, Cupisnique ceramics covered both sets of fields. Almost all ceramic sherds had evidence of wind abrasion or wind-polishing. The density of ceramic sherds on fields (in some cases up to 25 sherds or 350g of ceramic weight per m²) possibly indicates short-term re-use of fields, extensive fertilization with middens (Wilkinson 2003), or the intentional deposition of sherds as a form of lithic mulching (Lightfoot 1996).

Features revealed through excavation in CC7 also support data that point to a period of forest cover and moisture during the Early Horizon. Level 1 Layer B (N1-CB) in CC7 revealed a deer hoofprint (Figure 26). Several species of deer are known in coastal Peru, although almost all populations now occupy higher altitudes in the *yungas* zone or in coastal lomas. Iconographic evidence of deer hunting
dates to at least Ventarrón (4000 BP) (Wright et al. 2015). Faunal analysis at Cupisnique sites such as Caballo Muerto (Nesbitt 2016) and Puemape (Elera 1998) demonstrate that *Odocoileus virginianus* or the Peruvian white-tailed deer was a part of the Early Horizon diet, a tradition that likely dates to the Initial and Preceramic Periods (Pozorski and Pozorski 2006; Chauchat et al. 1998). For the purposes of this study, the existence of deer populations in the area of Mocan during the Early Horizon points to a vastly different ecology and related water regime.

Figure 26. Photograph of deer-hoof impression excavated in CC7. Impression is visible just below the arrow-end of the photograph scale. Photo by the author.

Early Horizon farming in the Pampa de Mocan took place in a very different ecological setting than that found today. The area experienced greater moisture in the past overall and possibly enjoyed seasonally-active streams, akin to the well-known Quebrada de Cupisnique. As discussed in Chapter 2, the frequency of El Niño events during this period was slowing down, but still higher than the modern-day regime which likely began around 3000 BP (~1000 BC). During this moister period, the occurrence of an El Niño event would have resulted in even greater biodiversity, spurring the growth of herbaceous
plants, trees and shrubs, attracting insects, game, and predators, and resulting in ponded, standing water and a higher water table. Cupisnique habitation will be discussed in greater depth in the following chapter, however, the evidence from the fields indicate that farmers likely moved into the Pampa de Mocan on a seasonal basis, taking advantage of wet-season and ENSO-related fluorescence. This practice continued without interruption into the Early Intermediate Period.

The Early Intermediate Period and Trunk Canal D.

Scholars agree that expansive canal and field systems existed in the coastal river valleys by at least the Early Intermediate Period (200 BC-AD 600). Ceramics related to the archaeological culture that overlaps and succeeds Cupisnique, known as “Gallinazo” or “Salinar” styles, are the earliest associated with a definitive trunk canal in the Pampa de Mocan (Canal D) although neither the intake nor connection to the Ascope Canal System could be identified for Canal D.

Canal D is an important feature in the Mocan landscape. It is almost certainly the earliest definitive trunk canal that crosses the Pampa. While Canal D could not be traced to the Ascope Canal System, it does apparently intersect with the Quebrada La Culebra. This Quebrada has clearly experienced significant water flows through time, and it is possible that it provided a seasonal source of water in the past, similar to the nearby Quebrada Cupisnique (see Larco Hoyle 2001). In fact, Chauchat et al. (1998) hypothesized the existence of springs in this area for the preceramic period and Benjamin Vining (communication) identified what is likely a high-water table signature in the near-infrared (NIR) wavelength of Sentinel 2 imagery taken after the most recent ENSO event in the same area (see Figure 7).

Canal D was breached by massive flood events a minimum of 43 times. Some of these breaks were likely related to the same event, and floodwaters tend to follow established channels, however, if a major flood in the Chicama occurs on average every 35 years, the history of breaches along this Canal may represent at least 1400 years. Canal D is the widest of the trunk canals measuring an average of 11m from berm to berm. The width of the canal can also serve as a relative proxy of age: canals widen over time with continual use and cleaning. At some point, likely after the Canal’s intake was destroyed, Canal
D enjoyed a second use-life. Fields were placed in the bed of the Canal near its distal end, taking advantage of favorable moisture capture and rich sediment laminates—just one of several examples of intra-canal fields in the Pampa de Mocan (Figure 27). Finally, embankment fields were constructed along the left bank of Canal D.

Figure 27. S-shaped field visible in the canal bed of Canal D. Large trunk canals had long and diverse use-lives, and possibly began as flood-diversion canals. Carito Tavera Medina, Field Assistant, is seen standing on the downslope (left) berm. Photo by the author.

Embarkment fields are formed through the construction of a closed border mound and, typically, a single entry-point for irrigation water and an exit for drainage (Figure 28). The total area of embankment fields identified in the Pampa de Mocan is 8.37ha. The embankment fields along Canal D were placed strategically to take advantage of flood waters in a controlled setting. During a flood event, initial water flow was blocked by the right bank of the canal—essentially forming a dam. As water buildup and flow continued it breached the right bank and collected in the canal bed (and at times also breached the left bank). Embankment fields are placed along the downslope side of the canal at points of
restricted flow. Intakes were likely constructed to distribute floodwaters to the closed, embanked field system. Although the intakes have not survived the centuries of posterior flooding, distribution canals leading from Canal D are still visible today. These fields were an ingenious adaptation to the periodic excess of water that would have affected the Pampa de Mocan even after Canal D’s function as a trunk canal became obsolete. Within the embankment itself, other field types are often found, especially those types designed to capture debris suspended in floodwaters. Several examples of rockpile fields were found within the bunds of embankment fields—making these embanked rockpile fields (Figure 29).

Figure 28. Location of embankment fields across AOI. Inset photograph is a UAV orthoimage of an Embankment Field and smaller inset is an example of S- and Straight Furrow Field types adjacent to one another within the same Embankment Field. The darker linear features are the embankment bunds. Drone photography by Luis Jaime Castillo.

CC3 is an example of a rock pile field. Rock pile fields, also known as mounded heaps or ‘grape mounds’, are well known in the Sonoran and Negev deserts (Evenari 1982; Fish 1985; Fish 2000) (Figures 29 and 30). While sometimes confused as field-clearance by-products, several archaeological and experimental studies demonstrate their utility for agriculture. Fish et al. (1985), in their excavations of
rock piles in the Sonoran Desert, found evidence for cultivation of Agave (*Agave americana*) also known as maguey and sometimes confused as *Furcraea* in Peru. Evenari et al. (1982) and Lahav and Steinberger’s (2001:127-147) studies of rockpile fields in the Negev prove that these features encourage biotic activity by increasing moisture retention and preventing erosion. CC3 represents the same type of agricultural technology.

Figure 29. UAV orthophoto of a rockpile field within an embankment. Drone photography by Luis Jaime Castillo.
CC3 consists of stone pile mounds, measuring on average 1.12m in length and .53m in width. Similar to the Cupisnique fields, the stones in this field system exhibit desert varnish, but are clearly younger than CC7 and CC2, lacking the deep red manganese of their more ancient patina. Moreover, desert pavement formation is not as advanced as in the Cupisnique fields. Excavation revealed thick sediments built up on on the NE side of the pile; this is the side that runs parallel to Canal D. The upslope side of the pile also included a disproportionate amount of gravel, indicating that water flow carrying sediments and small rocks was trapped on this side of the pile (Appendix B).

Ceramics are often included as construction material for the rock piles field type. Ceramic fragments in and around the piles were used to provide a relative date for construction. While rock pile fields are most prevalent in the Early Intermediate Period, one example of an Early Horizon rock pile field in the Pampa de Mocan is located just outside of the project’s polygon.
Field systems related to Canal F and G show remarkable diversity, indicating experimentation with water diversion and capture technology, changing environmental conditions, and an increase in the reliability, and perhaps control, of water. Walls appear in this period (dated based on alignment to other features). Their sole function seems to be the prevention of sand-invasion or wind erosion: all walls are located along the northern edge of the bajada and they are not closed features. Instead, they tend to run parallel to the slope (Figure 31). Indeed, wind does appear to have been a major factor in field preparation during this period, reflected through the practice of extensive lithic mulching (Figure 32). Lithic mulching is the layering of small pebbles or gravel fragments on the surface of a field to prevent wind and water erosion and improving moisture retention. A layer of lithic mulch also affects the surface temperature, a crucial variable of evapotranspiration. As Lightfoot (1996:209), explains:

“A lithic mulch also increases surface roughness, generating more turbulent air flow over the garden surface. This has the effect of reducing the hottest day-time temperatures and raising the lowest night-time temperatures, thus providing a more thermally stable and healthy environment for the emergence of seedlings and the growth of crops”.

Figure 31. Example of a wind-erosion prevention wall. The wall’s mud facing is in-tact thanks to the infilling by over 1m of wind-blown sand. Photo by the author.
Based on related surface ceramics, the total area covered by EIP fields is 84.15ha compared to the 20.56ha identified as Cupisnique fields (Early Horizon) (not accounting for preservation bias). Under a Boserupian-Wittfogelian rubric, this might be interpreted as a sudden increase in population or labor force. However, there is little evidence to suggest that these fields were contemporaneous or even worked by the same group of farmers. Field systems were laid out in an ad hoc manner—taking advantage of every feasible surface for farming. The field system layout reflects slow, incremental, and punctuated expansion, continuing the tradition of opportunism first exhibited by Early Horizon farmers. Only one field system was shown to have more than one use-life; instead, field systems were constructed quickly and directed at points along the major trunk canal where water was easily diverted and distributed.

Perhaps the most interesting development during this period were the myriad ways devised by ancient farmers to slow down the flow water being distributed to their fields in an effort to decrease erosion. In some cases, instead of simple parallel distribution canals (canals that run along the main trunk
canal for diversion into the fields), elaborate drop structures were constructed. In one case, circular ponds were built at gradually descending levels alongside the trunk canal. Field-types include the S-shaped, E-shaped (40.08ha) and Straight-furrow fields (129.65ha), however, rather than existing in discrete systems, they are often found together in the same field system. When used in the same system, the use of straight, vs. E- and S-shaped furrows responds to changing slope along the surface. Finally, a new ‘type’, the Posa or Check-flooding system, is related to Canal F (located between F and G)—the total area equals 1.02ha. The CC5 excavation was carried out on this field type and represents the only field that potentially exhibits more than one use-life (Figure 33). In fact, CC5 shows evidence of three irrigation moments; again, these moments are potentially suggestive of a longer-use-life than the other fields excavated, however, they may have occurred over the course of two consecutive growing seasons (as little as 1.5 years). Unlike other field systems of this time, CC5 features almost no ceramic sherd scatter on the surface (possibly related to the form of irrigation water application), but it was related to a nearby EIP stone field house and storage pit (P1). CC5 was sampled for microfossil data, including both phytoliths and starch and the results provide insight into the activities that occur in the field.
Posa-fields are flooded sequentially, beginning with the upslope side of the field, through a narrow access in each cell. The cells or posas are left to soak and excess water is drained off. The system was recorded by John K. Hatch (1974:45) in Motupe (Lambayeque) in 1972, in the aftermath of a major flood event. The corn farmers of Motupe (1974) worked over a 212-day calendar: 47 days prior to planting and 165 days of crop cycle with tools such as metal shovels and tractors. Hatch (1974:39), an economist, saw the labor invested in constructing these systems as a conservative water strategy, “Such infrastructure must be reconstructed every season with strenuous and time-consuming shovelwork. But the investment more than pays for itself in water economy”. Each posa is flooded with 10-15cm of water. The inundation results in a hardened, baked crust which serves to maintain moisture in the soil below. For the cultivation of maize, the technique requires just a few water applications per season—once every 20-30 days—and requires half of the amount of water as furrow irrigation, cutting back on the water loss that...
occurs through canal seepage and evaporation with repeated applications. Efforts to reduce loss during transport would be particularly apt in the Pampa de Mocan, where during the dry (winter) season, water from the Chicama River likely rarely reached the distal end of the irrigation system. The CC5 excavation unit was positioned within a posa toward the end of the check-flood matrix. Water would have pooled in these furrows leaving a strong laminate of alluvial sediments and allowing macrobotanical remains to concentrate in the unit as well. Indeed, during excavation, root hollows and in situ plant stems were observed. Microfossil results were particularly illustrative.

Phytoliths extracted from soil samples present as grasses, Asteraceae – likely weeds, diatoms and spores (mosses, ferns), indicative of agricultural activity and standing water. Starch remains included *Curcurbita moschata* and *Curcurbita* sp. *Lagenaria siceraria, Zea mays, Phaseolus vulgaris, Phaseolus* sp. and *Tropaelum/Solanum*. The contemporary farmers of Motupe grew maize exclusively in their posa field system; however, the maize-beans-squash triad has been observed in fields excavated in dammed quebradas near Ascope in the aftermath of the recent El Niño event (Figure 6). Among my samples, several of the *Zea mays* starch grains featured distinct morphologies caused by cooking and boiling—in other words, fermentation (see also Henry et al. 2009). These results point to the consumption of chicha beer in the fields themselves. Paerregaard (1994) described daily ‘pagos’ or ritual offerings, often of corn beer, at the level of the individual farmer during planting and harvesting in the Andean highlands. Even today in highland Peru, chicha consumption is an integral part of agricultural rituals of reciprocity and consumption, known as offerings to the Pachamama (earth goddess), and often take place in the field.

*Trunk Canal C.*

According to paleobotanical sampling results, the surrounding plant life at the beginning of the Middle Horizon (AD 600-1000) reflected disturbed-soil species related to farming practices, such as weeds (Asteraceae) and cultigens (*Phaesolus, Zea mays, Manihot, Curcurbit*) and invasive shrubs and trees (*Schinus molle*) that may be related to a sudden influx of water. The field system that is related to Middle Horizon period activity is CC8, where just a few ceramic sherds were recovered. CC8 is a border-strip
flooding field associated with Canal C measuring 3.85ha (Figure 34). According to Watson (1979:143) border-strip flooding has been recorded as a traditional irrigation practice in Iraq, the Sonoran Desert and other arid agricultural landscapes. The long strips of land, often running mostly parallel to the slope direction, are separated by low bunds. Runoff is directed to these strips where the slow wash allows silts and sediments to settle in each section. Indeed, there is little evidence that this field system was watered by Canal C: any distribution canals that may have connected the fields to the trunk canal have been lost. Instead, the field system conforms to the shape of now-dry washes or arroyos that breached the Canal. Each ‘terrace’ or strip of CC8 measures an average of 5.85m in width and approximately 1km in length. The borders of each terrace strip average 87cm in width and consist of piled cobbles and large stones. This field system, unlike those of the previous period (with the exception of CC5), featured almost no surface ceramics, and no evidence of Wari, or Tiwanaku material. The few sherds that were present were not known types, but rather, possibly originate from the adjacent highland region and belong to the loosely defined Yurraccama (Huamachuco) archaeological culture (Krzanowski 2006). Further analysis, including compositional analysis, would be required to understand the origin of these fragments.

The CC8 field system was based around a controlled-flooding strategy—what Doolittle (1984:126) refers to as a “water-harvesting”. Runoff water was directed to an enclosed catchment area, in this case an embankment field. Excess and drainage water moved out of the embankment and on to the border strips at a slower rate. Finally, CC8 was sampled for microfossil analysis. Starch grains included Phaseolus sp. (beans) and phytolith analysis reveal the presence of grasses (Festucoideae) and point to standing water with the presence of diatoms.
The area cultivated through border-strip irrigation in the Pampa de Mocan totals 30.13ha (only CC8 is affiliated with the Middle Horizon period; other fields are EIP and LIP). The entire area of border-strip fields depended entirely on seasonal or ENSO-related runoff events. In some areas, natural stream channels were reinforced through the construction of bunds to direct flow to the strips. These fields are entirely opportunistic in nature and laid out in an ad hoc manner, changing orientation and dimensions according to the runoff source and slope. In the Sonora Desert, Doolittle (1984:125) describes these fields as the result of incremental development, stating,

“New fields and associated features are not swiftly changed to a final form but are transformed while in use. In this process, acts of construction may not be distinguishable from other categories of agricultural inputs. Rather, construction is an ancillary by-product of cultivation and maintenance inputs and need not involve formal planning, engineering, or organization beyond that within the domain of the individual farmer or farm unit”.

Figure 34. Areas developed as border-strip fields and CC8 indicated. Inset photograph of plan-view of border strip fields. Drone photography by Luis Jaime Castillo.
The embankment fields, border-strip fields, raised fields and intra-canal fields discussed reflect opportunistic strategies. At the same time, even the massive trunk canals are being used in opportunistic ways to maximize seasonally-available water. The trunk canals were multi-purpose, and evidence suggests they were used and modified as flood diversion canals, and for tapping a variety of water sources, including both the Chicama River during seasons of high volume and ephemeral and seasonal streams. Rather than an abrupt change in strategy with the arrival of the Chimu state, the same combination of strategies continued throughout the Late Intermediate Period.

**Late Intermediate Period and Trunk Canals H and A-C.**

Possibly an artifact of preservation bias, the Late Intermediate Period witnessed the greatest diversity of field types and ceramic wares including Chimu, highland wares, and Lambayeque. Cajamarca sherds were also reported, and likely collected, by Chauchat et al. (1998). Highly centralized administration, corporate-level production, and technological achievement are often attributed to the Chimu archaeological culture, and the expected pattern of field systems would be uniform in technique, layout, and form. However, the LIP field systems, which were dated based on the presence of these diagnostic surface ceramics, carry on the previous traditions of opportunism and water-maximization, adapting field systems to surface requirements, tapping runoff water sources, and applying a variety of water application techniques. Trunk canals were modified, abandoned, and extended, just as in the previous centuries.

CC6 was a classic S-shaped field type with a furrow width of 77cm and length of 1m (Figure 35). The entire system area measures 6.85ha, with S-shaped furrows oriented both NE-SW and NW-SE. The field itself is located at the distal end of trunk Canal D, but its water source was at one time, Trunk Canal C, which deposited water to a related embankment or small reservoir. At a later period, the distribution canals of CC6 were redirected to a canal that carried the drainage waters of up-slope Canal A and its branches (a2, a2). Through a complex system of distribution canals and small aqueducts (Figure 36) that underwent multiple modifications and redirection, water from these sources reached the CC6 system. The
CC6 field system, located outside of the terminus of the irrigation trunk canals is an entirely runoff- or drainage-fed field system.

Figure 35. UAV orthoimage of S-shaped fields at the distal end of Canal D. Location of CC6 indicated and LIP (Lambayeque) site waypoint marked. Drone photography by Luis Jaime Castillo.
Figure 36. UAV orthoimage of small aqueduct crossing an entrenched arroyo or quebrada. The aqueduct connects Trunk Canal A between two alluvial platforms separating Complejo 1b.

The excavation unit of CC6 was selected based on its proximity to a small architectural cluster. The architectural units, associated with dense LIP ceramics, are located on an inactive dune on top of a Pleistocene-era swale overlooking the entire field system. The excavation unit was placed toward the distal end of the system, with an expectation of recovering any macro-remains that may have collected there. An ancient clod-breaker fragment was found nearby (Figure 37) (see Donkin 1970; Moore 1988:273; Rowe 1946:211). During excavation, an in situ trunk and root system was uncovered. The plant remains were not confidently identified, though they represent a hardwood shrub or tree, such as *Schinus molle*. Microremains recovered from CC6 sampling include starch grains of *Cucurbita* sp. and elongated phytoliths typical of woody shrubs.
A well (P3) was found in close proximity to LIP field systems. P3, is part of a formal platform complex related to a major highway (H3) (Figure 38). Excavation results from P3 will be discussed in greater detail in Chapter 6. The placement of a well near these field systems indicates a high-water table in the area in the past; it was likely constantly refreshed by seepage and upslope drainage.
LIP fields are often associated with small adobe or stone structures—likely the foundations of field houses. However, more substantial and formal examples of LIP structures also exist, and while these will be addressed in greater detail in the following chapter, one of these complexes is pertinent to the present discussion. Complejo1 consists of two architectural clusters: 1) the site known locally as San José (in the Mocan project system, 3D-65-Pl1-C1/1 or Complejo 1a for shorthand) and 2) a series of fourteen u-shaped banquetas structures, designated 3D-65-Pl1-C1/2-E1-15 or Complejo 1b. Complejo 1b also features two torreones or towers (Figures 39 and 40). The towers were apparently constructed from heaped stone and stand on either side of a wide stream bed. Such torres have few equivalents in the archaeological record, with the northern torre standing almost 3m tall and 13m wide at its base. Early chroniclers and colonial records mention that the Inca used mojones, mounds or small towers of stone, to mark the delimitation of their territory (Harris 1997:364; Ramírez 1986:32). Monolithic huancas and even
funerary *chullpas* have been identified as possible markers of ancestral or sacred boundaries. The stone torreones of Mocan were devoid of any artifacts, however, they are positioned high upon the bajada, seemingly to take advantage of the viewshed—perhaps these are viewing platforms or watch towers, related either to the nearby field systems or the adjacent highland territory.

Figure 39. Location of torreones and UAV orthophoto of torreones located in Complejo 8b (3D-65-P11-C1/2-E1-15).
One of the field systems associated with Complejo1 and the torreones was fed by trunk Canal A. This canal drew water from the ACS, ultimately, drawing water from the Chicama River and possibly at times the associated laguna or reservoir. It was likely connected to the Ascope Canal System and possibly the Ascope Aqueduct at one point in its history; in fact, smaller-scale aqueducts were constructed all along Trunk Canal A (see Figure 36). Canal A is highest of all the of the trunk canals that cross the Pampa de Mocan and therefore it crosses deeply incised stream beds along the piedmont apron. The LIP field systems were located on top of piedmont plateaus, where thick alluvial sediments sit high above the quebrada bottoms. Canal A, therefore wound its way around each platform, and crossed each quebrada at their narrowest point over a built-raised platform or aqueduct. The field type was S-shaped and the fields themselves totalled 10.61ha; the drainage and distribution canals of this system fed down-slope border-stripped fields and E-shaped fields.
Overall, farmers continued to create embankment fields, rock pile fields, posa-fields, utilize seasonal flows, the water table, as well as expand, modify and construct trunk canals and traditional furrow-irrigation fields throughout the Late Intermediate Period.

*Interpreting the fields: durable histories.*

“The entire region [Sonora, Mexico] is a hopeless desert, and few if any Americans reside in it. It is unadapted for agriculture, yet when the July rains commence, the Indians forsake their rancherias and hasten to their temporales, where they plant crops of corn, pumpkins, melons, squashes, etc.” (Gaillard 1894:293).

The diversity of field types and irrigation application represented in the Pampa de Mocan directly challenges the notion that arid environments require expansive, state-directed irrigation systems for development. The agricultural history of the Pampa de Mocan did not originate on the banks of the Chicama River, or even along the Ascope Acqueduct. Rather, beginning with the Cupisnique around 900BC, low-level opportunistic constructions catalyzed over 2000 years of development that resulted in a patchwork of diverse field types, divergence, drainer, and feeder canals, and eight massive trunk canals, some of which made up the Ascope Canal System.

Standing models of agricultural development on the coast predict that early farming would begin on the river floodplain—the extreme aridity of the region precluding productivity at any great distance from a permanent water source. However, fields dating to the Early Horizon (900-200 BC) were located in the Pampa de Mocan along ephemeral watercourses. Located principally along the lower bajada, where the alluvial fans begin to flatten and widen, Cupisnique farmers concentrated their efforts in capturing sheet floods, redirecting washes, and tapping flows from ephemeral or seasonal streams, even placing their fields in the watercourse itself.

By the Early Intermediate Period, the Pampa de Mocan agricultural system operated at two levels: one that relied on a predictable system of water delivery from the Chicama River, and another that responded to the spontaneous appearance of water. During the austral summer months when river volume was at its peak, trunk canals conducted water to fields.

The monumentality of the eight trunk canals suggests vast labor forces and a single, state-controlled construction project; however, evidence suggests that the original intakes of these trunk canals
may have been on the banks of ephemeral or seasonal streams. Moreover, multiple episodes of modification point to centuries of re-tooling and incremental extension. In this way, the trunk canals do not represent a single directive, rather, each reflects years of gradual extension, re-direction, and re-invention. This is further evidenced by the area of field systems designed to capture and redistribute flood water from sheet floods, reservoirs, or active watercourses. The Mocan farmed landscape reflects a cumulative history, a palimpsest of protracted geological and anthropogenic processes, populated by both complex and simple technologies.

“New fields and associated features are not swiftly changed to a final form but are transformed while in use. In this process, acts of construction may not be distinguishable from other categories of agricultural inputs. Rather, construction is an ancillary by-product of cultivation and maintenance inputs and need not involve formal planning, engineering, or organization beyond that within the domain of the individual farmer or farm unit” (Doolittle 1984:125).

Along with the use of trunk canals, opportunistic fields were established and made up a significant portion of the farmed landscape. During El Niño years or particularly wet summer seasons, the farmers of Mocan sited field locations along known seasonal water courses to take advantage of high-energy flows. Border-strip fields and embankment fields were constructed at a greater labor cost (see Doolittle 1984:126) for the sole purpose of capturing flood waters and suspended sediments and debris. Meanwhile, other field types were constructed in anticipation of dry seasons. Posa fields or check-flood fields were one of the most water-conservative field types found in the Pampa, requiring just two or three waterings per growing cycle. Lithic-mulch fields used the impermeable properties of gravel and pebbles (and possibly also ceramic sherds) to slow evaporation and increase biotic activity in the soil. Finally, fields were occasionally placed within irrigation features: intra-canal fields. These too were opportunistic in nature, with the express goal of capturing moisture retained in the fine sediment beds of large trunk canals. 67.34ha of the area identified through survey or excavation was dedicated to opportunistic or flood-water farming—almost 30% of the fields recorded and 4% of the entire survey universe.

The peril of farming in the desert of the north coast was not the poverty of soils or the paucity of suitable land, rather it was the availability of water and the readiness of water-capture and canalization infrastructure. The most pervasive risk faced by the farmers of Mocan was main channel lateral
movement and downcutting of the Chicama River, which would have rendered canal intakes obsolete almost every season, and the relatively-unpredictable appearance of flood waters. To mitigate these risks, farmers rotated around the broader landscape, practicing a high degree of mobility.

Opportunism marks the entire developmental trajectory of the Pampa de Mocan landscape, yet current models for agrarian change hold mobility and complexity as mutually exclusive. In the following chapter, I will discuss the second major assumption underlying north coast models of agrarian change: that complex agricultural systems require sedentism. Instead, the settlement data from the Pampa de Mocan supports a model of peripatetic agriculture.
CHAPTER 4. THE MOBILE AGRICULTURALISTS OF THE PAMPA DE MOCAN

“Archaeologists envision the ‘emergence’ of sedentism as a process akin to a settlement system’s batteries running down: People move less and less until they are not moving at all” (Kelly 1992:49).

The Pampa de Mocan was developed agriculturally from 900 BC-AD 1470, but rather than resulting from planned expansion from the center to the periphery, the history of farming in the Pampa de Mocan is marked by opportunism aimed at maximizing water. Presently, standing models of agrarian change (Chapter 1) predict: 1) agriculturalists work to maximize land, 2) land is a limited resource in arid environments; 3) sedentism is a necessary condition for intensive farming. This Chapter is centered on evaluating the relationship between opportunistic, seasonal, or shifting agricultural practices and mobile residence. First, I review ethnographic accounts of mobile farming, with a focus on identifying potential material correlates for the archaeological record. Next, I present the archaeological evidence for mobility among farmers in the Pampa de Mocan, which includes architecture, infrastructure, and foreign objects. Finally, this Chapter reviews the research on Colonial Period allusions to mobility among smallholders.

Scholars view ‘sedentism’ as a relative term, indicating less residential mobility than in previous cultural evolutionary phases (Kelly 1992:49). Robert L. Kelly (1992:50) argues, however, that while most archaeologists treat sedentism as existing along a continuum of residential mobility, it continues to be modeled as a ‘threshold phenomenon’: once societies become sedentary, they rarely revert back to a highly mobile subsistence strategy. According to Price and Brown (1985), prevailing hypotheses tie the origins of sedentism either to increasingly intensive agriculture, taken up by hunter-gatherers due to environmental or demographic pressures11 (push hypothesis), or thanks to resource abundance (pull hypothesis) (Price and Brown 1985). The archaeological signatures of greater degrees of sedentism include the appearance of domesticates and important cereals12 (Bar-Yosef and Belfer Cohen 1989; Bettinger, Robert L. 2017 Prehistoric hunter-gatherer population growth rates rival those of agriculturalists. *PNAS* 113(4):812-814. Heckenberger, Michael J. 1998 Manioc agriculture and sedentism in Amazonia: the Upper Xingu example. *Antiquity* 72(277):633-648.

11 Bettinger (2017) makes the argument that hunter-gatherers have higher population growth than many agricultural societies, possibly nullifying the demographic pressure ‘push’ hypothesis.

12 See Heckenberger (1998) for example of tuber cultigens related to sedentism.
Belfer-Cohen and Bar Yosef 2002; Liu 2006), permanent residential structures and storage units (Inomata et al. 2015), fired ceramics, and prestige-objects or material related to costly social signaling (Hayden 2009). However, as Kelly (1992:50) points out, the material record is not always a reliable metric for agricultural behavior characterized by punctuated or seasonal mobility:

“The nature of archaeological data makes it difficult to assess the accuracy of a model in which sedentism develops continuously over time. Imagine a settlement system oscillating between states of greater and lesser residential mobility. In all likelihood, sites produced when people are less residentially mobile will be more visible archaeologically; those produced by an intervening period of high residential mobility will be less visible and if undated may even be interpreted as special-purpose camps of the sedentary system. The assumption that sedentism ‘emerges’ slowly and is a ‘point of no return’ might erroneously appear to be confirmed”.

In other words, the nature of the archaeological record could bias results toward interpreting certain assemblages as representing sedentary behavior. Instead, Kelly (1992) suggests that archaeologists should avoid a gradualist approach. Residential mobility potentially involves multiple variables operating on several spatial and organizational scales, including individual versus group mobility, and large-scale migration patterns versus monthly, yearly or decadal shifts in residence. Moreover, although they may be difficult to identify in the archaeological record, there are ethnographic examples of mobile agriculturalists. In most ethnographic cases, mobility was practiced as a form of risk-aversion: by managing much larger agricultural landscapes, even on a regional scale, smallholders around the world defrayed the effects of environmental variability. The Pampa de Mocan history of settlement includes field houses, highways, and non-local materials, which, together with evidence of environmental variability and opportunistic farming (Chapter 3), point to the practice of peripatetic agriculture in the prehispanic past.

**Farming on the move in the ethnographic record.**

The Raramuri (Tarahumara) farmers of SW Chihuahua, Mexico are the most frequently cited ethnographic example of full-time agro-pastoralists who practice year-round residential mobility. There, communities maintain scattered fields and occupy three or more residences per year. Hard and Merrill’s (1992) work in the Rejogochi community established that 75% of local diet depends on maize, demonstrating that the principle subsistence practiced is agriculture (see also Bentley and Netting 1993).
The main residences of the community are located in a southern valley of the Sierra Madre mountains where occupants spend up to 6 months of the year. During the growing season, entire households move to already-established houses and storage structures outside of the valley near distant fields—up to 8.5km from the main residence. According to Hard and Merill (1992:607), some households own up to 10 different fields dispersed across the valley—each with their own field-houses. The same household may also maintain a second residence: the winter residence. These structures (often in rock shelters) are occupied between December and March and are sometimes positioned to allow households to view their main residence (Hard and Merrill 1992:607). These residences have the advantage of longer sunlight exposure, being high and dry, and being located near firewood resources. Finally, Graham (1993:27) notes that many Raramuri own fields in other communities, and likewise, have residences there, where they may live for several weeks 3-4 times a year. The Raramuri maintain their farming system on a regional scale by circulating around multiple residences.

As Bentley and Netting (1993) point out, while there are multiple and intersecting historical variables that led to the development of this practice, field scattering among the Raramuri is a crop-loss risk-management strategy, an approach that is not unique to NW Mexico. Among the Kofyar in the Jos Plateau, in north-central Nigeria, scattered farmsteads are maintained through a work-exchange arrangement among communities: laborers travel up to 7km in exchange for muos (millet beer) (Stone 1991). In the southern highlands of Peru, the farmers of Cuyo Cuyo plant 20 scattered fields per year. According to Goland (1993:317), while the immediate energy requirements spent on travel and transport are costly, the strategy results in a net benefit in the long-term, comparing it to playing the stock market: “As additional fields are added to the household’s land portfolio, aggregate production variance and the risk of failing to meet minimum needs are reduced”. Goland (1993) asserts that the unpredictability of the environment is what results in the year-to-year variance in yields. Meanwhile, there have been several archaeological studies, particularly in the arid SW United States, which suggest seasonal movement and field scattering among ancient agriculturalists.
Several studies of Mimbres Mogollon pithouses in Arizona and New Mexico point to seasonal mobility late into the Three Circle Phase (AD 750-1000), long after substantial settlements and storage structures were established (Rocek 2007; Stokes and Roth 1999). Excavations in pithouses, square, stone-lined structures, revealed lithic assemblages and plant and vessel remains that point to mobile foraging and hunting strategies (Gilman 1987; Rice 1975). Other work in the United States SW region support these findings for later periods, and further argue that discontinuities in the archaeological record, often identified as moments of conquest, migration, or abandonment, are in fact the result of an incongruent scale of analysis. For example, while archaeologists often operate in terms of individual field systems or canal branches, Nelson and Anyon (1996) use evidence from Puebloan (AD 1000-1150) New Mexico to suggest that agriculturalists fallowed entire valleys. Together with Nelson and LeBlanc (1986) they argue that this kind of regional mobility can be expected under the following conditions:

“(1) At times when agriculture is so thoroughly entrenched in the economy that it is necessary to commit a portion of the community to crop-tending between planting and harvesting; (2) when population density is low and land sufficiently abundant to permit some areas to remain unoccupied; and (3) where resources other than agricultural land constrain the length of stay, making it necessary for a population shift more than a few kilometers away in order to allow regeneration of critical resources” (Nelson and Anyon 1996:277).

Such studies indicate that typical archaeological units of analysis may be inadequate to capture the temporal and geographic scale of peripatetic agriculturalists.

Finally, Schachner (2012) describes a system of prehistoric “population circulation” in the El Morro Valley of the Zuni River drainage. “Population circulation”, he explains, is a term used by geographers to describe cyclical movement between traditional villages and newly-established urban centers (often related to a new an extractive industry in developing areas). The term was later applied to ‘short-term movements’, including those unrelated to the industrial economy (Schachner 2012:9). Human geographers recording population circulation in Melanesia assert that this type of short-term movement is central to the maintenance of economic, social and political ties in the area (Chapman and Prothero 2012). This behavior might be described as cyclical migration—residence is not permanent in either traditional homes or urban areas. For the ancient American SW, Schachner (2012:11) makes the argument that
population circulation led to episodes of sociopolitical divergence and convergence by promoting “fluidity in residence, social group membership and leadership”. For the ancient Zuni (AD 1150-1540), this practice was part of an agricultural strategy in a region that experienced both long-term and seasonal environmental variability. Schachner explains that ancient Zuni agriculturalists likely moved periodically from the lower valley to the surrounding plateau in accordance with wet and dry periods; he used Instrumental Neutron Activation Analysis (INAA) data to argue that farmers maintained residences in both areas (Schachner 2011). For Schachner, dual- or multiple-residence was a risk-management strategy that carried with it many social and political advantages.

Without the benefit of INAA or isotopic data, the archaeological signatures of mobile agriculturalists are difficult to tease apart from ‘sedentary’ material remains. Graham (1993) compiled observations of modern-day Raramuri material culture and architecture in their temporary residences: the material remains of periodic abandonment. The Raramuri planned returns to each of their residences, and that anticipation determined the objects that were transported and those that were left behind. Graham (1993:31) found that storage facilities were common at residences occupied during the growing season. The storage of maize allowed farmers to extend their stay while at a distance from their main residence. Moreover, she notes that while the Raramuri are constantly rotating between residences, they do create permanent architecture in both locales (Graham 1993:38).

While mobility clearly occurred, Graham (1993) concluded that the assemblages in both the main and seasonal residences do not differ. Tools crucial to occupation are never left behind in seasonal residences: “These items will be invisible archaeologically until they are sufficiently worn and then discarded, or if they are lost” (Graham 1993:38). Detecting mobile agriculturalists through their material remains, therefore, is nearly impossible, which explains why the archaeological record of this behavior is so thin. Instead, my project attempts to bring together multiple lines of evidence—land use (fields-Chapter 3), environmental (microbotany-Chapters 3 and 5), and material (settlement data-this Chapter), to address the issue of mobility in the Pampa de Mocan.
The archaeology of mobile labor in the Pampa de Mocan.

The data presented in the previous chapter reflect opportunistic approaches to agriculture and practices focused on the maximization of water, pointing to seasonal or episodic farming strategies. Currently, there is no clear evidence of marked boundaries around fields; excavations revealed shallow use-lives, lending support to the proposal that water, and not land, was the resource maximized in this area. The present chapter will examine how the material remains of agricultural labor concord with the conclusions drawn from the landesque features explored in Chapter 3.

As described in Chapter 3, I carried out one season of complete pedestrian survey across the 1707ha polygon in the Pampa de Mocan. The survey was originally planned in linear transects, but due to the difficulty of the terrain, the area was further divided into landform sectors. Survey with 25% collection of diagnostic ceramic material was conducted in each sector. Sites were defined by the presence of standing architecture; a total of 64 sites (Appendix C) were identified and 1713 sherds (Appendix E) were collected, photographed, and analyzed (Figure 41; see also Figure 16). This chapter will discuss a selection of the sites (for example, 5D-158-CsC3-2), ‘complejos’ or grouping of related sites (4B-176-PP2-C5/1), features related to movement such as highways (H1), and excavations, which were placed within architecture (R units) and over suspected storage structures (P units). Ceramic styles include Cupisnique, Salinar, Gallinazo, Moche, Lambayeque, Chimu, Chimu-Inca and several highland types. Ceramics received codes related to their sector, waypoint and unique ‘fragmento de ceramica’ or Fc numbers (5D-141-Fc39) (Figure 42). For each period, over 80% of collected sherds were characterized as cooking, storage, or serving plainwares.
Figure 41. Sites and collection units where diagnostic ceramics were collected. Inset photos are from left to right: Late Intermediate Period olla (cooking jar), a Moche face-neck jar, and Gallinazo face-neck jar. Photos by author.
Figure 42. Selection of ceramics from surface collections: a) LIP jar (cántaro) vessel handle and neck fragment; b) LIP ‘piel de ganzo’ Chimu (LIP) style body fragment; c) Unknown abstract design, red-on-white paint, unknown origin, likely LIP; d) Moche (EIP) face-neck jar fragment; e) EIP cooking vessel fragment (olla); f) Gallinazo (EIP) face-neck jar; g) Gallinazo (EIP) face-neck jar; h) EIP olla rim sherd; Cupisnique (EH) black-ware polished ‘plate’ or bowl; i) Cupisnique (EH) bottle spout and lip; Cupisnique (EH) dentate-impressed body sherd.

My project identified several general settlement trends (Figures 43, 44, 45). In terms of settlement chronology, Early Horizon (900-500 BC) sites were concentrated in two areas: the middle bajada and the upper piedmont flanks (Figure 43). This apparent clustering could be an artifact of preservation, but it is my contention that site-location was selected based on proximity to two major roads (H1 and H2). All Cupisnique sites were circular, rock-lined structures or windbreaks that clustered in honeycomb patterns.

In the following periods, EIP (AD 100-850) and LIP (AD 900-1460) sites and activity spread over the entire area, reflecting the turnover of active trunk canals (likely linked to upstream channel migration), but also the incorporation of a third major highway (H3) located along the northwestern edge
of the polygon (Figure 44). There are three types of occupational sites in the area: field houses, field-observation platforms, and formal architectural complexes. I identified field houses and field-observation platforms by their location in or adjacent to fields, while sites with more formal architecture closely resembled either ‘hinterland ceremonial centers’ (Swenson 2007; 2004) or ‘administrative’ compounds (Mackey 1987; Moseley 1982). Although my excavations were unable to elucidate the function of the latter group of sites, they will be referred to as hinterland ceremonial centers or administrative compounds for heuristic ease (Figure 45). In the following section, I present data from the field houses that indicate they were temporary or seasonal residences.

Figure 43. Settlement from the Cupisnique (EH) period and all R units and ancient roadways (H).
Figure 44. EIP and LIP Settlement, all R units and ancient highways (H).
Field houses. Field house types are difficult to define and their dimensions and form varied over time in the Pampa de Mocan. 92% of the sites identified across the Pampa de Mocan, were categorized as either ‘small’ (>25m²) or ‘medium’ (>100m²) structures (Table 6). Only 5% of sites measured over 100m² and none of these sites are considered field houses. Construction materials for field houses consisted of stone and adobe or tapia (poured adobe). Most LIP sites featured some remaining adobe material, while the other periods were characterized largely by stone masonry or double-faced stone-and-fill construction. I interpret this divergence as an artifact of preservation: adobe and tapia do not survive well in alternating wet-dry exposure. Additionally, wind was clearly a factor in site-location, and consequently preservation, especially for those sites associated with early periods. Most Cupisnique (Early Horizon) sites are wind-breaks and are located on the upslope side of natural mounds or canal berms—positioning that would lend protection from the S-SE winds.
Table 6. Size differentiation of sites. N=64.

Site 5D-158-CsC3-2 is an example of Cupisnique circular, stone-lined structures (Figure 46). The structures are clustered together and are located on the upslope side of a poorly-preserved canal channel. The straight-furrow field where excavation CC7 took place is located just beyond the canal (see Chapter 3). Excavation in a similar wind-break structure 200m to the southeast (in association with CC2) revealed data related to Cupisnique diet. The R4 excavation unit was placed in a small, poorly preserved windbreak (5D-174-CsC3-3). The unit measured 1x1m and reached a depth of just 33cm; this area of the wind-swept bajada is heavily deflated. Sediment samples from N2-CA (Level 2, Layer A) contained two *Lagenaria siceraria* (bottle gourd) starch grains and the same level (N2-CA) produced faunal material that point to foraging behavior, including (Table 7):

Table 7. Faunal finds recovered from N2-CA in Excavation R4.

<table>
<thead>
<tr>
<th>1</th>
<th>Crab claw fragment</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><em>Scutalus</em> (peruvian land snail) fragments</td>
</tr>
<tr>
<td>2</td>
<td>fish bones</td>
</tr>
<tr>
<td>1</td>
<td>Unidentified gastropod</td>
</tr>
</tbody>
</table>
Ceramic sherds all were apparently bottle, storage or cooking vessels, and some fragments had negative-painting decoration. All diagnostic ceramics were examples of Early Horizon Cupisnique or Salinar styles.

Figure 46. Site 5D-158-CsC3-2. Example of Cupisnique circular structure cluster

R3 (1x1m) was placed just outside of a windbreak structure (2C-85-PP1-C3/1) located on the upper piedmont flanks. This area featured deep sandy strata and excavation was halted at 1.10m, 80cm deeper than the last material remains. R3 produced very few artifacts, however, a very fragile tree branch was recovered (species unknown) along with several *Scutalus* fragments (4). The surface layer featured dense ceramic fragments, all identified as Cupisnique. Due to the depth of excavation, R3 was also tested for pollen. Very little was recovered, but 9 grains of *Zea mays* were identified from the same depth as the tree branch. All in all, excavations from Early Horizon occupational contexts (R4 and R3) reveal a mixture of foraging behavior alongside agriculture. It is also clear from the presence of marine fauna in R4, that these populations were either involved in local trade or were themselves moving around the valley, from the coast to the desert piedmont taking advantage of all available resources.

By the Early Intermediate Period, field houses had an orthogonal layout, but continued to be small or medium in size. Moreover, they continue to be mostly stone-masonry, with evidence of double-face-and-fill construction. Typical of Moche architectural preferences, field houses featured *banquetas* (benches that form part of the permanent architecture) and low platforms, although there was no evidence
of ramps, another Moche architectural favorite. *Donax* bivalve fragments were found scattered on the surface of patios or just outside of these structures.

5C-207-CsC4-7 is an example of a small EIP (possibly Moche) field house with associated structures. The surface remains from this structure consisted of storage and cooking vessel fragments. The structure itself was poorly preserved and the remains of the walls were stone with some adobe melt. However, the secondary structure associated with this field house was likely used for storage. I placed an excavation unit (P1) over the secondary structure to determine its function.

P1 (3x3m) was placed around the rectangular stone-lined structure (Figure 47). The structure was semi-subterranean and had two levels: a floor-capped level in the northern half and an unfinished half in the southern end. The unfinished side was centered around a large, smooth boulder. The boulder clearly pre-dates the construction of the structure: excavation showed that the SW wall of the structure was one course of stones thinner than the other walls in order to accommodate the rock. The boulder was probably used as metate. The northern half of the unit, where a finished floor was found, was devoid of artifacts, but several pieces of carbon were included in the floor mud (Appendix B). After abandonment, the unit was filled with rock fill, ash (possibly infiltrating from modern cane-burning), and sand layers. Outside of the structure, however, an organic layer, filled with likely *cuy* or guinea pig coprolites was swept up against the stone walls. Included in this layer were the remains of multiple *Scutalus* shells which were also found on top of the rock walls. Craig (1992) has argued that this species often seeks out moisture and quickly dies, resulting in mass death events. These gastropod remains, therefore, were not considered part of the ancient faunal assemblage. However, remains of bivalves were also recovered, suggesting the continued practice of circulation around the broader landscape.
External storage units were commonly found near field houses, but storage was not limited to these types of structures; buried storage vessels are also found around the Pampa de Mocan landscape (Figure 48). These large, multi-gallon (~20) vessels are known as *paicas*, *tinajas* or *tinajones*; paica
fragments are some of the most numerous of the collected assemblage. Ethnographic observations of the production and use of paica vessels among contemporary communities of the far north coast (Piura and Lambayeque regions) reveal their primary functions as storage vessels and for brewing chicha or corn beer (Bankes 1985; Cleland and Shimada 1998; Hayashida 2008). Large paica fragments were also found laid on top of several rock piles in rock pile fields. These sherds were likely placed there to act as additional impermeable layer, adding to the intended effect of such piles: capturing and retaining moisture in the soils below.

Figure 48. Fractured rim of a still-buried paica storage vessel. Photo by the author.

Late Intermediate Period field houses continue to have some tapia and adobe preserved, and in some cases, excavation (R2) revealed roof-collapse material (Appendix B). A frequent feature of this late period was evidence of sealed doorways. These houses continued to be located just beyond associated fields. The most spectacular expression of Late Intermediate Period field houses was Complejo 1b (Figure 49). Complejo 1b was located near the northeastern corner of the survey universe at the edge of the
piedmont apron. Here, high alluvial platforms are flat with thick, rich sediments, however they are divided by entrenched stream beds. Cupisnique windbreak sites were identified just beyond Complejo 1. Complejo 1b consisted of 14 U-shaped and banqueta (bench) structures, all oriented 45° E of N. These fourteen structures were bounded on the western end by a canal, which fed S-shaped fields just below on the platform.

Two excavation units, R8 (1x1m) and R6 (1x1m) were placed in this complex. R8 was placed on top of the banqueta of structure E-3. Malacological remains of *Scutalus* were recovered in excavation, and a small hearth was identified at a depth of 19cm. R6, meanwhile, was placed in an area where a concentration of bivalve *Donax* were scattered on the surface. Excavation recovered malacological remains of *Donax* and an unidentified gastropod. Surface ceramics could not be identified as either Chimú or Lambayeque, and while some of the paste examples appeared to be of coastal original, the decorative style is unknown, possibly examples of foreign plainwares. A major road (H1) passed just in front of Complejo 1a and 1b and a set of torres or stone-mounded towers (see Figures 39 and 40), possibly watchtowers, were set on either side of that road, such that one of the torres is on the edge of the alluvial platform of Complejo 1b (a fifteenth structure) and the other across the road and ravine on an alluvial platform opposite the complex.
Finally, very small (>15m²) observation platform structures were the most numerous site-type. These structures were located adjacent to fields but even more commonly on the slopes of trunk canal berms—positioned in order to achieve a greater viewshed over the associated field (Figure 50). These small platforms resemble modern-day field guard-houses: small, usually reed-and-thatch built roofed structures that farmers occupy while overseeing their fields during the approach to harvest season.
Figure 50. Map of locations of observation platforms. They tend to appear on the berm slopes of trunk canals. a.) Example of the foundations stones of an ancient u-shaped observation platform with canal just behind; b) modern observation structure made of palm thatch and reeds (2013); and c.) modern observation structure located near opportunistic field 07-(2017). Photos by author.

Non-domestic sites. While 70% of sites identified in the Pampa de Mocan are classified as field observation structures, field houses and related structures, there are several sites that do not conform to these types. Those include ‘hinterland ceremonial sites’ and ‘administrative’ compounds. Two sites, 4C-125-CsC3-5 and Complejo1b:E-15 fit Swenson’s (2004) category of ‘hinterland ceremonial sites’ (HCS), which date to the Late Moche Period of the Jequetepeque Valley (AD 650-850) (Figure 51). These sites are composed of architectural components known as tablados (Bawden 1982). Tablados are rock-and-fill platforms with a raised banqueta (bench), a central ramp and one or more internal divisions. For Bawden (1982:302), tablados are essentially pared-down huacas: they represent the spaces where important ceremonial presentations would take place on huacas, but without monumental adobe architecture (Figure 52). Swenson (2004:418) identified these architectonic units in ‘hinterland’ sites across the Jequetepeque Valley, including San Ildefonso and Cerro Chepen. According to Swenson, HCS’s are related to local sacred huacas and venerated mountains. Swenson argues that their use was not limited to religious rituals; his analysis of the material records suggests a mixture of domestic, religious, and political functions.
The two Mocan examples of HCSs were U-shaped structures with uneven arms, a central banqueta and ramp, and internal divisions. They were both oriented at approximately 45E of N, however their entrances were on opposite sides of that axis. For 4C-125-CsC3-5, the entrance faced 225E of N,
while Complejo1b:E-15’s entrance faced 45°E of N. This divergence may reflect the veneration of separate peaks, though 4C-3-125’s orientation did not line up with any known huacas or peaks. Meanwhile, Complejo1b:E-15’s entrance faces the Cerros Higueron, whose highest visible peak reaches 2015masl. Complejo1b:E-15 was located on the same alluvial platform as the 14-field house cluster described above (Complejo1b—See Figure 49). Complejo1b was separated from the surrounding piedmont hills and adjacent alluvial platforms by channel washes on three sides. A related site, Complejo 1a, was located on the adjacent alluvial platform, just 150km to the north, and was the only site in the Pampa de Mocan that has previously entered the published academic literature, known as a Chimú ‘rural administrative center’ (Pozorski 1987).

The Programa Riego Antiguo (1976-1979) carried out a widespread investigation into the sequence of canal construction around the Chimú capital of Chan Chan in the Moche Valley. As a result of this investigation, Pozorski (1987) identified several levels of Chimú state control over the agrarian landscape. ‘Rural administrative centers’, according to Pozorski, varied to some degree in area, but included audiencias, or U-shaped, niched administrative architectonic units, internal divisions, and baffled entryways. Pozorski (1987:115) identified at least four of these centers in the broader Chimú region. Two were located within the Moche Valley (El Milagro and Quebrada Katuay) and two in the Chicama Valley: Quebrada del Oso in the southern margin and one in the Pampa de Mocan, which he named Pampa Mocan. Although Pozorski did not report any excavations at Pampa Mocan, his initial observations and the architectural similarity of the site to other better-known sites, such as Quebrada del Oso, led him to argue that Pampa Mocan was a Chimú administrative outpost in a “previously unexploited” desert landscape (Pozorski 1987:114):

“Distribution of crops from fields watered by these canals would have been regulated by the Pampa Mocan audiencia. Therefore, this site probably served two functions: first as an administrative center for canal and field construction and later as an administrative center to oversee maintenance and crop production for the functioning canals and fields” (Pozorski 1987:116).

Of course, my seasons of mapping and excavation now show that the Pampa de Mocan was developed agriculturally since at least the Early Horizon (900-200 BC), almost 2000 years before the arrival of the
Chimu. However, in part based on Pozorski’s observations, Mackey (1987), Pillsbury and Leonard (2004), Warner (2010), and Clément (2015) interpreted the Pampa Mocan Site as the smallest type-site of Chimu rural administrative centers, and by extension, representative of a tertiary tier of Chimu state control. My project refers to the ‘Pampa Mocan’ site as 3D-103-Pl1-C1/1 or Complejo1a, although Peruvian Ministry archaeologists familiar with the site have also called it the ‘Huaca San José’ (Figure 53).

Figure 53. Plan view photo of Complejo1a (3D-103-Pl1-C1/1) or the "Pampa Mocan" site. To the left is the 2017 plan map of the site, niches recorded by Thomas Pozorski in 1987 are no longer identifiable today. Drone photography by Luis Jaime Castillo.

Pozorski’s (1987) published plan of the site featured a central patio, interior patio, and 3 interior rooms. One of these interior rooms featured niches, which led Pozorski to identify it as a U-shaped audiencia. Mackey (1987) extrapolating from Pozorski’s plan map, reported a total area of 1479m$^2$ (51x29m) for the compound. My project’s mapping of the complex recorded 1m more to its length—resulting in an area of 1508m$^2$. Our mapping also found that the niches that Pozorski observed were no
longer visible. More importantly, however, while Pozorski (1987) discusses this site as existing in isolation, my project’s research beyond Complejo 1a to the adjacent alluvial platform (a little over 150m SE), identified the related complex of 13 u-shaped-banqueta field houses, a torre and one ‘hinterland ceremonial center’ (Complejo 1b) (Figures 49 and 54). As discussed above, these sites are associated with midden, LIP ceramic fragments, some of which appear to be non-local, and S-shaped fields related to the field houses. Like the 15 architectural units in Complejo 1b, Complejo 1a or the ‘Pampa Mocan’ site is oriented with an entrance facing 45° E of N—toward the Cerros Higueron. This orientation means that the site’s entrance faced opposite all of the agricultural fields and even the highest trunk canal in the Pampa.

![Figure 54. Entire Complejo 1 including Complejo 1a (“Pampa Mocan Site”) and 15 structures in Complejo 1b. A small segment of the ancient road is visible just beyond the northeastern edge of these complexes and two torreones are on either site of the projected path of the road.](image-url)

Two excavation units (1x1m) R7 and R1 were centered on Complejo 1a (Figure 55). R7 was placed in the interior central patio and R1 was placed outside of the exterior southern wall. Excavation in
R7 revealed a very thin floor only a few centimeters beneath the sandy alluvial sediments. The floor itself was built directly on top of the sand and gravel material that make up the alluvial platform. R7 was devoid of any artifacts, much like the rest of the interior of Complejo 1a, either due to fastidious cleaning in prehistory or subsequent collection by passersbys (a modern-day road constructed for prospection by the Chavimochik project cuts past Complejo1).

Meanwhile, R1 was placed outside of the southern wall of Complejo1a, confirming that this structure was built directly on top of the alluvial sediments. While R1 did not provide any diagnostic clues to the Complejo’s cultural affiliation, a small lithic artifact was recovered (Figure 56). This small, smoothed, almost perfectly square (2.7 x 2.8cm) object was identified by project member Neri Escobedo Alzugaray as an open-weave fishing-net measure. Escobedo, who lives in the traditional coastal fishing town of Magdalena de Cao, explains that the small stone square would have been used during net-making to measure each hole in the net. The object did present wear across its center and comparing the dimensions of this artifact to museum collections of fishing tools and nets will be part of a future project. If this artifact is connected to the occupation of the Complejo1a site itself, it could supplement evidence

![Figure 55. Complejo 1a and location R units. Inset: photo of N1-CB of R7.](image-url)
from Complejo1b and from other field houses across Mocan that point to a mobile population moving to collect resources from the coast and episodically returning to agricultural land near the inland piedmont flanks.

Figure 56. Lithic recovered from R1 excavation. a.) front plan view; b.) oblique view: indentation from wear in the middle of the stone is visible.

My contention regarding the function of Complejo1a or ‘Pampa Mocan’ challenges the hypothesis that this site was a Chimú installation meant to oversee the construction of canals and fields. Rather, its orientation toward Cerros Higueron and, more importantly, the ancient highway (H1) that crosses in front of its eastern wall and then passes the adjacent Complejo1b (just 150m south east of 1a), strongly suggests that Complejo1 exists in relation to movement from the adjacent highlands. Moreover, the presence of two towers on either side of H1 signifies the importance of monitoring this thoroughfare. It seems indubitable that Complejo1a and 1b are related, given their proximity and concordance in orientation. Finally, while no diagnostic ceramics were recovered from Complejo1a, those collected from Complejo1b were all identifiable to the LIP; however, many fragments were styles unknown to any of the project members or coastal archaeologists consulted, suggesting they may be non-local or unknown Chimú types. Thus, my project found no definitive evidence that Complejo1a or the ‘Pampa Mocan’ site was affiliated with the Chimú state. Instead, closer investigation suggests the site had little to do with overseeing the fields and canals and much more to do with channeling movement through the piedmont flanks of the Pampa de Mocan.
My project also recorded an LIP ceramic workshop just outside of our collection limits. The wasters and vessels observed on the surface were stylistically Lambayeque. All whole vessels and diagnostic rim sherds were related to storage or cooking vessels. While Graham (1993) does not mention ceramic workshops in her description of seasonal field houses and related structures among the Raramuri of Mexico, this fixture in a seasonally-occupied landscape makes a great deal of economic sense. Transporting large ceramic storage and cooking vessels around the valley or greater region is costly, especially without the advantage of beasts of burden (see Shimada and Shimada 1985). Moreover, the density of ceramic sherds on the fields in the Pampa de Mocan suggests that vessels were somewhat disposable. The presence of a workshop for plainware utilitarian vessels would have provided a useful service for sesasional or episodic farmers.

Two other large, orthogonal sites (6B-142-CsC4-C8/1-4 or Complejo 8a and 8b for shorthand) with interior rooms were identified at the opposite end of the survey universe (Figure 57). Again, these complexes were sited adjacent and oriented to a formal highway (H3). Unfortunately, these important compounds were badly damaged, apparently by tractors. The sites were surrounded by property markers of the nearby agro-industrial giant Casa Grande (Grupo Gloria). While I filed an official denouncement of this activity with the Ministry of Culture in 2014, a recent television report by the channel CONTACTO indicates that systematic site destruction in this area is on-going. My project mapped and gathered what information we could from the remaining architecture. 8a is an adobe- and stone-built structure with nested orthogonal rooms, while just a few meters north of 8a, 8b is made of stone and consists of four almost identical rooms lined up next to one another. Almost no ceramic material was present on the surface of these sites, making them very difficult to date. The preservation and style of architecture suggests they date to the LIP. Their function is likely related to the nearby road (H3) and the connected water-well (P3) (see below).
Fixtures on the landscape. As mentioned previously, the project identified three major roads across the Pampa de Mocan, one (H1) associated with Complejo 1, one that passes through the middle of the bajada past several Cupisnique sites and fields (H2), and one located on the lowest edge of the survey universe (H3). H1 has been very badly damaged and obscured by a modern road related to prospection for the incoming irrigation project Chavimochic. H2 survives in only a few segments and H3 retains portions of formal walls. All three of these routes were likely used throughout several periods, however, the transformation of H3 into a formal highway occurred in the LIP.

H2 dates to at least the Early Horizon (900-200 BC). Although the road is lost after just a few short stretches, H2 segments pass by Cupisnique sites (including 5D-158-CsC3-2, 5D-174-CsC3-3 and R4, and CC7) and at least two geoglyphs; one of these geoglyphs was covered in Cupisnique ceramic fragments. Colleen Beck (1979:115) reported three types of Cupisnique roads in the southern deserts between the Chicama and Moche Valleys; one of these she described as “Cleared with stone side lines (1.20-11.20m wide)”. H2 fits this description, consisting of simple stone-lined borders and measuring approximately 5m wide. H1 is also largely lost to both encroaching dunes and the modern road; as a
result, its trajectory was not determined. H3, however, enjoyed better preservation in some segments thanks to formal adobe-and-tapia walls added in the LIP.

H3 is related to Complejo 8 a&b and passes by another remarkable feature: a raised 30m-long entrance platform (8c) leading to an 8x6.5m raised patio (8d). In the center of the patio was a subterranea rectangular unit with two steps (which was targeted through excavation designated P3). Excavation revealed this was once a water-well, featuring compact, thin, alluvial bedding in the southern half of the unit. The presence of a formal well with an entrance connected to H3 indicates this highway was well-traveled. While much of the highway is lost beneath the neighboring dune field, my team and I were able to find the road again where it re-emerged onto older land surfaces. The road led to a low pass where Cerro Tres Puntas and Cerro Colorado meet. There, dozens of ceramic sherds and lithic points were found at the base of the pass from a range of time periods and widespread regions, reflecting the time depth of this thoroughfare and the diversity of its travelers.

Foreign objects in the Pampa de Mocan. A final data set that points to the movement of people through this landscape is a group of foreign ceramic sherds. The correlation of pots with people is, of course, untenable, however, the presence of foreign plainwares is more likely to reflect the presence of owners or artisans. 1.2% of collected sherds were suspected to be non-local forms or decorative styles, with n=1713 total sherds (Figure 58). Several of these sherds were identified on the basis of polychrome decoration, which is rare for all periods on the north coast. However, others featured unusual light beige to white paste and decorative motifs.
Sherd 5C-214-CsC4-Fe21 is one of several from the collection that hints at movement of highlanders to the Pampa de Mocan from the adjacent sierra region or vice versa (FIGURE 59). The sherd is made up of a very light-beige paste, uncommon for coastal pottery. While white, kaolin-based clays were used in highland Cajamarca ceramics, the inflection-point angle, modeling around the collar, and incised circular motif do not conform to known Cajamarca styles. The best comparative collection for this sherd comes from a black-and-white set of drawings compiled by Andrzej Krzanowski (2006) in the course of his highland survey of Alto Chicama. Krzanowski’s work, which began in 1973, is unique—the only published survey of the highland region of the Chicama Valley. Krzanowski refers to the ceramic type attributed to the LIP as the Yurracama Phase, and the most recognizable ceramic decoration is known as Huamachuco Impreso. Huamachuco Impreso was first identified by McCown (1945) at the site of Marcahuamahucho in the highlands of the neighboring Moche Valley (see also Thatcher 1972; Topic
Based on comparison to his detailed publications and through consultation with Dr. Krzanowski via email, 5C-214-CsC4-Fc21 is likely a fragment of Huamachuco Impreso, though without further materials analysis, the location of production remains unclear (see also Krzanowski 1980). Several other examples of Alto Chicama or Huamachuco fragments collected in the Pampa de Mocan are displayed in Figure 4.15.

![Figure 59. Possible Huamachuco wares. Upper two photographs are of Sherd #5C-214-CsC4-Fc21. Lower two were found but not collected during survey. Photos by the author.](image)

**Summary.** Field houses dominate the Pampa de Mocan landscape; however, excavation reveals very shallow use-lives and sealed doorways in late prehistory, indicating planned abandonment and re-habitation. Several more formal constructions are oriented around the presence of major highways. Foreign ceramic wares and the presence of shellfish in almost every period further suggests a mobile population. Based on this evidence, in conjunction with the data collected from excavation and identification of opportunistic and seasonal agricultural fields, I argue:
The farming population of the Pampa de Mocan was largely mobile; it occupied this landscape periodically throughout history as an adaptive strategy, reacting to the seasonal and episodic availability of water.

Such a flexible system has broader implications for the prehispanic and contact-period economic system, calling into question the necessary emergence of private land rights alongside intensive agriculture. The colonial record provides some hints to this end. In the following section, I will review the literature on the colonial encounter with the prehispanic system of farming.

**Attitudes toward land tenure: flexible ownership and labor.**

In contrast to medieval irrigation practices in Spain, where water apportionment was proportional to the amount of land held by an irrigator (Glick 1970:207), the base unit of measure in the prehispanic system may have been the water itself. As Patricia Netherly (1977, 1981, 1984) and others (Ramírez-Horton 1977; Ramírez 1996:51) point out, local informants in the Chicama Valley referred to quantities of agricultural products in terms of the quantity of water required to produce them: “cinco acequias de maíz” [“five ditches of corn”-Translation by Patricia Netherly] (Netherly 1984:239). Ethnohistorian Susan Ramírez (1996:47) analyzed the earliest primary sources from the Chicama and nearby valleys and noticed the conspicuous absence of references to private land holdings. Instead, locals described their rights to *access* lands. Rather than using vocabulary that indicated ‘ownership’, they used terms such as “occupation, possession, and dominion”. At the same time, lands were clearly not ‘communal’—instead, Ramírez (1996:50) suggested that rights to land are best described as ‘usufruct’. Indeed, the language used in primary sources in describing legal claims focus on the products of the contested lands, not the plots of land themselves. Many early 16th century wills of local curacas or local lords, bequeathed to their inheritors, not plots of land, but rather the yields of said plots (Ramírez 1996:48). Moreover, there was a clear distinction between “lands” and “*chacaras*” (fields) – i.e. the difference between unworked and worked lands.
Ramírez (1996) postulated that this organization around ‘usufruct’ land rights, reflected a deeper conceptual dichotomy between the “cooked” and the “raw.” John Murra (1981) first interpreted Levi-Strauss’ (1969) model for the Andean region, recognizing this divide: crudo or raw resources were considered unworked, unprocessed, unspoiled, while cocido or cooked resources had been modified, improved, or labor or irrigation water had been applied (Ramírez 1996:52-53). Raw resources were ‘open access’, while cooked resources, such as land that had been irrigated or planted, were claimed temporarily by their developers. While the weaknesses of the structuralist approach have been argued at length (see Gelles 1995; Starn 1991, 1994), these interpretations fit well with concepts reflected in the ethnohistoric record.

In 1566, the corregidor Gregorio González de Cuenca carried out a formal visit (visita) in the Chicama Valley and established the towns of Paiján, Magdalena de Cao, Chocope, Santiago de Cao, and Ascope by resettling the populations that were ‘scattered’ across the landscape into reducciones (Cummins 2002; Mumford 2012; Rostworowski de Diez Canseco 1985; Zevallos Quiñones 1992:14,159) (See Chapter 6). As their visitas were carried out across north Peru, Spanish chroniclers mention that many communities had more houses than they had occupants, and it was not uncommon to find coastal peoples in the highlands and vice-versa. Drawing from just one example from the colonial archival records identified by Ramírez (1996:37-38), in 1566, the corregidor Gregorio González de Cuenca ordered highlander subjects of a coastal lord to stop migrating to the coast during the summer, because of they often became sick.

This form of territorialidad salpicada, shared or dispersed settlement, was an artifact of the usufruct land tenure system, which depended on water and labor rather than on plots of land (Ramírez 1996). The Cuenca-established towns reduced the widespread populations into a few, urban centers, and in doing so disrupted the formerly flexible and fluid prehispanic system, replacing it with permanent, bounded settlement (see Ramírez 1995:256). As land, labor, and water were tethered to one another and to fixed places on the landscape, the prehispanic system of adaptive flexibility was replaced by the Spanish colonial system of optimization with permanent settlement.
Interpretations.

Mobile agriculturalists often go unseen in the archaeological record because they create the same or similar material assemblages as year-round sedentary farmers. This dissertation combines multiple lines of evidence that together, converge on mobile behavior. The settlement data from the Pampa de Mocan include low site-use intensity, fixtures on the landscape, such as highways and formal administrative sites that functioned to channel movement, and the presence of foreign plainwares. Both the agricultural landscape features and the evidence from habitation sites come together to suggest that labor was transhumant—not unlike the labor organization in the territorialidad salpicada model of proposed by Ramírez (Ramírez-Horton 1977; 1986). In such a system, land is essentially valueless, therefore it is neither held in common nor in private hands, but instead, rights are usufruct.

The archaeological evidence gathered from survey and excavation indicates that peripatetic agricultural structured the land-use history of the Pampa de Mocan; next, I will present the environmental data that demonstrate both the periodicity of water influxes and human response in the past. In Chapter 3, I presented phytolith, starch and diatom data, which spoke to the plant records of individual fields. In the following Chapter, I will present the results of the pollen samples collected from pits placed around the Mocan landscape and P3; these results reflect the broader environment and point to change over time. The pollen records from several contexts suggest that the area oscillated between wet and dry periods.
CHAPTER 5: ENVIRONMENTAL DYNAMISM IN THE PAMPA DE MOCAN: THE PALEOBOTANICAL RECORD.

“The once-abiding belief in a balance of nature is deeply questioned and, in many quarters is now rejected outright. Instead, a large number of cornerstone ecological processes are described as nonequilibrium dynamics, long-term shifts, and historical conditionalities such as path dependencies and trajectories” (Zimmerer 2000: 356).

The previous chapters addressed two fundamental postulates centered on the relationship between intensive agriculture and society: first, that arid environments impose limitations on agricultural strategies, and second, that sedentary farming is a by-product of intensive irrigation in arid environments. Chapters 3 and 4 presented archaeological evidence from survey and excavation across the ancient field systems and sites of the Pampa de Mocan that point to peripatetic farming practices. Instead of finding settlement patterns reflective of long-term, permanent residence, the domestic sites in the area were seasonal field houses periodically occupied by a mobile population. The form of the ancient agricultural fields in the Pampa de Mocan, which included trunk-canal fed and opportunistic irrigation, was a response to the sudden appearance of floodwaters, and the need to prevent erosion, conserve water and moisture, and manage soil development. Rather than an ordered, uniform, state-administered landscape, agricultural development in the Pampa de Mocan was both seasonal and opportunistic, and intensive. Indeed, the labor and maintenance requirements of field technologies aimed at capturing floodwaters certainly met and possibly exceeded that of the traditional canal-fed field systems (see Hatch 1974).

The prerequisites for the opportunistic behavior observed in the arid Pampa de Mocan landscape included, 1) viable soil in the area and 2) the sudden appearance of water, either due to seasonal streams or El Niño flood events. While geographers expect poor soils in similar arid landscapes, in Chapter 2, I examined the soil, temperature, and climate of this region and determined that conditions were suitable for agriculture. The soils of these coastal deserts are remarkably rich in loess in part thanks to the sediment transport effects of El Niño. The addition of irrigation waters can result in increased cloud-cover and even cooler surface temperatures—especially if lithic mulching is applied to fields—affecting local climate. Moreover, my colleagues from the Universidad Peruana Cayetano Heredia and I recorded the
dynamism of desert plant life after the 2017 El Niño Costero (Coastal El Niño). The potential for similar blooming events in the past would have had positive effects on the water table level, erosion, and organic content of the soils. Chapter 2 hypothesized the potential for environmental dynamism for coastal deserts in the past; the present chapter tests that hypothesis against paleobotanical data from the Pampa de Mocan.

This chapter presents the environmental reconstruction data collected from excavations across the Pampa de Mocan. The results are based on pollen remains extracted from sediment samples. The paleobotanical evidence collected from the Pampa de Mocan demonstrates that the coastal environment may have changed significantly in the time between the close of the Early Horizon (900-500 BC) and abandonment at the end of the Late Intermediate Period (AD 1000-1470). This potential environmental plasticity has far-reaching implications for the landscape history of the Pampa and perhaps the coastal region more broadly. In this chapter, I approach a reconstruction of environmental history through close analysis of pollen data. Although by no means comprehensive or complete, the records I present here have inspired two conclusions: 1) that the Pampa de Mocan landscape has undergone marked environmental change over the course of its history; and 2) that one factor contributing to this long-term, nonlinear change was the episodic appearance of water and related blooming events.

Microfossils and tracing environmental change.

In Chapter 3, I discussed the phytolith and starch results from the excavated fields in the Pampa de Mocan. Both phytoliths and starch are microfossil remains of plants that can be extracted from sediments and identified with some taxonomic precision. Phytoliths are mineral (silica) casts of plant cells that

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13 The 2017 El Niño event has been qualified as ‘coastal’ because of its localized nature. Normally, sea surface temperatures begin to rise in the central Pacific before they reach the eastern Pacific and coasts of Ecuador and Peru. In the case of the 2017 El Niño, the temperature rise was not detected until the warm waters were already localized along the coast of Ecuador and Peru. The effects of the El Niño were the same or similar to a typical El Niño, however, due to the late detection of warning signs, modern states were unprepared. See:

survive in slightly alkaline soils (~7pH) (Coil et al. 2003; Piperno 2006). Similarly, starch remains also survive under alkaline conditions (Korstanje 2003) and are often recovered from artifacts (Piperno and Holst 1998; Piperno 2008). Starch is produced by amyloplasts found in the storage organs of plants, especially tubers and rhizomes. Under normal conditions, starch and phytolith microfossils reflect the physical presence of plant remains in or very near the sample: they are the cell casts or surviving organelles of decomposed plant parts and when drawn from archaeological contexts, they can be directly related to human management. While pollen is highly mobile, starch and phytoliths remains are largely stationary and therefore serve as reliable indicators of the site-specific presence of related plants; however, they do not capture the full range of plant diversity in the catchment area. Phytoliths and starch can often be identified to the family level, and more rarely to the genus or species level, while pollen can reach a greater degree of taxonomic precision. In other words, phytoliths, starch, and pollen, offer complementary data points and should be collected and analyzed together whenever possible (see Horrocks and Wozniak 2008). In the case of the samples collected and processed from the Pampa de Mocan, phytolith and starch remains were used to both confirm the presence of cultigens and diatoms (single-cell algae) in field systems in the past and to test the fealty of the pollen records collected from nearby excavations.

Archaeological pollen.

Pollen in archaeological contexts must be interpreted differently than pollen records derived from lake cores, marine cores, or ice cores, which derive largely from wind-pollinating plants. Instead, pollen extracted from anthropogenic features or sites can derive from a number sources. Pollen rain describes the natural dispersal of pollen grains in the open environment, particularly from anemophilous (air born pollen) species; consequently, in semi-closed or roofed structures, pollen rain is at least partially obstructed. However, pollen can also be dispersed through animal or insect transport (zoophilous) or the movement of water (hydrophilous). Therefore, contexts surrounding features such as agricultural fields or canals may contain a variety of pollen types that typically do not enter lake, marine or ice core records.
Pollen samples from archaeological sites pose challenges to data analysis, but they also allow for unique opportunities, especially in the investigation of past land-use over time (Bardseth and Sandvik 2010; Bozarth 1996; Damp et al. 2002; Horrocks and Wozniak 2008; McLauchlan 2003). For example, in a lake-core, the pollen record reflects continuous deposition of pollen rain from the catchment area. In many archaeological contexts, however, pollen deposition is episodic (Mercuri et al. 2010:888). At the same time, the archaeological record provides spatial and anthropogenic data that are typically absent from environmental samples (Hjelle et al. 2012:1368). In extracting pollen from terrestrial soils, archaeologists must be aware of potential issues for preservation.

Pollen grains have a thick, durable outer layer known as the exine, the primary material of which is sporopollenin (an organic biopolymer) (Figure 60). The exine layer typically features sculptural ornamentation, which can be diagnostic of the parent plant. Sporopollenin’s durability means a pollen grain can maintain its shape and ornamentation over hundreds and even thousands of years under anaerobic conditions, however, the material is vulnerable to alkaline environments (pH above 6). The mean pH of soils on the north coast today is 7.7, which means that terrestrial pollen records will be at least partially degraded. Even more detrimental to the survival of pollen grains is the process of oxidization in soils—soils that were once saturated and then aerated. At first glance, the Pampa de Mocan seems to be a tenuous setting for the survival of pollen grains. However, well-drained soils, such as those identified in excavations in Mocan, can delay and slow degradation processes; in fact, Dimbleby (1957:18-20) notes that tropical soils exhibit surprisingly good survival rates. Moreover, argues Dimbleby (1957:18), if hydrofluoric acid can be used as the separator, the probability of pollen recovery increases.
Pollen collection and processing methodology.

Archaeological pollen records, even more so than phytoliths and starch, are vulnerable to modern contamination. Modern-day pollen can enter a sediment sample if exposed to wind or if collected with a contaminated implement. In the case of the Pampa de Mocan samples, collection occurred exclusively in the mornings, when wind was low. A separate and sterilized spoon was used to collect each sample beginning at the bottom of the excavation profile (Pearsall 2015:208-209). Ideally, if funding allows, archaeological pollen records should be compared to samples collected from the modern surface; this was not financially feasible for my project, however a reference profile was compiled based on the modern plant life observed in the area. The absence of any pollen from any of the modern reference taxa in our samples speaks to the integrity of the records. Moreover, the degree of overlap between the archaeological records of pollen, phytoliths and starch in preliminary samples adds further credence to the pollen results (Table 8).
Table 8. Plants identified in the Pampa de Mocan

<table>
<thead>
<tr>
<th>Plant Family</th>
<th>Plants Collected in 2017</th>
<th>Pollen Collected from Archaeological context</th>
<th>Pollen Collected from Geological Test Pits</th>
<th>Starch collected from Archaeological Context</th>
<th>Starch from Geological Test Pits</th>
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<td>Amaranthaceae</td>
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<td>Amaranthus</td>
<td>Amaranthaceae</td>
<td>Amaranthaceae &amp; Chenopodiaceae</td>
<td>Chenopodiaceae &amp; Amaranthaceae</td>
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<td>Amaranthaceae</td>
<td>Amaranthaceae</td>
<td>Amaranthaceae</td>
<td>Chenopodiaceae &amp; Amaranthaceae</td>
</tr>
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Pollen extraction and analysis of the Pampa de Mocan samples was carried out in the Laboratorio de Palinología y Paleobotánica in the Universidad Peruana Cayetano Heredia, in Lima. The laboratory director, Luis Huaman Mesía, hosted the author for one year (2014-2015) for intensive training in botany, palynology, and phytolith and starch identification. There, together with biologists Geraldine Borja, Claudia R. Morales, and Fiorella Villanueva, the Pampa de Mocan samples were processed and analyzed.

Luis Huaman’s laboratory has a dedicated fume hood for paleobotanical sample processing, allowing for the use of hydrofluoric acid in the separation process. The sediments were measured to about 5g each, to which one pill of *Lycodopodium* was added; this allows for both the calculation of pollen concentration and acts as a reference for pollen loss during processing. Hydrochloric acid at 10% concentration was used to dissolve initial organics. Hydrofluoric acid was added to the samples and left for 8-12 hours to dissolve remaining organic materials and then was thoroughly washed. Zinc bromide was applied to further separate the pollen remains from the solution. Finally, safranin was used to dye the grains, and glycerine was added to adhere them to glass slides. A light microscope was used for identifications.

**Pollen records from test pits.**

In 2013, the project Chicama Valley Landuse Survey (CVLS) placed geological test pits across the Pampa de Mocan landscape for the purpose of establishing a reference record of geological strata and depth for future excavations (Figure 61). During the course of these test excavations, I collected sediment samples for pollen analysis. These samples were directed at measuring the degree of pollen preservation in the Pampa de Mocan soils. While pollen preservation was low in the areas with extensive dune invasion,

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14 For detailed description of sediment processing for pollen analysis, see:
Coil, James, M. Alejandra Korstanje, Steven Archer and Christine Hastorf
Dimbleby, Geoffrey W.
Faegri, Knut
those pits placed in the agricultural sectors, where soils were likely well-drained in the past, and in the area between the Pampa de Mocan study area and the Ascope Aqueduct, produced significant pollen concentrations. However, well-drained soils entail the risk of vertical movement of pollen grains between strata. Therefore, the results were compared to a modern-day vegetation profile to determine if any modern-pollen contamination existed. The most common pollen producer in the Pampa de Mocan today is *Capparis*, a desert fruit-bearing shrub (most other plants are cacti, which are rarely represented in pollen records). No *Capparis* pollen grains were present in the samples, therefore I feel confident that there is no modern contamination. However, I cannot establish the age of the results, nor the sequence; moreover, the relative concentration of each species has likely been affected by vertical movement. For these reasons, only presence-absence data are presented here.

Figure 61. Locations of CVLS test pits.
While, the results of the CVLS test pits do not represent a continuous chronological sequence, together, these records are a collection of separate moments of plant life in the Pampa de Mocan and its surroundings at different points in the past. Therefore, these data can speak to past plant diversity and provide a sense of change relative to the modern-day plant regime (Figure 61).

![Figure 62. CVLS geological test pit results. Sample names are on the Y-axis.](image)

The results of the CVLS test pits pollen analysis point to a very different environment in the past. While pollen from conifers like *Alnus* and Podocarpaceae can enter the atmosphere and therefore do not necessarily represent species living in the Pampa de Mocan environment, the Mimosoideae and the *Schinus molle* do represent past, *in situ*, tree life. The most common Mimosoideae in the north coast environment today is *Prosopis* juliflora also known as *algarrobo*. Algarrobo forest and stands are known throughout the north coast, though they are increasingly diminished today (Weberbauer 1945). The modern-day Pampa de Mocan is home to very few algarrobo trees; instead, the Pampa features scattered *Capparis* or sapote shrubs. *Capparis*, like *Prosopis*, are a desert species but *Capparis* play a very different role in desert ecology. *Capparis* grow low to ground and have broad, dense foliage, making them popular homes for desert fauna, especially foxes. The dense leaf cover arrests wind-blown sand, which, over time, accumulates to form dunes known as shrub-coppice dunes (Kar 2006).

*Prosopis*, in contrast, are tree species with small, pinnate leaves and dispersed ramification—they rarely initiate dune formation. They produce edible legumes, which can be ground into coarse flour. The
fruit also supports animal life, including populations of cañanes or *Dicrodon* lizards. These lizards make up an important food resource, both in the past and today. They are actively hunted in the Moche, Virú and Chao Valleys, and Chicama locals have also reported to me their taste for *cañanes*, although I do not know of active hunting parties. Elaborate traps are set along edge of algarrobo stands, sometimes measuring 100m long, and hunters can gather up to 130 lizards in one day (Holmberg 1957:208). Lizard populations are completely dependent on *Prosopis*. The tree gum of *Prosopis* is used as a syrup and in some archaeological examples, it was used to make repairs in broken gourd vessels (Pasiecznik 2001). By far the most valuable product of *Prosopis juliflora* and *Prosopis pallida* (*huarango*) is fuel: *Prosopis* has a very hard and slow-burning wood, making excellent material for charcoal. The tree is considered a threatened species on the coast of Peru today due to overexploitation for charcoal. Most importantly, however, *Prosopis* plays a central role in local desert ecology.

All plant cover in arid landscapes helps to prevent mechanical erosion—either by wind or water. Unlike most plants, however, *Prosopis* develops deep taproot systems, which both act as anchors on a wind-blown landscape, and maintain the water table level. Moreover, *Prosopis* canopies have been shown to increase under-story humidity, lower surface temperature, and lower wind speeds. The trees are nitrogen-fixers and leaf litter provides organic material, phosphorus, and nitrogen to surrounding soils (Pasiecznik 2001:62). Beresford-Jones’ (2004, 2009) work on *Prosopis pallida*, known as *huarango* on the south coast, in Samaca near the Ica River, demonstrates that this species is a keystone of desert ecology. The felling of *Prosopis* stands in favor of farmland in the past was detrimental to the local environment, resulting in widespread erosion and a dramatic drop in the water table (Beresford-Jones 2009; Heggarty and Beresford-Jones 2010).

*Schinus molle* is similar to *Prosopis* with respect to its role in desert ecology. Like *Prosopis*, *Schinus* wood is highly sought-after as a fuel and its canopy creates a similar microclimate—cooling surface temperatures and increasing under-story humidity. Archaeologists working at the site of Cerro Baúl in the Moquegua Valley of south coast discovered thousands of molle seeds; evidence of ancient *chicha de molle* production (Goldstein 2004:526; see also Valdèz 2006). Additionally, *chicha de molle*
has been recorded in both ethnographic and ethnohistoric accounts of the central Andes (Valdés 2012). Unlike *Prosopis*, which is only suggested by the Mimosoideae type-pollen, *Schinus* pollen was abundant in the CVLS Geo-Test pit records—it is largely *Schinus* that makes up the spike in pollen concentration between 6B-5B indicating that the tree was present in the immediate area in the past (See Dimbleby 1957 16-17). The presence of this species in the Pampa de Mocan landscape in the past is intriguing given that it is not found in the area today. Again, *Schinus*, unlike *Prosopis*, is largely a riparian plant, often found growing along river banks or canals; it also reproduces readily in agricultural areas with the help of human intervention (Goldstein 2004:524). Today, *Schinus* is largely restricted to the altitudes of 500masl or higher; although its current distribution may be the result of modern climate-change (Morueta-Holme Naia et al. 2015). The presence of *Schinus* in this landscape in the past is a definitive marker of significant environmental change since the prehispanic period.

The presence of several other species highlights the drastic change in plant life, and by extension, water availability from prehispanic Mocan to today. Araceae is a family of spadix-flower plants (a familiar, though not South American example is the calla-lily), which are indigenous to very humid, tropical regions. *Monnina* is a typical herb of lomas plant communities. Lomas plants, including *Monnina*, capture moisture from dense, low-hanging clouds during the austral winter. Today, lomas do not exist on the coast north of Cerro Campana (just to the south of the Chicama Valley). The presence of *Monnina* indicates a past cloud cover regime very different than the modern-day—possibly encouraged by the ancient irrigation activity and formerly dense plant-cover overall. Sample 5B featured the greatest diversity of cultigens, all present in the same layer. Among the cultigens, tropical fruits (*Passiflora, Pouteria*), tubers (*Ipomoea, Manihot*), a variety of small squash (*Cyclanthera*), and *Zea mays* speak to a strategy of crop diversification. The presence of several of these (*Zea mays, Manihot*) was further confirmed by the recovery of starch grains.

The data derived from the CVLS Test Pits demonstrate the drastic transformation of the Pampa de Mocan landscape from a mesic to a xerophytic environment. However, because of the nature of pollen deposition in these soils, the CVLS record cannot speak to specific climate events or even chronological
sequence. For a continuous pollen sequence and abundance-data, I turn to the pollen record recovered from P3, an ancient well located along the formal road H3 (see Groenman-van Waateringe 1992 for a relevant case study). There, the sealed context produced much higher quantities of preserved pollen grains.

P3, as described in the previous chapter, was a 3x3m excavation placed around a rectangular, stone-built, semi-subterranean structure. A raised platform was constructed around the structure, and a raised causeway led to the platform from the formal road, H3. Excavation revealed a finished floor around the structure with scattered bivalves. Two steps led down into the area that I identified as a well. The fill consisted of a thick and hard mud with gravel inclusions, followed by very thin alluvial bedding and sand layers. The entire deposit was sealed by extensive wall-fall, preventing any visible oxidization of the layers below. Pollen samples derived from the bedding layers beneath the wall fall, which represent sedimentation after the well was out of use, but before the wall fall event. I attribute the wall fall to antiquity and link it to other activities across the platform that suggest the intentional destruction of the floor, walls, and surrounding architectonic elements of this complex (Figure 63). No diagnostic ceramic material was recovered from this area; the nearest associated sites are Complejo8a and 8b, which were tentatively dated to the Late Intermediate Period. Likewise, the pollen results are not dated. They are, however, sequential, and therefore represent a floating chronology. Although not tied to an absolute date, the sequence speaks to both the nature and frequency of plant-life change, and by proxy, climatic events in the Pampa de Mocan’s prehispanic past.
Figure 63. Plan view of P3. Left: E profile of excavation; Right: S profile of excavation; H3 marked in red.
Figure 64. P3 pollen results.
Unlike the CVLS Geo Pits, the sediments in P3 presented no visible evidence of oxidization; pollen was well-preserved, and concentrations were high enough to present abundance data (Figure 64).

Generally, the pollen concentration is interpreted as a simple proxy of pollen abundance: pollen grains per gram of sample. The profiles to the right of the diagram display the pollen concentration. In samples from layers B-D, pollen concentration was quite high; meanwhile in samples A-B and E-F pollen concentration drops. Despite fluctuation across samples, the concentration is high throughout the sequence. While pollen concentration can reflect plant density (the number of plants per m²), the individual histograms of each species or family in the diagram are not necessarily reflective of the density of that plant type. Pollen is produced in different quantities across plant families, often depending on the form of pollen transport (Faegri 1989). For example, while insect-pollinating plants such as *Acer* produce around 1000 grains per anther, wind-pollinating plants, including many trees, produce pollen at a much greater scale, approximately 10,000 grains per anther (Faegri 1989:14-15). It can be extremely difficult to control for these differences in terrestrial soil records. Therefore, rather than reading the diagram in terms of relative abundance across plant types, here the emphasis is placed on the presence of a given taxa and whether it increased or decreased over time (not how much it increased or decreased).

In terms of plant types, I have identified 4 paleo-phases in the P3 record. The earliest phase begins with level F, which presents an important marker for the presence of standing water: *Typha*. *Typha* or cattail is a common sedge of marshy or wetland areas of the Peruvian coast, however, it is rarely found so far inland and never in dry environments. *Typha* can grow along slow-moving canals, though it prefers still-water environments. *Typha* has several archaeologically-identified economic uses as a fiber for baskets, mats, and other woven objects, and its edible rhizome may have been collected as a food resource (Towle 1961:16). However, there is little evidence that *Typha* was actively managed for its caloric value. In this area of the Chicama Valley, *Typha* serves as a proxy for the presence of abundant, standing water—conditions that might be expected in the aftermath of a flood event. *Typha* is present in Level F but decreases in the Level E and disappears from our records in Levels D and C. Coinciding with *Typha*...
in Level F is Asteraceae and several Amaranthaceae, both shrubs or herbaceous plants that require reasonable amounts of water.

The subsequent Level E sees a decrease in Typha, Asteraceae, and one Amaranthus, alongside a jump in cultigens: Zea mays and Pachyrhizus. Pachyrhizus is the tuberous root crop known as ‘jicama’ and outside of the Spanish-speaking world, as ‘yam bean’ (Towle 1961:51). Importantly, the presence of these crops coincides with a marked decrease in weedy herbaceous plants such as Asteraceae, but also other grasses (Poaceae >50um) and Sonchus (dandelion). Throughout the record, there is a negative-relationship between the presence of maize and these weedy plant families, and Typha. The suggestion here is that as waters recede, farmers move in to the area to cultivate fields; while farmers are managing their fields, weedy invaders are also being managed. Meanwhile, in the next two levels, there is a marked increase in the richness (diversity) of weedy taxa, while cultigens sharply decline—this phase (levels C and D) likely reflects the abandonment of agricultural fields in the immediate area.

Levels C and D witnessed a steep increase in plant diversity, alongside a decrease in the presence of cultigens, especially maize. The plants that were thriving during this phase include the algarrobo tree (Prosopis), Alternanthera (Amaranthus) and Amaranthus haughtii, Asteraceae (flowering shrubs and weeds), grasses (Poaceae >50um), Waltheria (flowering mallow), and Solanum (nightshades).

Meanwhile, no evidence of standing water is extant (i.e. Typha does not re-enter the record). The absence of evidence for great amounts of standing water is not definitive, especially when analyzing archaeological pollen records. However, given that the preceding phase (Level E) saw a decrease in Typha and presented data related to farming and cultivation, I interpret Levels C and D as a phase of farm-abandonment rather than an ENSO-related blooming event: as seasonal farmers moved out of Mocan, weedy invaders began to move back in. It is very likely that this was a short-term or seasonal abandonment because by the end of the subsequent Level B, Prosopis shows a downturn likely pointing to human interference, specifically, the felling of these trees for firewood or construction. The decrease in Prosopis is likely not related to a water shortage, for example, because contemporaneous water-loving herbs are prosperous.
Finally, Level A is identified as an ENSO-related blooming event. It has the highest richness (S) score out of all levels sampled and there is a sudden surge in Typha (Table 9). There is 35% overlap between the modern plants that my colleagues and I collected in the Pampa de Mocan in the aftermath of the 2017 El Niño (see Table 8), and the ancient plants identified through pollen analysis in Level A of the P3 record. Given that many plant species are likely not represented in the archaeological record, that degree of overlap is significant. These three lines of evidence, the sudden presence of Typha, the jump in plant diversity, and the parallels in taxa identified in our reference modern ENSO-blooming collection and the archaeological P3 pollen record, combine to suggest that Level A represents an ENSO-related blooming event. Finally, both Pachyrhizus and Zea mays are present in this blooming-level, which could indicate the return of farmers and beginning of opportunistic cultivation.

Table 9. P3 Richness (S) scores.

Again, this pollen sequence reflects plant life history after the abandonment or drying-out of this well. The record is not tethered to an absolute date, but it is sequential and therefore provides evidence for the dynamics of seasonal farming and episodic water-influx events over a period of time. The P3 pollen record demonstrates that prehispanic plant life in the Pampa de Mocan was far more diverse than today. Moreover, the negative relationship between cultigens, some weedy herbaceous growth, and Prosopis provides insight into both human-plant interaction and management and the benefit of seasonal farming,
which allows for the regrowth of crucial species (*Prosopis*) in the local ecology. Finally, evidence for an ENSO-related blooming event alongside the reappearance of cultigens suggests that ancient farmers did indeed take advantage of the sudden appearance of water in the Pampa de Mocan, and, likely, other extenuating benefits (higher water table, flushing out of salts, faunal migration, new plant growth). In other words, the P3 data alongside CVLS data provide an archaeological record in support of the hypothesis presented in Chapter 2: environmental dynamism, particularly the markedness of seasons, has changed significantly since the prehispanic period, and farming strategies were organized around the seasonal or episodic appearances of water in the landscape.

The most recent phase of the Pampa de Mocan landuse history has been sustained abandonment: the area has remained uninhabited and undeveloped agriculturally since prehispanic times. The abandonment of the Pampa de Mocan in prehistory might be considered to mark an end point in its trajectory, however the area has recently become a central component of a modern-day development plan. In the following chapter, I will explore how the abandonment of this landscape is inextricably intertwined with the environmental and economic structure of the Chicama Valley today.
CHAPTER 6: PAST AND PRESENT IN THE PAMPA DE MOCAN

“The study of the relationship between the recurring and the unique has led to unsuspected and often counterintuitive results, linking phenomena at the microscopic level (in our case that of the individual) to those at the macroscopic level (in our case that of the society) and explaining the spontaneous emergence of qualitative transformations” (van der Leeuw and McGlade 1997:2).

In the previous chapters, evidence from the Pampa de Mocan has shown the traces of an ancient peripatetic intensive farming system capable of responding to environmental and seasonal fluctuations in the landscape. The movement of labor to take advantage of seasonal or episodic resources is a risk management strategy: by diversifying both their land and their labor ‘portfolios’, ancient agriculturalists as a group adjusted for frequent and at times violent changes in water variability. Moreover, flexibility in land rights and property allowed irrigators to move freely to cut new canals further up or downstream as needed during periods of floods or main-channel migration. This system, was indeed, intensive in the Boserupian sense: it scaled up the amount of territory utilized by farmers but required the simultaneous operation of both river-fed irrigation canals and opportunistic fields, which often involved great labor investments in the immediate or short-term.

The Chicama today is inextricably connected to the history of use and abandonment of this ancient farmland in the past—the Pampa de Mocan is a key breakpoint along the historical path of this important Valley. Although rich in archaeological remains, the modern-day Pampa de Mocan is unoccupied. The only signs of modern interference are several property markers concentrated in the southwest corner of the survey polygon, a road associated with the incoming state-sponsored irrigation project Chavimochic, and two, now nearly illegible, Instituto Nacional de Cultura (INC) signs.15 The nearest town is Mocan, so-named for the associated colonial hacienda, which is located about 6.5km to the southeast. Meanwhile, the floodplain of the Chicama Valley is the consummate image of the ‘anthropocene’. As mentioned in Chapter 1, over 90% of the Valley floor is dedicated to cane production carried out by a single company: Grupo Gloria. In fact, today’s Chicama represents the opposite of the

15 The Instituto Nacional de Cultura became the Ministry of Culture in July 2010.
opportunistic, water-conservative, risk-averse, multi-cropping farming strategies encapsulated by the Pampa de Mocan.

This Chapter will address how and when the Pampa de Mocan was abandoned. The archaeological evidence suggests very thin Late Horizon (AD 1470-1532) activity and no clear evidence of colonial occupation. Water distribution and water rights defined the colonial geography; therefore, I begin by attempting to reconstruct the colonial history of water administration in the Chicama Valley to test whether the Pampa de Mocan was a part of that system. Next, I turn to archival documents and toponyms to narrow-in on the date of abandonment. After the abandonment of the Pampa de Mocan, the Chicama Valley transformed as a result of a paradigm shift: water and labor ceased to be the primary resources, and instead land became the object of maximization strategies. The transition between the prehispanic and colonial water-use landscapes was not seamless. Abrupt ruptures in traditions of water management and settlement had visceral effects on the colonial landscape that continue to affect the Chicama Valley today. Even the seemingly passive processes of irrigation-branch abandonment have helped corral the political, economic, and social histories of the Chicama Valley into their present state. This chapter explores these threads—political, economic, and social—from the perspective of the landscape of the Chicama Valley from its past to the present. In doing so, it identifies a positive-feedback loop of land-holding consolidation followed by system breakdown that has pervaded landscape history in this region since the Republican era. The erasure of the principles of flexibility, opportunism, mobility, and risk-management, so central to the success of the ancient Mocan landscape, catalyzed a breakpoint that set-off this cycle.

The colonial history of water administration on the north coast.

After a brief, and apparently indirect Inca occupation, the north coast experienced decades of political, social and economic stability in the aftermath of Spanish Conquest. A cycle of power consolidation followed by disintegration can be traced back to at least the Colonial Period, beginning with the encomienda system. The institution of the encomienda dates to Medieval Spain during the re-conquest of
territory from the Moors, and it was put to use almost immediately by colonizers in Hispaniola, Mexico, Peru, and Chile (Batchelder and Sanchez 2013:46-47). Encomiendas were awarded to loyal subjects of the Crown and consisted of temporary and non-transferable grants in tribute and labor from a group of native occupants. The grants benefited the Crown by assigning a steward for the native population, thereby protecting their labor force; but at the same time, the system was designed to prevent the emergence of a powerful landed-elite as grants were not heritable. Meanwhile, the encomendero had wide power to administer the collection of tribute with the help of local curacas (Batchelder and Sanchez 2013). Curacas continued the management of water in much the way they had in the decades preceding the Conquest (Keith 1971). Crucially, an encomienda was not a land grant; at the time, land had virtually no value without the labor force required to make it productive (Keith 1971:434). However, as encomenderos began to monopolize labor and water, in an attempt to convert their conditional rights into permanent ownership, the Crown took steps to break up the concentration of power.

The prehispanic management of water is not fully understood, but colonial legal and administrative documents allude to past practices. “Interesados” or those communities or groups farming along an acequia, distributed water based on ‘turnos’ (turn-taking) (Netherly 1984). A similar system of turnos or “mitas de agua” continue to be in use in the high Andes today (see Mayer 2002:259). Moreover, ethnographic evidence from the highlands of Peru suggests that, in some cases, the apportionment of water was tied to a ritual calendar that pervaded daily life (Gelles 1995:87-92, 2000; Urton 1996). According to Clément (2015:121), Spanish colonists continued the use of the prehispanic turn-system: by taking turns irrigating farmland, the limited river volume was distributed to the entire valley rather than being spent on the upstream-branches. In the prehispanic system, however, fields along the canal were irrigated tail to head (i.e. downstream to upstream) (Netherly 1984:246; see also de la Vega 1963 [1586-1600]:153), while the Spanish system watered those fields closest to the canal intakes first (Glick 1970). Canal maintenance and cleaning was organized in a similar manner, with the principal canal divided into sections by feeder canals and each sub-polity or group responsible for their assigned section (Netherly
This organization was fundamentally different from that of the Spanish, which, by the time the encomienda system had become obsolete, distributed irrigation water through the payment of fees.

By the 1550s, the Spanish Crown became increasingly concerned with the abuses of the encomienda institution and fearful of an emerging landed-elite class. Consequently, the administrative rights of encomenderos were restricted and handed over to Crown-appointed corregidores. The corregimiento effectively replaced the encomiendas’ role in collecting tribute, severely undercutting their efficacy and further tying the institution into the European economy. The Crown’s corregidores reshaped the human geography of the north coast by implementing a system of forced resettlement: moving thousands of dispersed people into planned towns or reducciones concentrated in the lower and middle areas of the valleys. In the Chicama Valley, 14 or 15 settlements were reduced to just 4-5 urban towns between the years of 1572-1573—the process had far-reaching social and environmental consequences (Cummins 2002; Mumford 2012; Ramírez 1996:71).

The Chicama Valley. Prior to the implementation of reducciones, many settlements in the Chicama Valley had been located at the valley neck, adjacent to important canal intakes. Richard Schaedel (1981:315) argued that the down-river shift in settlement threw entire irrigation branches into peril. Trunk systems were no longer under the management of proximal curacas and were left abandoned by their encomenderos in favor of pastureland (Schaedel 1981:316). At the same time, the contraction of population into urban centers disrupted encomenderos’ formerly exclusive rights to native labor. Land was suddenly in high demand, especially around the newly established Spanish towns (Keith 1971). In response, encomenderos and other enterprising colonists, began to purchase land grants, many of which included tenant-or serf-like farmers. These haciendas redistributed wealth and power from the hands of a few encomenderos to a new, larger group of landed-elite. However, haciendas differed from their encomienda predecessors in other ways. They ushered in a fundamental shift of economic organization: instead of having purview over a labor population, which potentially allowed for mobile and flexible responses to water shortages or disaster, hacendados held power in land-rights. Land tenure, and
consequently water rights, were fixed resources on the landscape, and their fixity necessarily restricted agro-pastoral movement.

The 1572-1573 resettlement campaign of then-corregidor Juan de Hoçes, is perhaps the most far-reaching legacy of this period; among its many effects, it exacerbated natural disasters on the coast. Soon after resettlement was complete, a powerful El Niño struck the region. The El Niño event of 1578 had devastating effects on the new colonial geography – for example, the reducción of Magdalena de Cao in the Chicama Valley was almost completely wiped-out and a new town was relocated on higher ground, where it still exists today as part of the El Brujo archaeological complex. While there are examples of sacrificial acts and destruction related to powerful El Niño floods in the prehispanic period, the concentration of population and infrastructure into urban towns and lands located along the river banks and at the bases of coastal mountains during the Colonial period certainly compounded the devastation caused by this event. Colonial smallholders were now spatially restricted—tied to their plots of land or plantation. The new system prevented ancient risk-management strategies involving mobility and temporary fields, which further lengthened recovery times and added to food shortage crises. While the El Niño event of 1578 wreaked havoc on urban settlement and irrigation infrastructure, and led to disease and food and water shortages, ultimately, the colonial response was to essentially restore the 1572-1573 settlement plan, which has remained the same until today.

‘Mocan’ in the colonial record. Throughout the late 1500s and the 1600s, as haciendas came to replace encomiendas, land was increasingly considered private property and this transition gave rise to conflict. Records related to the Chicama Valley in the Archivo Regional de La Libertad in Trujillo and the Archivo General de la Nación in Lima, Peru consist almost entirely of property and water disputes. These records form a rich repository of toponyms often related to canals. How and when the Pampa de Mocan fits within this history can speak to the timing of the abandonment of the Pampa. Indeed, the Spanish paid meticulous attention to the Chicama Valley, the site of one of the earliest encomienda divisions and corregidor visitas, and one of the earliest ingenios de azucar (an apparatus used to grind sugarcane) in Perú (Ramírez 1995:260). Consequently, the Chicama Valley has been the subject of several important
Francisco Pizarro founded the city of Trujillo on March 5, 1535. Shortly after, he divided the neighboring Chicama Valley into two large encomiendas: Chicama, allocated to Diego de Mora, and Licapa, also known as Paijan, granted to Francisco de Fuentes around 1538. The organization and boundaries of both encomiendas were defined by the prehispanic acequias, principal irrigation ditches that continued to be in use at the time. It seems likely that these divisions reflected prehispanic socio-political groupings as well. Patricia Netherly’s (1984) analysis of legal and administrative colonial documents reveals that the prehispanic sociopolitical system of the Chicama Valley was organized around a system of asymmetric dualism, or “dual corporate organization” (Netherly 1984:231). According to Netherly, the Valley was not controlled by a single ruler; rather, both territory and power were split between two moieties, each with their own internal dualistic hierarchical divisions (Table 10). These divisions were referred to by the Spanish administrators as parcialedades and the polity as a whole as a repartimiento. The geographic unit of the Chicama Valley, therefore, consisted of two polities: Licapa and Chicama.

Table 10. Local leaders from the Licapa parcialidad. Compiled from Ramírez (1995) and Zevallos (1992).

<table>
<thead>
<tr>
<th>Señores Principales or Caciques of the Cacicazgo de Licapa or Paiján*</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Francisco de Fuentes (Encomendero)</td>
<td>1538</td>
</tr>
<tr>
<td>Quyñop</td>
<td>pre-1532</td>
</tr>
<tr>
<td>Don Francisco Nujar el Viejo</td>
<td>1532-1565</td>
</tr>
<tr>
<td>Don Juan Chachaynamo</td>
<td>1565</td>
</tr>
<tr>
<td>Don Gonzalo Ynosupo (principal of Yalpa)</td>
<td>post-1565</td>
</tr>
<tr>
<td>Alonso Sichay</td>
<td>post-1565</td>
</tr>
<tr>
<td>Gonzalo Nuxa</td>
<td>death 1609</td>
</tr>
<tr>
<td>Doña Juana Najar</td>
<td>post-1565</td>
</tr>
</tbody>
</table>

Recreating a landscape through toponyms: methodology.

Over the course of two weeks at the end of July 2017, I reviewed colonial documents in the Archivo Nacional de La Libertad, located in Trujillo, Peru. My study was directed at identifying dated documents that referenced Mocan or the ancient Pampa. I reviewed 40 documents dating from 1608-1820; I did not
According to the colonial records, the Licapa polity was bounded by the Ascope acequia to the northeast and the Yalpa acequia to the southwest. The Pampa de Mocan should be located within the area hypothesized for this polity. A hacienda named Mocan was established about 3km southeast of the nearest edge the Pampa sometime in the mid-1700s. In 1794, the hacendado of Mocan, Fermín Matos y Risco, appealed to the authority in Trujillo from the “Hacienda de Licapa” to forgive his taxes for the year, because his hacienda Mocan had an unproductive year both due to the scarcity of water and the location of his hacienda far from the main road, the Camino Real:

“los pocos frutos, que produce se vé en la necesidad de introducirlos a la Ciudad, por que no lo es fácil salir de ellos en la propia hacienda por estar desviada del Camino en cuyo supuesto así por hallarme [?] en sumo atraso como por un distancia los pasajeros devuelven a otra hacienda inmediata en donde logran comprar los afectos que necesitan, y que así mismo se halla sasionado [?] de la carencia que tiene de aguas…” [Cabildo-Causas Ordinarias 135:271 (December 6, 1794)].

“it is seen to be necessary to bring the few fruits that are produced to the City, because it is not easy to leave from there to the given hacienda due to that it is a detour from the Highway in such a case so to find me [?] is at most a delay for the distance passangers return to a different hacienda close to where they manage to buy the affections they need, and so it is found [?] of the lack of water ...” [Cabildo-Causas Ordinarias 135:271 (December 6, 1794)] [Translation by the author].

Based on this document, the Mocan hacienda pertained to the Licapa hacienda and was located at some distance from the Camino Real (today-the Panamerican Highway). The hacendado also was concerned over the lack of water, which was affecting his crop. The modern-day town of Mocan is situated in the same area as the colonial hacienda today and continues to suffer from water shortages. Meanwhile, the Pampa de Mocan is not named in any colonial documents reviewed to date, but, based on its proximity to both the hacienda of Mocan and the Ascope canal, it likely corresponded to the Licapa parcialidad (ANP Aguas 3.3.1.10) (Netherly 1984:232).

_A place with no name is no place._ Toponyms are crucial data-points for the history of the north coast landscape: they often pre-date the arrival of the Spanish and they can be descriptive of the place they assign. In the Chicama Valley, at least two important languages were recorded at the time of Conquest: Muchik, reportedly spoken north of the Chicama Valley, and Quignam, also known as Yunga.
and possibly Pescadora, spoken south of the Chicama Valley (Carrera 1880[1644]; Krzanowski 1978). Zevallos Quiñones (1944:7) reports that many toponyms on the north coast end with the syllable CAN, such as Mocan, a termination that does not exist in the highland languages of Quechua or Aymara. Rather, the Yunga meaning of AN is “house”; and coincidentally, CAN in the Maya language Quiché means “to live” or “to stay”. In 1566 a newly established Spanish town was given the name “Paiján”. PAI (paijein – voltrear)-JA (Ja – agua) -AN (An – casa), a Mochica word, likely means “Casa donde voltea el agua” [House where the water turns around], a possible reference to a canal intake or turnout, and indeed, a major acequia was known as Paiján (Esquerre 2016:205-206). Further examination confirms that colonial hacendados structured space around canals and categories of land, including the wild, invasive brush vegetation described as monte (Glick 1970; Ramírez 1995; Zimmerer 2007).

Towns, tierras [lands], and even people shared names with the corresponding principal canal (acequia). Netherly (1984: 231, 237-238) argued that socio-economic parcialidades were organized along these acequias – some fed only one parcialidad, others, fed more than one grouping. For example, the acequia Paiján watered the parcialidad of Nuxa, and probably also Licapa. Netherly (1984:239) reported that the Paiján acequia moved past the near-river lands even traveling over wooden aqueducts to feed the areas of Nuxa, Paiján, and Licapa. In this way, Mocan, Nuxa, Paijan, and Licapa are all potentially synonyms, making place-identification challenging. Among the archival documents from my study, one record, dated November 2, 1803 from the Cabildo de Trujillo, read, “…hallan impuestos en las [tierras?] de San Josef de Nunja alias Mocan, y las de Nacóp, conocidos por Gavidia [Gabidia]” (Cabildo-Causas Ordinarias:63:1080). Indeed, San Jose or Josef de Nunja, Nuxa or Nuja, and Mocan are often used interchangeably in the documentation. A selection of a few texts demonstrates this issue: in 1815, “…y en la hacienda de San José de Nunja y Mocan [73:1201]”; in 1816, “…de la hacienda nombrada San Josef de Mocan”; in 1685, “…en especial de la hacienda San Josef de Nuxa [206:1484]”; and in 1653, “…mi hacienda que se llama San Jose de Nuxa – tierras de Nacop arrundamiento – 98 fenegas [20:434]”. In 1566, the curaca of Paiján appeals to the local authority for the rights to both the Colupe and Nuxa (also
called Pucnec) canal, indicating that both Colupe and Nuxa communities had been re-settled into the town of Paiján (Clément 2015:114-115).

Despite the lack of clarity among the use of these toponyms, it is clear from the records that “Nuxa” was the name of an important canal: “…Expediente promovido por D. Diego de Salta, cacique y Gobernador de Paijan contra Gaspar de Espinoza Guzman, Protector de los Naturales, por usurpación del agua de la acequia principal llamada Nuxa” [Alcalde de Aguas:110:2049] (September 5,1617). By compiling the references and dates for Mocan, Nuxa, Nuja, Nunja, and Nacope, I have concluded that “Nuxa” is probably the earliest identifier for the area along a principal canal by the same name (Figure 65).

Figure 65. Timeline and corresponding toponyms. Frequency of names reflects the frequency of their appearance in the archival documents reviewed in July 2017.
The above passages confirm that the acequias themselves were identified with their Muchik names, which in turn became toponyms for surrounding lands, and incorporated into names for later
colonial haciendas. Of course, as mentioned above, the entire prehispanic canal system is the basis of modern industrial irrigation. Figure 66 combines Patricia Netherly’s (1977) compilation of the Muchik names for modern principal canals in the Chicama Valley, toponyms reported and described by Jorge Zevallos Quiñones (1992) and Rocío Delibes Mateos (In Preparation), and my own research from the Archivo Regional de la Libertad in Trujillo.

According to the colonial documentation, the Nuxa canal watered the Mocan hacienda. Rocío Delibes Mateos’s work in the Archivo Regional de La Libertad (ARL) uncovered a schematic of the colonial canals dating to 1565 (pre-dating the establishment of a Nuxa or Mocan hacienda). There, the Nuxa canal and ‘sus interesados’, including Facala, were listed and the canal itself was positioned immediately downstream from the Ascope Canal (see Figure 66). Meanwhile, the cacique principal Juan de Mora was said to possess lands near the hillslopes upstream from the Nuxa and Ascope canals at the Valley neck. His territory ended in front of the “facalan tower” (Clément 2015:116-117) (Figure 66). There is no mention of any lands downstream of that same irrigation branch. At the same time, the Pampa de Mocan is located upslope from the Nuxa canal, and therefore could not have been watered by it.

Topographically and hydraulically, the Pampa de Mocan corresponds to the Ascope canal branch system. This connection has been confirmed archaeologically (see Chapter 3). However, according to the Delibes Mateos’ schematic, the Ascope Canal watered only two groups of interesados, “Ascope de don Alvaro” and “Clara de Alvarado” in 1565. There are no groups listed further downstream of Clara de Alvarado. The absence of any known reference to the Pampa de Mocan in the colonial documents suggests that the area had been 1) unoccupied at the time of Conquest and, in the aftermath of population decline, it was never re-occupied; or 2) abandoned by the time of the Spanish arrival to the north coast.

Lands, canals, or settlements that might have been located in the general vicinity of the Pampa de Mocan have not appeared in the colonial record to date. Given the assiduity of the Spanish in their acquisition of arable lands, and the location of an ingenio de azucar in nearby Ascope, it is likely that the Pampa de Mocan was devoid of settlement and desertified at the time of Spanish Conquest. Susan Ramírez (1995:261-262) points out that early chroniclers such as Pedro Cieza de León extolled the
agricultural bounty of the north coast river valleys in the 1530s and 40s. Just a few years later, the Spanish complained that the Chicama Valley was covered in monte, which loosely translates to uncultivated land covered in shrubby brush or xerophytic trees, bramble, and sand (Ramírez 1995:262), due to the abandonment or lack of maintenance of canals. Scholars point to the sharp population decline at the time of Conquest (between one tenth and one fifth of the former population of the north coast was accounted for by 1567) (Cook 1981; Netherly 1977; Wachtel 1977), the introduction of European plants and grazing animals, and the disruption of social and labor networks as contributing factors to environmental degradation (Brüning 1989; Schaedel 1981, 1992). Similarly, the abandonment of the Pampa may have been caused by either natural or human-induced environmental degradation, the disruption of regional social networks, such as the territorialidad salpicada system (see Chapter 4), or the arrival of the Inca imperial campaign to the north coast, estimated to have occurred around AD 1470.

Although abandoned, the Pampa de Mocan has played a crucial role in the long-term formation of the Chicama Valley. Its location and dimensions suggest that it was an important territory of the Licapa polity—undoubtedly, the loss of this territory had political and economic implications. Moreover, the geomorphological consequences that result from the abandonment of an agricultural landscape of this size (totaling 5800ha) certainly affected the sediment loads picked up by trade winds, invading nearby fields, and blocking canals further inland. While the processes that led to the Pampa de Mocan’s abandonment remain elusive, there is no doubt that the shift in agricultural practices from one centered on available water and labor to one that maximized available land had long-term disastrous environmental effects for the Chicama Valley.

_The nineteenth and twentieth centuries in the Chicama and the politics of water._

The early Colonial Period of the Chicama Valley was marked by the emergence of landed-elite: hacienda owners who consolidated power, in part, by controlling the distribution of irrigation waters. The archival record is replete with disputes concerning water rights and plaintive appeals to local authorities over wide-spread water shortages. The colonial land-centered approach to irrigation—one that generated
competition over land rather than labor—suggests that Chicama River volume was almost always
exhausted, an inference supported by the number of colonial archival records devoted to water litigation.
Water, the lack of water, and abuses of traditional water rights marked the socio-political landscape of the
Chicama Valley, especially since the shift from the encomienda-system to haciendas.

By 1870, an elite class of about 25 hacienda families ruled the Chicama Valley, but by 1910
many of these families had sold their property or moved to Lima in the aftermath of the War of the Pacific
(1879-1883). Two families, the Gildemeisters in their estate at Casa Grande, and the Larcos, in Roma,
Chiclin, and Chiquitoy, began acquiring land and picking up where the previous hacendados had left off:
planting and processing sugar cane. Rafael Larco Hoyle’s archaeological investigations, which are
foundational for north coast and Moche archaeology, largely took place on his expansive properties
across the Chicama. A third company, Cartavio (a member of the American Grace Company), also
established a sugar plant in the area of Santiago de Cao. By the 1920s, the Chicama Valley was producing
sugar almost exclusively and became greatly dependent on global sugar exports; therefore, post-World
War inflation had devastating effects for the Valley. In 1927, the Larcos handed over the vast majority of
their holdings to the Gildemeisters, leaving approximately 80% of the Valley in the hands of a single
family (Klarén 1970:64). These so-called ‘sugar barons’ acquired many of the remaining small farms;
consequently, the local peasant farmers lost their independence, but more importantly, their access to
water:

“These peasants, members of a rural middle class, had traditionally cultivated small lots located in urban
centers and their surroundings. However, as the sugar industry developed more and more, they were victims of
the inexorable pressure of the sugar companies that sought to gain access to both water rights and the land of the
entire valley in order to expand their cane crops” (Klarén 1970:260) [Translation by the author].16

By the end of the mid-twentieth century, north coast sugar production accounted for 3.9% of the national
GDP and 7.2% of all domestic exports (Helfgott 2016:82). The Chicama Valley was, and continues to be,

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16 Original quote in Spanish: “Estos campesinos, integrantes de una clase media rural, tradicionalmente habían
cultivado pequeños lotes ubicados en los centros urbanos y sus alrededores. Sin embargo, conforme se desarrolló la
industria azucarera en forma creciente fueron víctimas de la inexorable presión de las compañías azucareras que
ambicionaban ganar acceso tanto a los derechos de agua como a la tierra de todo el valle para así expandir sus
cultivos de caña” (Klarén 1970:260).
the most significant area of production for sugar cane in Peru. The Chicama Valley, and its sugar barons, would spur on radical economic and political change in their inexorable pursuit of more land for growing cane, but even more importantly, for control over water in the valley (Klarén 1970:260). These changes, including the rise of Alianza Popular Revolucionaria Americana (APRA) Party, and the Agrarian Reform of 1968, continue to shape the socio-economic realities of the north coast and the Peruvian State today: APRA currently holds 5 congressional seats and most of the Supreme Court. The consolidation of land and water in the hands of so few became a rallying-call for a political revolution and ultimately, led to a reconfiguration of the socio-economic structure of the Valley.

21st century Peruvian water politics.

By the 1940s, the concentration of water control began to affect the local environment. Peruvian agronomist José Sabogal Wiesse recorded the attitudes of local farmers in the town of Santiago de Cao, where he worked for Cartavio in the mid-1940s (Balarezo 2013). Encroaching deserts plagued the farmers; meanwhile, the remnants of ancient canals were visible in the dunes:

“There was a set of agronomic knowledge that allows the conservation and extension of fields cultivated in the desert” (Sabogal Wiesse 1974: 267) [Translation by the author].

Sabogal Wiesse posed the question, how was it possible for prehispanic civilizations to exceed the levels of agricultural productivity of a developing industrial economy (Sabogal Wiesse 1974:268)? First, he concluded, sugarcane required vast quantities of water in comparison to native plants such as maize, cotton and beans (Table 11).

17 Original quote in Spanish: “Existía un conjunto de conocimientos agronómicos que permita la conservación y la extension de los campos cultivados en el desierto” (Sabogal Wiesse 1974: 267).
Table 11. Crop water requirements. Adapted from Netherly (1984: Table 2). Data derived from the Banco Agrario del Perú.

<table>
<thead>
<tr>
<th>Crop</th>
<th>m³ per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar cane</td>
<td>25,000</td>
</tr>
<tr>
<td>Hybrid corn (maíz)</td>
<td>12,000</td>
</tr>
<tr>
<td>Native corn (maíz criollo)</td>
<td>9,000</td>
</tr>
<tr>
<td>Hybrid cotton</td>
<td>10,000-13,000</td>
</tr>
<tr>
<td>Native cotton (algodón criollo)</td>
<td>9,000</td>
</tr>
<tr>
<td>Beans</td>
<td>15,000</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>11,000</td>
</tr>
</tbody>
</table>

Sabogal Wiesse’s (1975) informants also linked the modern-day failures to the misuse of water, which included irrigation water, runoff, and El-Niño-related ‘abundance.’ While traditional agriculturalists channeled El Niño floodwaters to lowland marshes or wooded areas, encouraging the growth of woody species, trees and wetlands, and thereby maintaining the water table, plantation owners diverted flow directly to the Pacific Ocean, to avoid erosion. While the traditional Santiago de Cao farmers dug wells (*puquios*) and constructed water storage devices (*cochas*) near the coastline to capture runoff (Sabogal Wiesse 1975:271), Cartavio placed a major well upstream from the town’s principal canal, the Pongo Chongo, tapping the water supply for the lands around Santiago de Cao (Sabogal Wiesse 1975). Finally, Casa Grande and the other large plantations managed the lands surrounding the river headwaters, and in this way, were positioned to control the distribution of irrigation water (Helfgott 2016:79). It was this transgression against traditional water rights that resulted in the extreme poverty of Valley towns such as Ascope, Paiján, and Santiago de Cao. The economic impacts of the monopoly of
water alongside an admiration and nostalgia for traditional farming practices coincided with the emerging indigenista and transformative political movements of the 1920s and 30s.

“The greatest anxiety in this entire desert region relates, however, to the supply of irrigated water. They repeat it, and we cite it at every moment, as if it were one the characteristics of this subculture: ‘where there is water, there is life’. But, they also repeat many times, ‘it was not like this before’. Santiago de Cao had a provision of water for permanent irrigation, which made their gardens flourish and their fields always green. But this transcendental change in the life of the people is also questioned many times by the elderly. So much so that we ask ourselves if it would not be possible to return to what was before, when the neighboring cane plantation estate had not yet taken over their irrigation supply” (Sabogal Wiesse 1975:87) [Translation by the author].

By 1963, 83% of arable land in Peru was in the hands of 0.8% of landholders (Grayson 1970:66). The avarice for consolidated land and water resulted in a shortage of land dedicated to food production. Wage laborers, the majority migrants from the neighboring highlands, became increasingly dependent on landholders and in some cases, victims of their ‘enganches’ or debt-traps. Meanwhile, landholders aggressively reacted to changes in the market, leaving workers vulnerable to their caprice. Indeed, during the Korean War and the Cuban Revolution, as supply outpaced demand, prices dropped, and landowners made investments in machinery (Klarén 2005). As a result, laborers suffered massive paycuts or were laid off; the sugar-dominated landscape of the north coast left these workers with little other employment opportunities (Klarén 2005:43-44). Pressure for reform had been building for decades in the Chicama Valley, even resulting in a violent rebellion in 1921. Disenfranchised sugar workers formed the major voting block for the Trujillo-based political party, Alianza Popular Revolucionaria Americana (APRA). The Party’s populist platform and their indigenista rhetoric mobilized this electorate beginning in the 1920s. APRA actively organized labor unions and even nominated a presidential candidate, party founder Haya de la Torre, who lost the narrowly to Luis M. Sanchez Cerro in 1931 (Klarén 2005:42, 1970). While APRA made its name promoting a populist agenda and the rights of sugar wage-laborers, it was not in

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18 Original quote in Spanish: “La mayor ansiedad en toda esta región desértica se refiere, no obstante, al suministro del agua de regadío. Lo repiten, y lo citamos a cada momento, tal como una de las características de esta subcultura: ‘donde hay agua, hay vida’. Pero, también lo repiten muchas veces, ‘antes no era así’. Santiago de Cao tuvo una provisión de agua para regadío permanente, lo que hacia que sus huertos estuvieron florecientes y sus campiñas siempre verdes. Pero este cambio transcendental en la vida del pueblo, también lo cuestionan muchas veces los ancianos. Tanto que nos preguntamos si es que no será posible retornar a lo de antes, cuando el latifundio cañavelero vecino no se había apoderado aún de su caudal de riego” (Sabogal Wiesse 1975:87).
favor of the 1968 Agrarian Reform, which dealt a heavy blow to the so-called sugar barons of the north coast.

The Agrarian Reform, which was carried out by General and then President by way of military coup Juan Velasco Alvarado, nationalized the sugar industry, converting powerful haciendas to cooperatives (Figure 67). Reform began with the north coast sugar barons in the Chicama Valley exactly one day after Velasco signed the Acta Reforma Agraria. The Reform succeeded in redistributing 50% of arable land to 33% of the rural population (Saleth 1991:85), although the long-term effects were mired in poor management, corruption, and other factors (Klarén 2005:47). Again, the emphasis on the redistribution of land was coupled with reform over the control of water, with a section of the Acta stating:

“There is no private property of water nor acquired rights. The justified and rational use of water can only be granted in harmony with the national interest and the development of the country (Grayson 1970:70).”

Figure 67. Political poster, titled, “El Azúcar: Primera Industria sin Patrones en el Continente Americano; Published by the DDRA 1968-70” dating to 1970. Poster is typical of those used in the Chicama Valley at the time of APRA organization. Taken from (Cant 2012).
Water took center stage in the political and economic reforms of the Chicama Valley in the 1960s; however, the Reforma was later mired by corruption and led to widespread poverty and political chaos. Many of the new cooperative members sold their stakes to incoming private industries, including the Grupo Gloria—known locally as Casa Grande. Like the reclamation of the old Gildemeister hacienda’s name, the history of land-holding consolidation in the Chicama since the Reforma Agraria has repeated itself. Still, the APRA movement owes much of its mobilization to the Chicama Valley and the system of water distribution; the party today holds 5 seats in Congress, almost half of the Supreme Court seats and put forth a presidential candidate in the 2016 election.

The Chicama Valley and the Pampa de Mocan: the present day.

Today, the desertified and wind-deflated Pampa de Mocan is at the center of a bitter land-dispute between two agro-industrial companies: Casa Grande (owned by the dairy conglomerate, Grupo Gloria) and Agricola Chicama (Gildemeister & Co). In fact, north coast pampas are increasingly the site of experiments in ‘reclaiming’ deserts for agricultural production. In the desert area bordering the Chicama Valley to the north, strong, unobstructed trade winds, and dune invasion pose formidable challenges to the expansion of farmland. Meanwhile, the Pampa de Mocan is located further upland and beyond the coastal mountain range, and therefore enjoys greater protection from the coastal winds. The Peruvian State has identified this area for agricultural development and is pushing forward with a multi million-dollar inter-valley irrigation project: the Proyecto Especial Chavimochic (Figure 2). The combination of receding glaciers in the highlands and industrial investment in irrigation agriculture on the coast has resulted in mass migration from the sierra to the coast. Nicholas Casey’s reporting for the New York Times attests to an increase in population in Virú from just 9000 inhabitants in the 1990s to over 80,000 people today, because of the promises of Chavimochic (Casey 2017). Much like in the 16th and 19th centuries, north coast valleys are undergoing a consolidation of power and wealth in the hands of a few agro-industrial giants; meanwhile, populations are increasingly concentrated in urban centers.
This past spring (February-April 2017), the north coast of Peru witnessed one of the most significant El Niño events in recent memory, resulting in 158 flood-related deaths and 1,372,260 people displaced or otherwise affected. The devastation was compounded in the Chicama Valley in particular, where urban settlement in Paiján, Ascope, and Chocope are increasingly expanding into the surrounding dry ravines or hillsides. The heavy rains were channeled through these ravines or quebradas taking these new settlements with them. In addition to human settlements, the El Niño caused widespread destruction to agricultural systems, including the main canal of the Proyecto Especial Chavimochic. El Niño floods created critical vulnerabilities along 37 different sections of the canal, and washed out several others, rendering it obsolete and temporarily ceasing construction. This is not the first time the Chavimochic project and El Niño have collided: in 1998, the project spent 20 million USD in repairs following the floods. It seems that the Chicama Valley has been trapped in the same cause-and-effect dynamic since at least 1578. Ironically, the same event that likely initiated agricultural development of the Pampa de Mocan in the prehispanic, intervened in 2017 to delay its erasure under sugarcane fields.

**Interpretations.**

“The complexity of the arrangement is itself relevant to my theme since such a system is virtually unalterable. Although the present generation of Pul Eliya villagers are not at all clear about the inner logic of it all they are keenly aware that the numerical formulae handed down from ancient times are very important. The general view seems to be: ‘We don’t understand why things are arranged like this, but this is how they are, and we had better leave them alone’” (Leach 1961:164-165).

The most significant change in land-management that occurred around the time of the Conquest on the north coast was the replacement of a formerly mobile agricultural work force with a permanent one. Tying farmers to specific places put a premium on both land and water, bringing about a new level of competition for both. While conflict has surrounded the control of water since pre-history, the Spanish attitude toward property catalyzed a shift in the economy: the prehispanic system whose organizing principal was the conservation of water was replaced by a Spanish system that optimized the productivity of land. This breakpoint in the landscape history of the Chicama Valley set off a positive feedback loop of land-holding consolidation, followed by dissolution: the encomienda system was replaced by numerous haciendas; haciendas were broken up in the aftermath of the War of the Pacific and subsumed into the
hands of just a few sugar barons; the concentration of land-holdings peaked in the 1950s and 60s with the failure of the Larco hacienda; political movements advanced the Land Reform Act, which redistributed the holdings to local farmers; and finally, today, the incorporation of approximately 90% of the Valley’s arable land into a single company (Grupo Gloria). The state-sponsored project (Proyecto Especial Chavimochic) to re-claim the bordering desert areas for further production represents another phase of concentration. The evolutionary history of the Chicama Valley is therefore inextricably linked to the land, labor, and water practices of the prehispanic past, even in those cases where such practices may have failed.
CONCLUSIONS

The farmers of Mocan challenge archaeological notions of how sophisticated irrigation systems operated in the past, which water sources were targeted, what environmental marginality implies for agricultural strategies, and what degree of order, sedentism, and permanence is required for intensive, complex agriculture. This dissertation began by revisiting the origins of two fundamental assumptions regarding arid-zone irrigation: 1) that environmental limitations of arid landscapes preclude shifting agricultural strategies; and 2) that complex agricultural systems necessarily require sedentism. Instead, coastal and Andean cultures have been characterized by both movement and the exploitation of multiple resource niches throughout prehistory.

In Chapter 1, a close review of the literature revealed a tradition of adherence to environmental determinism in Andean scholarship, especially regarding coastal farming strategies. While in the highlands irrigated farming and pastoral practices have been viewed as operating at both a local and a regional scale, and as inherent to myth, ritual, and social relations, ancient coastal irrigation has traditionally been evaluated along a continuum of simple to complex, and little is known about ritual life surrounding irrigation. While anthropologists and ethnohistorians have observed that ritual calendars were closely related to agricultural timing, identifying the ritual behavior in the archaeological record has proved a difficult task (Lansing 1991; Zuidema 2010). Among the rich iconographic datasets of the Moche, Nasca, and Chimu, which are often referenced to provide insight into ancient ritual life, to date, no depictions of canals are known; the topic awaits future investigation.

Critics of Wittfogelian and Boserupian models of socio-agrarian change catalyzed important shifts in landscape studies toward historical ecology by elevating the issue of historical contingency through concepts such as ‘landesque capital’ (Blaikie and Brookfield 1987). However, historical ecology approaches to archaeology, in part because of the nature of the record, tend toward progressive, slow, patterns of change. Chapters 2-6 demonstrated that the history of land-use in the Pampa de Mocan is a confluence of human-environment and environment-human interactions—human ecodynamics—occurring on micro- and macro-time and action scales (McGlade 1995:113-115). The Pampa de Mocan
was not progressing toward any identifiable ‘end;’ rather, collective behavior centering on water
maximization resulted in a highly complex, intensively managed landscape.

Chapter 2 offered a close-reading of the ecology, geomorphology, and pedology of the north
coast desert. Instead of a barren, static landscape, the Pampa de Mocan and other north coast deserts were
found to be dynamic and productive. Perhaps any misconception about the exceptionalism of desert
farming derives from a western cultural filter. As Suzanne Fish (2004:116), a scholar of Southwest
farming practices, iterates:

“A pervasive theme in characterizations of the indigenous agriculture of the North American Southwest is
the marginality and precariousness of farming in the face of aridity and other environmental challenges.
This perception arose with the beginnings of regional archaeology north of the international border…Like
most of their countrymen who had resided in the North American Southwest for fewer than 50 years, these
early scholars harbored expectations based in the agricultural experience of the eastern United States and
ultimately rooted in European traditions. By comparison, the hard-won harvests of Indian peoples served
mainly to illustrate the vicissitudes that these cultivators had had to overcome”.

The soils of north coast of Peru, although they receive as little as 5mm of precipitation per year, undergo
renewal as a result of sediment transport catalyzed by El Niño events. The potential of these desert soils—
especially those located in the well-drained areas outside of the river floodplain—was put on full display
during the 2017 El Niño Costero. The Pampa de Mocan, typically populated by xerophytic plant
communities, experienced an increase in plant ground cover and the appearance of 45 new species in just
a few months after El Niño rains commenced. Meanwhile, main channel lateral migration has led to
significant land-loss during episodic flood events. While many archaeological studies have hypothesized
the potential paralyzing effects of El Niño floods on canal systems, it was likely these factors—main
channel migration and near-channel land-loss—that were among the most detrimental to prehistoric
irrigation systems. Indeed, instead of system collapse, several ethnographic observations reported modern
agriculturalists creating diversion canals and implementing other forms of infrastructure to capture and
take advantage of El Niño runoff during the 1983 and 1998 events. This seemingly minor opportunistic
behavior taken in reaction to such events was the fundamental organizing principle of the complex and
multi-scalar operation of irrigation systems in the prehispanic era.
Chapter 3 reported the results of survey and excavation of the ancient fields of the Pampa de Mocan. The diversity of field types, their use-lives, and the manner of irrigation-water application, point to a system that operated at two levels: opportunism directed at the sudden appearance of sheet-floods or the activation of seasonal watercourses, and, at the same time, the semi-regular delivery of irrigation waters from a main channel further upstream. Excavation in the fossil fields, both opportunistic and those dependent on trunk canals, revealed shallow use-lives. Rather than returning to a particular field year after year or passing down property across generations, the farmers of Mocan used and discarded their fields after just a few seasons or irrigation applications. The nature of the seasonal river volume disparities and flood events likely resulted in frequent channel migration and the destruction of upstream intakes. Consequently, the trunk canals were probably constantly undergoing repairs and modifications to accommodate the new position of the intake. In other words, the trunk canals themselves were not necessarily meant to be permanently-functioning features on the landscape, rather their use-lives were relatively short—probably just several decades—and they too could be decommissioned with some frequency and then re-used in new ways, as canals linking up to reservoirs or ephemeral streams, as channels for sudden flood events, or as fields themselves. While the spatial extent of furrowed fields and canals has been used as a proxy for territorial, socio-political or economic expansion, a closer look at the system in the Pampa de Mocan revealed that what appears to reflect gradual progress, in fact, goes hand-in-hand with sporadic incrementalism. And, just as in the highland Andes or the Sonoran Desert in the North American Southwest, these two approaches to agriculture can be practiced simultaneously:

“The typical farmer of such agriculturally marginal lands as those of the Southwest is much more interested in how to get a decent crop from this particular plot in this particular year than he is in providing an easily interpreted archaeological record. Thus we should not be so naïve as to allow ourselves to fall into the trap of assuming that if a complex irrigation farming technology is manifested at one location in an area, then the same people who built it could not also have constructed a simple, unirrigated, undammed, unraised field only a few kilometers away” (Woosley 1980:317).

Opportunism, rather than top-down planning, characterized the logic behind the agricultural strategies observed in the Pampa de Mocan through time; moreover, this dissertation argued that opportunism does not preclude the construction of monumental trunk canals or their co-articulation with small, flood-wash fields. Fields were built to prevent water-logging, to capture flood-suspended sediments, and tocreate
embankments. Meanwhile, other field types point to water conservation methods (check-flood or posa fields, rock-pile fields, lithic mulching). From the surfaces chosen for fields, to their size and shape, water capture devices and distribution, early farmers in Mocan were both reactive and proactive to fluctuating water availability and water capture.

Chapter 4 centered on the nature of the ‘labor’ of the ancient Pampa de Mocan farmland. Fields were active on both a seasonal and an episodic basis; likewise, the archaeological evidence related to settlement reflected a mobile, seasonal population, likely maintaining dual, or multiple residences. The majority of sites identified across the survey universe were characterized as field houses or small observation structures related to field systems. Ceramics were almost entirely domestic storage vessels, and a significant portion of the ceramics collected were categorized as non-local. Finally, three important roadways crossing the landscape at different elevations along the bajada point to a deep history of movement across this area. Especially when considered in light of evidence of environmental change and stochasticism (Chapter 5), this dissertation argued that the strategy of population circulation or rotation around the valley-wide irrigation system emerged as an adaptation to the local desert climate and ecology.

Pollen data from the Pampa de Mocan, although not informative of time-intervals, demonstrated the degree of environmental change since the prehispanic period. Samples collected from geological test pits pointed to the presence of keystone tree species in the past. Meanwhile, pollen extracted from the stratigraphic profile of an intentionally-terminated Late Intermediate Period formal well suggested that 1) farming behavior followed moments of water-influx (either through episodic, El Niño flooding or the seasonal presence and capture of water); 2) farms were abandoned relatively soon after such moments; and 3) El Niño floods resulted in blooming events, which were quickly appropriated by opportunistic farming or activated dormant cultigen seeds. Indeed, the environment of Mocan today, rather than precluding the success of farming, is an artifact of the absence of human intervention.

Chapter 6 considered the potential reasons for Mocan’s abandonment, and how a significant break-point in the Valley’s history has set the Chicama and the broader north coast, on a self-reinforcing path of environmental deterioration and resource-exhaustion. The labor banked in the Pampa de Mocan did
not dissolve after the end of its prehispanic use-life; rather, its abandonment had significant consequences for the Licapa polity during the colonial period. In the later colonial and Republican eras, it informed the cartographic imaginings of the Chicama Valley, and today, the loose sediments continue to invade bordering fields and active canals. The shift in system-logic, from one which adapted labor and land to the appearance and availability of water to one which applied water and labor to land, reconfigured the agricultural history of the entire Valley. Since that time, the Peruvian state, at both local and national levels, has struggled against water shortages, which, historically, have had the power to initiate political movements. The relationship between humans and their landscapes, and humans and their ditches and acequias, especially mitigated through the management of water and plants, can structure historical paths long after productivity ceases. In the case of the Chicama Valley, these dynamics set off a positive feedback loop that brought about irreversible change to the social and economic landscape.

The Pampa de Mocan is made up of multiple co-occurring histories playing out at different rates and rhythms: monumental irrigation constructions in conjunction with opportunistic water-capture fields; long-term aridification punctuated by seasonal and episodic flood events; and regional-scale transhumance coexisting with local practices and materials. This system likely functioned around a concept of ‘the commons’: resources that pertained to the individual or farmstead that held them in use at any given time—an arrangement that ethnohistorians have called ‘usufruct’ land rights (Ramírez 1986). In his seminal study of Swiss village farming, Robert Netting (1976) observed that the commons were managed through locally-mandated controls: cattle herders were restricted from expanding their stock beyond that which a single member could maintain during a winter season. Similarly, Edmund Leach’s (1961) work in dry-zone Sri Lanka further clarifies that farmers did not hold land-in-common—resources were not pooled and divvied-out in equal portions—rather, farmers developed a complex system of irrigation turn-taking, which was designed to prevent the over-extension of resources. On the north coast, the turmoil caused in the aftermath of the privatization of land during the colonial period, at the expense of the water supply, suggests that a similar morality likely governed prehispanic water management before the arrival of the Spanish.
As Bayliss-Smith (2007) has argued in reference to the irrigation networks of Kuk Swamp in New Guinea, ditches can have multiple ‘meanings’ and far-reaching legacies:

“Ditches as a reflection of economic rationality;  
Ditches as the outcome of social inequality;  
Ditches as a response to population crisis;  
Ditches as an investment in future security;  
Ditches as a symbol of property in the landscape;  
Ditches as an adaptation to climate change” (2007:130).

The legacy of the Pampa de Mocan and its ditches, rather than being an homage to an ancient, western-idealized pre-industrial state, is in their reflection of an acute knowledge of water, water movement and water appearance. Awareness of water resulted in structural flexibility built in to an otherwise rigid technology. This world-view runs counter to modern-day industrial-scale farming, however, the ancient farmers of Mocan would have been far better equipped to respond to the increasingly urgent global water crisis.
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## APPENDIX A

**Known ENSO events**

<table>
<thead>
<tr>
<th>Source</th>
<th>Proposed Event Year</th>
<th>Strength?</th>
<th>Location (where reported)</th>
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<tbody>
<tr>
<td>Moy et al. 2002</td>
<td>Beginning by 12,000 B.P.</td>
<td>n/a</td>
<td>Laguna Pallcacocha</td>
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<td>Moy et al. 2002</td>
<td>Uptick at 7000 BP</td>
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<td>Laguna Pallcacocha</td>
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<td>Sandweiss et al. 2001</td>
<td>Uptick at 5800 BP</td>
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<td>Keefer et al. 2003</td>
<td>Uptick 5300 BP</td>
<td></td>
<td>Quebrada Tacahuay</td>
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<tr>
<td>Rodbell et al. 1999</td>
<td>Modern conditions by 5000 BP</td>
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<td>Ecuador</td>
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<tr>
<td>Rein et al. 2005</td>
<td>Modern conditions by 4000-5000 BP</td>
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<td>Lima</td>
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<td>Sandweiss et al. 2003</td>
<td>Modern conditions by 3000 BP</td>
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<td>1432 ±115 B.P.</td>
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<td>500 BC</td>
<td>VS</td>
<td>Moche Valley</td>
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<td>AD 500?</td>
<td>VS</td>
<td>Rio Moche Neck</td>
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<tr>
<td>Craig and Shimada 1986</td>
<td>AD 650-1000</td>
<td>VS</td>
<td>Jayanca, Poma, Batan Grande</td>
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<td>Moseley et al 1982</td>
<td>AD 500</td>
<td>VS</td>
<td>Moche Valley</td>
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<td>AD 100</td>
<td>VS</td>
<td>Moche Valley</td>
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<td>AD 1100</td>
<td>VS</td>
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<td>1546-1547</td>
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<td>Piura</td>
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<td>Ortlieb 2000</td>
<td>1578</td>
<td>VS</td>
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<td>VS</td>
<td>Trujillo; Paita; Zaña; Coast of Peru; Cuzco; Chocope; Chicama; Catacaos; Sechura; N. Peru; Piura</td>
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<td>S</td>
<td>Lambayeque; N.Peru; Piura; Lima</td>
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<td>Quinn et al. 1978</td>
<td>1972</td>
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<td>*1976</td>
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<td>*1982-1983</td>
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<td>*1998</td>
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<td>*2017</td>
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</table>
APPENDIX B

CC1: 693557 E; 9158367.8 N

Field Type: “Borrow pit”
CC1: Excavation

**CC 1 - N4 CA**

- Porous sediment with rootlets and small pebbles
- Sterile
- Large cobbles

**CC 1 - Eastern Profile**

- Sterile
- Porous sediment, rootlets and small pebbles
- Large stones
- Soil samples
CC2: 693529 E; 9158862 N

Field Type: Raised Field
CC2: Excavation

**CC 2 - Plan view - N2 CB**

- Excavation bisect line
- Fine compact sediment
- Rocks (I-5-10cm)
- Sterile
- Elevation (cm)

**CC2 - South Profile**

- Fine alluvial sediment
- Yellow sediment with small pebble inclusions
- Packed cobble stones (5-10cm)
- Compact sediment, light yellow color
- Sterile
- Soil Samples
CC3: 693363 E; 9159377 N

Field type: “Rock Pile”
CC3: Excavation

CC 3 - Plan view - Surface

- Sand and small gravel fragments
- Large cobble rocks with advanced varnish

CC 3 - South Profile

- Sand with small gravel inclusions
- Sand with very small rock inclusions (>3cm)
- Large cobble rocks with desert varnish (5cm-12cm)
- Sterile
- Samples
CC5: 692565 E; 9158987 N

Field Type: “Posa/Check-Flood Field”
CC5: Excavation

**CC 5 - Plan view - Surface**

- Scale 1mm: 10cm
- Furrows composed of clasts and fine sand
- Alluvial sediment
- Elevations

**CC 5 - East Profile**

- Scale 1mm: 10cm
- Eutic Sediment
- Alluvial sediment with organic material
- Organic sediments with rootlets and root casts
- Compact alluvial sediment
- Sandy semi-compact sediment with small rock inclusions
- Sterile
- Samples
CC6: 692463 E; 9160132.5 N

Field Type: S-shaped
CC6: Excavation

Campo de Cultivo 6 - Plan View - N1 - CB

Sand and compact alluvial sediment
Depression
Elevation

Campo de Cultivo 6 - North Profile

Loose sand
Compact sand
Compact and porous sandy loam
Sterile
Sample
CC7: 693259 E; 9158957 N

Field Type: Straight Furrow
CC7: Excavation

Campo de Cultivo 7 - Planview: Surface

Campo de Cultivo 7 - East Profile

Small stones mixed with mud and sand
Sterile
Medium cobbles (3-7cm)
Sample
CC8: 693139 E; 9159783.2 N

Field type: Border strip
CC8: Excavation

*Campo de Cultivo 8 - Plan View - N1 CB*

1. Small, mounded stones
2. Sandy sediment of alluvial origin
3. Large and medium sized stones (3-12cm)
4. Elevations

*Campo de Cultivo 8 - East profile*

- Superficial sand
- Small, well-rounded stones
- Sediment and aeolic sand
- Alluvial sediment with clay inclusions
- sterile
- Small and medium sized stones (3-12cm)
- Sample
CC9: 693869 E; 9159649.73 N

Field type: E-shaped
CC9 Excavation:

**CC9 - Plan View N1 CA**

![Plan View N1 CA]

**CC9 North Profile**

![North Profile]

Legend:
- Sandy sediment with clay inclusions
- Sediment with small rock inclusions
- Cobbles
- Elevations
- Bulk sand
- Compact alluvial sediment
- Sandy alluvial sediment
- Compact sediment with rock inclusions
- Sterile
- Sample
P1 Excavation
P3: 691407.3 E; 9158500.4 N
P3: Excavation

Pozo 3 - Plan view - N2 CA

Legend:
- Floor
- Large river cobbles
- Palaeoecological material
- Wall fill with gravel inclusion
- Depression
Pozo 3 - East Profile
P5: 692515.45 E; 9160161.01 N
P5 Excavation:

Pozo 5 - Plan View - N3-CA

Pozo 5 - South Profile
R1: 693643.9 E; 9161682.8 N
R1: Excavation
R2: 692143.1 E; 9158500.4 N
R2: Excavation

R2 - Plan View - N2 CA

R2 - South Profile
R3: 693531.45 E; 9162521.5 N
R4: 693419.1 E; 9158772 N
R4: Excavation
R6: 693745.9 E; 9161520 N
R6: Excavation

*R6 - Plan view - N1 CA*

*R6 - East Profile*
R7: Excavation
R8: 693708.8 E; 9161528.7 N
R8: Excavation

R8 - Plan view - N2 CB

R8 - South Profile
### APPENDIX C
Archaeological Sites

<table>
<thead>
<tr>
<th>Local ID</th>
<th>GPS #</th>
<th>WPT #</th>
<th>Cuadrant</th>
<th>UTM</th>
<th>Description</th>
<th>Sector</th>
<th>Complejo?</th>
<th>Structure #</th>
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<td>74</td>
<td>3C</td>
<td>693575</td>
<td>Square structure in the middle of haueque wells. Ceramic paleteada present.</td>
<td>Campos de Cultivo 2</td>
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<td>692340</td>
<td>Set of small stone buildings</td>
<td>Campos de Cultivo 4</td>
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<td>Ellipsoidal stone structure</td>
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<td>Quadrangular structure of adobe and stone. Entrance oriented N. Two small enclosures inside.</td>
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<td>Quadrangular stone enclosure</td>
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<td>U-shaped stone construction</td>
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<td>Lithic workshop with tips paijan</td>
<td>Plataforma 1</td>
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<tr>
<td>8</td>
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<td>65</td>
<td>3D</td>
<td>693811</td>
<td>Complejo 1, large stone complex, multiple plazas, indirect entrances, recintos and pasillos. Located on Platform 1. 3 units of collection</td>
<td>Plataforma 1</td>
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<td>Complejo 2, Platform 2. Grouping of 16 u-shaped structures, delimited by a canal - the same canal that crosses platforms 1-9 (Acequia A-E). All structures are of stone. Beyond the canal, only fields and sherd scatter.</td>
<td>Plataforma 2</td>
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<td>10</td>
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<td>74</td>
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<td>9161423</td>
<td>Round or semi circular stone structures; Stone, semi-circular structures clustered together. General Collection.</td>
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<td>Torreón, large stone tower located just beyond the edge of Platform 2. Complejo 2. Located on Platform 4.</td>
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<td>Estructura Cupisnique. Probable cemetery. Pampa de Paijan 1. 2 units of collection.</td>
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<tr>
<td>18</td>
<td>2; 3</td>
<td>103; 98</td>
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<td>693326</td>
<td>Structures of the complex 07 that comprises the road with the wpt's 100 - 102</td>
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<td>106</td>
<td>3E</td>
<td>693822</td>
<td>Estructura Plataforma 3. Stone structure with banquetas and platforms, small, very much in the style of architecture of Cerro Chepen. Estructura 1</td>
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<td>20</td>
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<td>694465</td>
<td>Small structure together with the Aeqquia A-E.</td>
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<td>21</td>
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<td>138</td>
<td>4C</td>
<td>692830</td>
<td>Stone structure with channel entrance to the interior and presence of crop fields</td>
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<td>141</td>
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<td>691429</td>
<td>Structure to the north of the wall 02 with agricultural fields annexed to the east. Wall structure with aligned stones.</td>
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<td>152</td>
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<td>694184</td>
<td>Small Stone Square structure with only 3 sides. 4th side is cut by a quebrada. 3.9mx8mx5.20m Fotos only.</td>
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<td>25</td>
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<td>158</td>
<td>5D</td>
<td>693420</td>
<td>Cupisnique filiation structure. Fields of Cultivation 3. Related to roads. Cupisnique road-side site. Structure 1. Geoglyph 1 (Spiral). Geoglyph Corners are rounded. The structure itself is stone-built and in the form of a long rectangle. Geoglyph is inside the structure. It has been cut by several streams or streams. The southern half of the structure is especially covered in Cupisnique fragments. 4 Units of collection.</td>
<td></td>
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<td>26</td>
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<td>173</td>
<td>5D</td>
<td>693306</td>
<td>Cupisnique paravientos. Structures (3) semicirculars next to wpt 174 de filiación cupisnique. Cupisnique-period paravientos. Stone-built. About 3 of these clustered together.</td>
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<td>27</td>
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<td>184</td>
<td>5C</td>
<td>693160</td>
<td>Early Intermediate Period (?) Stone structure. Small, square with an East facing entrance. Great deal of wall fall - difficult to discern internal features.</td>
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<td>28</td>
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<td>4B</td>
<td>691951</td>
<td>Wall structure with some stone alignments. Structure has a large space and one forward and together with the first (on the E side) a little smaller. Associated with walls of wall and fields of culture. Fields of Cultivation 4.</td>
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<td>201</td>
<td>4B</td>
<td>692510</td>
<td>Estructura 02 del complejo 05. Complejo 5. Estructura 2 - stone, square structure. Quite large and heavy looting. Tardio ceramics nearby.</td>
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<tr>
<td>30</td>
<td>2; 1</td>
<td>202; 82</td>
<td>4B</td>
<td>692535</td>
<td>Estructura 03 del complejo 05. Complejo 5. Estructura 3. Very heavily disturbed stone structure. Mostly rock fall and ceramic sherds including large paica sherds. One possible pozo de paica</td>
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Campos de Cultivo 3  n/a  2

Campos de Cultivo 3  n/a  3

Campos de Cultivo 3  n/a  4

Campos de Cultivo 4  n/a  6

Pampa de Paijan 2  5  2

Pampa de Paijan 2  5  3

303
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<th>Grid 1</th>
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<th>Grid 3</th>
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<td>125</td>
<td>4C</td>
<td>692787</td>
<td>9159927</td>
<td>Templo Moche. Stone temple, two long arms and a small closed room in the back with a central platform and ramp. Oriented W.</td>
<td>Campos de Cultivo 3</td>
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<td>162</td>
<td>5D</td>
<td>693291</td>
<td>9158923</td>
<td>Early Intermediate Period rectangular structure with tower or possibly a high well associated. Water well (?) Or tower and high-mounded furrows associated.</td>
<td>Campos de Cultivo 3</td>
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<td>167</td>
<td>5C</td>
<td>692806</td>
<td>9159675</td>
<td>Small EIP house with banquetas and terrazas. Nearby is another structure with one dividing wall. All oriented to the E.</td>
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<td>168; 90-92</td>
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<td>692878</td>
<td>9159751</td>
<td>Complejo 4. Estructura 3 - small stone structure, related to EIP ceramics.</td>
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<td>174</td>
<td>4C</td>
<td>692939</td>
<td>9159987</td>
<td>Small stone platform located near Muralla 1 and fields. Square form</td>
<td>Pampa de Paijan 2</td>
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<td>37</td>
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<td>176</td>
<td>4B</td>
<td>692512</td>
<td>9160155</td>
<td>Possible well? Located atop a high alluvial platform near extensive sherd scatter. Overlooking fields seperated by Murallal1 below. Estructura 1 of Complejo 5.</td>
<td>Pampa de Paijan 2</td>
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<td>204</td>
<td>5C</td>
<td>692509</td>
<td>9159192</td>
<td>Small raised platform structure - one on top of another. Stone. Apparently facing north. Complejo 6, Structure1.</td>
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<td>Rectangular stone structure with entrance facing north. Eastern wall is cut through by a canal. Complejo 6, Structure 2</td>
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<td>305</td>
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<td>Stone structure. Square with a patio and a well inside (internal subterranean structure). Only 3 walls survive. Ceramics are EIP.</td>
<td>Campos de Cultivo 4</td>
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<td>692442</td>
<td>9159231</td>
<td>Small square stone structure near stone wall. Oriented E-W</td>
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<td>9159062</td>
<td>Small three-sided (3) stone structure oriented N-S</td>
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<td>5C</td>
<td>692822</td>
<td>9158426</td>
<td>Small tapia structure. Probably a house. Located on a quebrada and near stone mound grouping and road (GPS 3 218). Ceramics seem late. EIP or LIP</td>
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<td>Small stone acequia-side structure</td>
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<td>Semicircular structure with mochica pottery east of the road</td>
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<td>81; 90-92</td>
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<td>Complejo 4 - e1. Rectangular with stone masonry in fields</td>
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<td>691000</td>
<td>9159233</td>
<td>Ceramic workshop? It consists of a structure of adobe and features of ovens around</td>
<td>Pampa de Paijan 2</td>
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APPENDIX D
Waypoints:

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<td>Acequia orientation E-W</td>
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<td>9160230</td>
<td>Minor aqueduct on platform of complejo 05</td>
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<td>693287</td>
<td>9158810</td>
<td>Alignment of stone-piled monticulos. Perhaps a wall?</td>
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<td>9158914</td>
<td>Another stone wall, also oriented N-S with fields on at least one side.</td>
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<td>Another tapia and stone wall oriented N-S</td>
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<td>Path to the west of site Cupisnique. GPS2_158. Dibujo #</td>
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<td>693518</td>
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<td>Path on platform 11</td>
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<td>Camino. Road. Oriented E-W alongside Cupisnique site. Same as points 155-156.</td>
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<td>Campo de cultivo / general collection. Campos de cultivo. Field furrows and feeder canals. Some finer vessel sherds found.</td>
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<td>22</td>
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<td>Campo de cultivo / general collection. Unusual field formations. To the north of cupisnique road-side site (gps2 wpt 158).</td>
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<td>Campos de cultivo located near Cupisnique site (GPS2_158)</td>
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<td>Campos de cultivo located near Cupisnique site (GPS2_158)</td>
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<td>Campos de cultivo located near Cupisnique site (GPS2_158)</td>
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<td>33</td>
<td>2</td>
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<td>5C</td>
<td>692872</td>
<td>9159401</td>
<td>Campos de cultivo, Campos de cultivo associated with the small stone ép structure (gps 3 167). Piles of small pebbles are the product of cleaning the canals and furrows.</td>
</tr>
<tr>
<td>34</td>
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<td>Campos de Cultivo. Located on a triangular platform. Curved furrows.</td>
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<td>693399</td>
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<td>Canal &quot;G&quot;, terraces abutting canal berm, Gallinazo (?) Fragment</td>
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<tr>
<td>42</td>
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<td>Minor channel that extends on the platform of the complejo 05</td>
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<td>Canal which connects with larger acequia (modified?) By Casa Grande</td>
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<tr>
<td>No.</td>
<td>Level</td>
<td>Code</td>
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<td>Canal with blocked entrance - sam level as the bigger (modified?) Canal</td>
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<td>Casa Grande modified (?) Canal</td>
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<td>9160088</td>
<td>Farm near the canal; Black ceramic fragments obtained</td>
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<td>Circular structures between GPS2 164 and GPS 2 158</td>
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<td>65</td>
<td>3D</td>
<td>693811</td>
<td>9161423</td>
<td>Complejo 1, large stone complex, multiple plazas, indirect entrances, recintos and pasillos. Located on Platform 1. 3 units of collection</td>
</tr>
<tr>
<td>59</td>
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<td>70</td>
<td>3D</td>
<td>693811</td>
<td>9161423</td>
<td>Complejo 2, Platform 2. Grouping of 16 u-shaped structures, delimited by a canal - the same canal that crosses platforms 1-9 (Acequia A-E). All structures are of stone. Beyond the canal, only fields and sherd scatter.</td>
</tr>
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<td>Complejo 4. Estructura 3 - small stone structure, related to EIP ceramics.</td>
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<td>Concentration of diagnostic domestic ceramic</td>
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<td>Concentration of diagnostic domestic ceramic and non-diagnostic ceramics</td>
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<td>Concentration of non-diagnostic domestic ceramics</td>
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<td>Set of small stone buildings</td>
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<td>5C</td>
<td>692455</td>
<td>9158869</td>
<td>Conjunto of mounded stone piles, all sharing a wall. About 3 of these. All hollow at the top. All of similar diameter and height.</td>
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<td>75</td>
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<td>Stone constructions</td>
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<td>Delimitation of GPS 2 WPT 141</td>
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<td>Delimitation of GPS 2 WPT 141. Late ceramic sherds in the Pampa de Paijan 1</td>
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<td>693160</td>
<td>9160274</td>
<td>Early Intermediate Period (?) Stone structure. Small, square with an East facing entrance. Great deal of wall fall - difficult to discern internal features.</td>
</tr>
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<td>84</td>
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<td>162</td>
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<td>693291</td>
<td>9158923</td>
<td>Early Intermediate Period rectangular structure with tower or possibly a high well associated. Water well (?) Or tower and high-mounded furrows associated.</td>
</tr>
<tr>
<td>85</td>
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<td>9160170</td>
<td>Estructura 02 del complejo 05. Complejo 5. Estructura 2 - stone, square structure. Quite large and heavy looting. Tardio ceramics nearby.</td>
</tr>
<tr>
<td>86</td>
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<td>4B</td>
<td>692535</td>
<td>9160211</td>
<td>Estructura 03 del complejo 05. Complejo 5. Estructura 3. Very heavily disturbed stone structure. Mostly rock fall and ceramic sherds including large paica sherds. One possible pozo de paica</td>
</tr>
<tr>
<td>88</td>
<td>2</td>
<td>141</td>
<td>5B</td>
<td>691429</td>
<td>9158755</td>
<td>Structure to the north of the wall 02 with agricultural fields annexed to the east</td>
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<tr>
<td>89</td>
<td>2</td>
<td>152</td>
<td>5D</td>
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<td>9158953</td>
<td>Estructura al sur de la quebrada 5. Small stone square structure with only 3 sides. 4th side is cut by a quebrada. Fotos only.</td>
</tr>
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<td>90</td>
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<td>206</td>
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<td>9160194</td>
<td>Circular structure on platform of complejo 05</td>
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<td>693575</td>
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<td>Square structure in the middle of hauqueo wells. Paletaed ceramics present.</td>
</tr>
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<td>117</td>
<td>5C</td>
<td>692144</td>
<td>9158484</td>
<td>Quadrangular adobe and stone structure</td>
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<tr>
<td>93</td>
<td>2</td>
<td>85</td>
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<td>9162457</td>
<td>Estructura Cupisnique. Probable cemetery. Pampa de Paijan 1 Complejo 3. 2 units of collection.</td>
</tr>
<tr>
<td>No.</td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
<td>5th</td>
<td>6th</td>
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<tr>
<td>94</td>
<td>2</td>
<td>158</td>
<td>5D</td>
<td>693420</td>
<td>9158769</td>
<td>Estructura Cupisnique association and Campos de Cultivo 3. Related to path or road. Cupisnique road-side site. Estructura 1. Geoglyph 1 (Spiral). Geoglifo. Corners are rounded, The structure itself is stone-built and in the form of a long rectangle. Geoglyph is inside the structure. It has been cut by several arroyos or quebradas. The southern half of the structure is especially covered in Cupisnique fragments. 4 Units of collection.</td>
</tr>
<tr>
<td>95</td>
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<td>Stone structure</td>
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<td>96</td>
<td>2</td>
<td>138</td>
<td>4C</td>
<td>692830</td>
<td>9159909</td>
<td>Stone structure with channel entrance to the interior and presence of crop fields</td>
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<tr>
<td>97</td>
<td>2</td>
<td>195</td>
<td>4B</td>
<td>691951</td>
<td>9159550</td>
<td>Wall structure with some stone alignments. Structure has a large space and one forward and together with the first (on the E side) a little smaller. Associated with walls of wall and fields of culture. Fields of Cultivation 4.</td>
</tr>
<tr>
<td>98</td>
<td>2</td>
<td>196</td>
<td>4B</td>
<td>691931</td>
<td>9159545</td>
<td>Wall structure with some stone alignments. Structure has a large space and one forward and together with the first (on the E side) a little smaller. Associated with walls of wall and fields of culture. Fields of Cultivation 4.</td>
</tr>
<tr>
<td>99</td>
<td>2</td>
<td>140</td>
<td>5B</td>
<td>692151</td>
<td>9158478</td>
<td>Possible structure of the Chimu affiliation</td>
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<td>Estructura Plataforma 3. Stone structure with banquetas and platforms, small, very much in the style of architecture of Cerro Chepen. Estructura 1</td>
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<td>Round or semi circular stone structures; Stone, semi-circular structures clustered together. General Collection.</td>
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<td>Feeder canal or the original, smaller canal of the now-modified (?) By Casa Grande acequia.</td>
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<td>Possible well? Located atop a high alluvial platform near extensive sherd scatter. Overlooking fields separated by Murallal below. Estructura 1 of Complejo 5.</td>
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<td>Same alignment of stone-pile monticulos. Again, perhaps a road? Wall? (GPS3 153)</td>
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<td>Second camino (?). Also to the west of Cupisnique site (GPS2-158) but to the east of the original road (GPS3-150)</td>
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<td>Small delimiting wall near fields. Photo is of the associated ceramics</td>
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<td>Small EIP house with banquetas and terrazas. Nearby is another structure with one dividing wall. All oriented to the E.</td>
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<td>Small feeder canal located on top of the alluvial platform</td>
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<td>Small raised platform structure - one on top of another. Stone. Apparently facing north. Complejo 6, structure 1</td>
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<td>Small round stone structure surrounded by domestic fragments</td>
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<td>Small square stone structure near stone wall. Oriented E-W</td>
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<td>Small stone acequia-side structure</td>
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<td>Small stone platform located near Muralla 1 and fields. Square form</td>
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<td>Small tapia structure. Probably a house. Located on a quebrada and near stone mound grouping and road (GPS 3 218). Ceramics seem late. EIP or LIP</td>
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<td>Small three-sided (3) stone structure oriented N-S</td>
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<td>Stone rock pile located on the alluvial platform</td>
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<td>Stone rock pile located on the alluvial platform</td>
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<td>Stone rock piles or mounds in a large grouping</td>
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<td>Stone structure. Square with a patio and a well inside (internal subterranean structure). Only 3 walls survive. Ceramics are EIP.</td>
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<td>Templo Moche. Stone temple, two long arms and a small closed room in the back with a central platform and ramp. Oriented W.</td>
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<td>Torreón, large stone tower located just beyond the edge of Platform 2, Complejo 2. Located on Platform 4.</td>
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<td>Unidad 01 del wpt # 87 gps 2 pampa de paijan 01 / complejo 03. Unit of collection. Unit 1. Located on the southern side of the cupisnique complex</td>
<td>Unidad 1. NE corner. Collection of ceramics located on the site of Cupisnique paravientos (GPS 2-173)</td>
<td>Unidad 1. NO corner. Collection of ceramics located on the site of Cupisnique paravientos (GPS 2-173)</td>
<td>Unidad 1. SE corner. Collection of ceramics located on the site of Cupisnique paravientos (GPS 2-173)</td>
<td>Unidad 1. SO corner. Collection of ceramics located on the site of Cupisnique paravientos (GPS 2-173)</td>
<td>Unidad 01 del wpt # 87 gps 2 pampa de paijan 01 / complejo 03. Unit of collection. Unit 1. Located on the southern side of the cupisnique complex</td>
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<td>Unidad 2. Complejo 2 - estructura 15.</td>
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<td>Collection unit 3. Unit placed to the far west of the Cupisnique Road-side structure (GPS2 158) in nearby road. (GPS3 153).</td>
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<td>Collection unit 3. Unit placed to the far west of the Cupisnique Road-side structure (GPS2 158) in nearby road. (GPS3 153).</td>
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<td>Collection unit 5. Placed in campos de cultivo. Field canals and furrows.</td>
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<td>Collection unit 5. Placed in campos de cultivo. Field canals and furrows.</td>
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<td>Collection unit 5. Placed in campos de cultivo. Field canals and furrows.</td>
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<td>Collection unit 6. Just to the west of Canal G. Campos de cultivo. Field furrows and feeder canals.</td>
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<td>Collection unit 6. Just to the west of Canal G. Campos de cultivo. Field furrows and feeder canals.</td>
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## APPENDIX E

Ceramic Collection Data

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General collection – Campos de Cultivo 2 - complex 05. Between structures 1 and 3 of complex 4 that is associated with ceramics of the early intermediate period. To the south of the Canal H.

General collection – Campo de Cultivo 4 - structure 6. To the west of the quadrangular adobe structure (wpt195 -196).

General collection - Pampa de Paijan 02. Small stone platform, probably natural, located to the partition of 2 canals. Late Intermediate Ceramics.

General collection E1 - Pampa de Paijan 02 - structure 1. Small stone structure in the pampa sector of paijan 2. Located at anchor to some fields delimited by the wall 1.

General collection - Pampa de Paijan 02 - complex 5 - structure 1.

General collection – Campos de Cultivo 4. Cultivation field southwest of the wpt 195 site (gps2); Late intermediate ceramics.
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General collection - Pampa de Paijan 2 - complex 5 - structure 2. Structure of quadrangular stone. Approximately 6 m long with its eastern side preserved but with many locks of huaquero. Late ceramic. Located on a platform with fields below.

General collection - Pampa de Paijan 02- complex 5 - structure 3. Too much erosion by a platform / square structure. Alignments to support present paicas. Located at e of structures 1 and 2.

General collection - Pampa de Paijan 2- complex 5 - structure 4. Set of 4 structures associated with a minor channel. Ceramic of late period.
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Whole vessel - paijan pampa 2 - structure 2. Vessel found next to a huaqueo well southeast of wpt 84 (gps1). Corresponding to a ceramic workshop. Rectangular structure of wall with evidence of adobes burned around.

Whole pot - paijan de paijan 2 - structure 2. Pot found next to a hollowing pit to the southeast of the structure corresponding to wpt 84 (gps1) of rectangular shape made of a wall. Possible ceramic workshop with evidence of adobes burned around.

General collection – Campos de Cutlivo 2. Fragmented dish in unoccupied area.


General collection - Pampa de Paijan 2. General collection of a windbreak (?) Located on the same platform as the complex 5.
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General collection - Pampa de paijan 2 - structure 2. In ceramic fragments workshop collected around wpt 84 (gps1).