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Bringing an Early City Back to Life: Plant Foodways as Social Fields at the La Blanca Site (900-500 BCE), Pacific Coast of Guatemala

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Bringing an Early City Back to Life: Plant Foodways as Social Fields at the La Blanca Site (900-500 BCE), Pacific Coast of Guatemala

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Anthropology

by

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ABSTRACT

Bringing an Early City Back to Life: Plant Foodways as Social Fields at the La Blanca Site (900-500 BCE), Pacific Coast of Guatemala

by

Mallory Anne Melton

The emergence of an incipient city represents not only a moment in time, but also the beginnings of a social experiment. Aggregated living introduced new challenges such as the need to feed more mouths than ever before. Yet studying responses to these challenges becomes difficult in the case of early cities as excavations of these contexts do not provide adequate temporal and/or spatial resolution to assess change over time. This dissertation examines subsistence strategies at the archaeological site of La Blanca (900-500 BCE), a Middle Preclassic period incipient city on the Pacific coast of Guatemala with a long history of household excavations. I analyze macrobotanical and microbotanical plant remains from La Blanca to assess both the types of foods used to feed inhabitants and the distribution of intra-site food processing activities across time and space.

The analysis of plant remains can provide unique insights into social differentiation in comparison to other commonly used indices, such as the distribution of prestige goods. I rely on Pierre Bourdieu's theoretical construct of social fields to disentangle the study of economic ranking based on prestige goods from economic activities pursued by households.

Rather than grouping households by elite or commoner status first and then comparing plant remains second, I look to the plant data first to assess their own non-binary insights into social relations. My research uses Exploratory Data Analysis to investigate spatial and temporal patterning. I integrate a wide variety of techniques including paleoethnobotanical methods (macrobotanical, starch granule, and phytolith analysis), spatial statistics, and Bayesian analysis of radiocarbon dates to conduct intra-site and inter-site comparisons of plant data from the La Blanca site.

My results present novel perspectives on subsistence planning in early cities and long-term changes in the regional subsistence practices of Pacific Mexico and Guatemala during the Preclassic period. Spatial statistics reveal that domestic contexts at La Blanca are clustered, identifying five neighborhoods and one additional area with a more complex use history. Comparisons of botanical remains from these six locales indicate that their uses changed over time. Moreover, temporal comparisons illustrate that diversification played a key role in meeting subsistence needs during the Conchas D subphase, the most populous period of the early city's occupation. Inter-site comparisons with other Early and Middle Preclassic sites on the Pacific Coast indicate that, contrary to expectations, maize intensification predated the initial urbanization of the region. La Blanca also represents the highest taxonomic diversity of the sequence, revealing that diversification is more characteristic of early urbanism on the Pacific Coast than previously considered. Analysis of plant use as a social field does not provide strong evidence of differences in household subsistence strategies by economic ranking, but instead highlights key differences by spatial cluster that are more indicative of early efforts at city planning.

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CHAPTER 1: THE LIFE OF AN EARLY CITY

“But a city is more than a place in space, it is a drama in time.” – Patrick Geddes

Cities have categorical life stages that loosely resemble those of their human inhabitants. Both cities and humans come into existence, mature, and decline. But while humans have a fixed, unidirectional life course, cities may flexibly wax and wane in prominence. Early cities are no exception (Joyce 2009; Lucero et al. 2015; Smith 2003; Yoffee 2005). Yet due to difficulties with attaining adequate spatial and temporal resolution, it is often the case that examples of early urbanism must be studied as fixed social entities rather than moving targets. Daily life, when examined at the household level, offers a means of enlivening the histories of individual actors and the incipient city itself.

In this dissertation, I use plant remains to study the life of La Blanca, a Middle Preclassic period (900-500 BCE) incipient city located on the Pacific coast of Guatemala. This early city, represented archaeologically by the La Blanca site, is exceptional in many ways. It signifies one of the earliest examples of urbanism in Mesoamerica and the earliest example from the Pacific Coast. It is also one of the earliest regional examples of stratification in household economic rank (Love and Guernsey 2011). The La Blanca site has been subject to decades of excavations that have identified houses over a large portion of the site, which covered at least 300 hectares in total area (Love 2002a). These excavations are remarkable in the scope of the archaeology of Preclassic period Mesoamerica in that they have sampled 21 of the over 100 households, with surface collections from many more. Analysis of material remains recovered from these investigations has illuminated various aspects of daily life such as prestige goods circulation (Love and Guernsey 2011), lithics manufacture (Borrero 2014), hunting practices (Wake and Harrington 2002), domestic/public rituals (Guernsey 2020; Guernsey and Love 2019), and articulation of differences in household rank (Love and Guernsey 2011).

The current study makes a unique contribution to our understanding of the social fabric of the city of La Blanca through conceptualizing different aspects of foodways as separate but related social fields (*sensu* Bourdieu 1996, 2000, 2004). I argue that this approach is beneficial in that it analytically separates social relationships formed through food-related activities from those related to the circulation of prestige goods, a common proxy for status differentiation. In doing so, this approach situates food as its own independent line of evidence for evaluating inter-household social relationships rather than being dependent on the initial determination of household status affiliations using other lines of evidence and then structuring comparisons based on those affiliations.

Each of the eight chapters in this dissertation contributes to building a food-centric theoretical approach that approaches ancient cities as lived spaces. In doing so, I reflect on the power of findings from the La Blanca site to inform our understandings of the key characteristics of early urbanism on the Pacific Coast. Chapter 2 elaborates on the temporal and spatial context of La Blanca and the theoretical approach adopted by the current study. Chapter 3 discusses the likely disconnect between modern and ancient ecosystems of the Pacific Coast, interweaving evidence on plant management strategies from across the Maya world. Chapter 4 explains methods employed to collect and analyze plant remains from La Blanca. Chapter 5 presents an overview of the results, including evidence for food processing strategies at the site. Chapter 6 presents a spatial analysis of habitation and food-related activities at the La Blanca site, identifying neighborhoods and their differential participation in feeding residents. Chapter 7 builds on the analysis presented in the previous chapter by integrating a temporal analysis that addresses changes over the course of the city's lifespan. Chapter 8 situates La Blanca results in context with botanical data from other Preclassic sites on the Pacific Coast and summarizes the conclusions of the study. Lastly, I propose opportunities for applying these findings to address modern issues of urban sustainability, food security, and climate change resilience.

CHAPTER 2: FACETS OF URBAN LIVING AND SOCIAL DIFFERENTIATION

Histories of the emergence of urbanism and social stratification are intertwined on the Pacific Coast. During the Preclassic period, this area of Mesoamerica experienced transformational demographic and political changes through which nodes of political power emerged, declined, and reemerged in new areas. This flow of power, perhaps operating in a cyclical manner (Love 2002b), became manifested in the creation of urban centers by the Middle Preclassic period, each with its own hinterland and relationships to distant trading partners. Although Preclassic period hinterlands have been identified via survey, it is the primary centers that have been subject to the most intensive excavations.

The current study considers life inside one of these primary centers, La Blanca. The La Blanca site is unique in that represents one of the earliest examples of urbanism in Mesoamerica and a first step in the incipient urbanization of the Pacific Coast. This chapter discusses historical changes on the Pacific Coast leading up to the emergence of La Blanca in the Middle Preclassic period. I also explore the challenges of maintaining an early city, challenges that would have been faced by La Blanca's inhabitants over the course of its four centuries of occupation. I adopt Bourdieu's construct of social fields to propose that ancient cities offered many avenues for acquiring power and manifesting inequality. Finally, I provide a concise history of excavations and paleoethnobotanical analyses at the La Blanca site that allows me to identify new research directions.

Urbanization on the Pacific Coast: A Historical Perspective

The Pacific Coast (Figure 1) along with the Valley of Oaxaca, the Mixtec Highlands, and the Gulf coast of Mexico represent the earliest regions of urbanization in Mesoamerica (Joyce 2009:192). In each of these regions, the founding of urban centers happened independently during the Middle to Late Preclassic periods (900 BCE-100 CE). This dissertation examines incipient urbanism in the area along the Pacific coasts of modern-day Mexico and Guatemala (Figure 2). Following Love (2011a) and Chinchilla Mazariegos (2021), I refer to this region as the Pacific Coast. The Pacific Coast does not represent an isolated region, but rather one node in the interconnected social fabric of Preclassic Mesoamerica.

Figure 1. Relative location of the Pacific Coast.

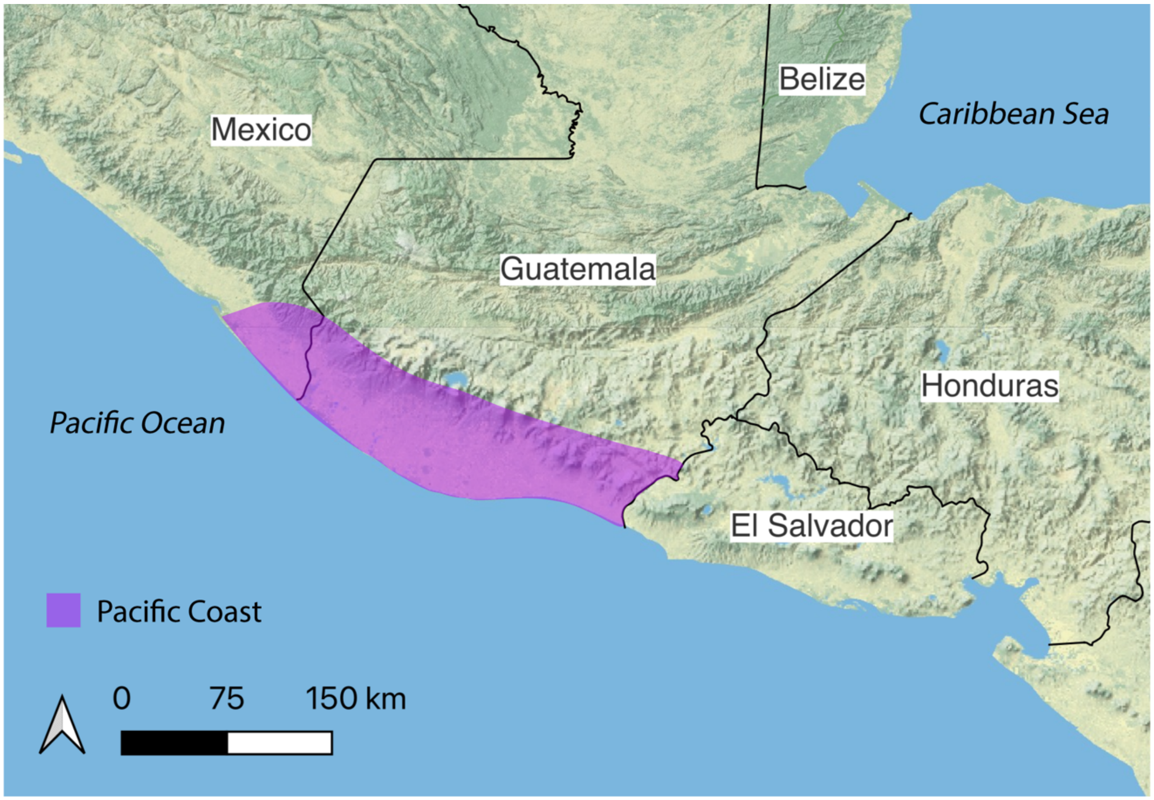

Figure 2. Map of the Pacific Coast (Guatemala and Mexico) during the Preclassic period. Adapted from Chinchilla Mazariegos 2021:Figure 1.

An inter-regional relationship between inhabitants of the Pacific Coast and the Olmec stylistic heartland (Gulf coast) is evident by the Preclassic period (Figure 3). Yet the power dynamics of this relationship have been persistently debated. Proponents of the mother culture hypothesis argue that inhabitants of the Gulf coast created Olmec styles and they then spread outwards from this origin point (Clark and Blake 1989; Clark and Pye 2000; Pye et al. 2011). Alternatively, the sister culture hypothesis proposes that Gulf and Pacific coast societies interacted as peers, with Olmec styles as a product of these interactions (Flannery and Marcus 2000; Love 2007).

Evidence for the exchange of various goods and iconographic elements between the Olmec heartland and the Pacific Coast suggests a two-way relationship; Flannery and colleagues (2005) argue that concept of one-way trade neither aligns with ethnohistoric records nor is economically viable. The Isthmus of Tehuantepec, a route historically used to move goods between the Gulf and Pacific coasts, would have offered a convenient path for canoe transport along portions of the Coatzalcalcos River for San Lorenzo wares recovered non-locally (Rosenswig 2010). Results of INAA on ceramic sherds from the Acapetahua estuary, situated between the Gulf coast and the Mazatán area, provide evidence of pottery made in San Lorenzo and other parts of the Soconusco (Cheetham and Coe 2017; Gomez et al. 2011). In the Olmec heartland, other non-local goods such as obsidian from the highlands of Guatemala (Hirth et al. 2013) demonstrate a two-way exchange relationship. Residents of the Middle Preclassic site of La Blanca on the Pacific coast also exploited two of the same highland sources (El Chayal and Ixtepeque) along with San Martín Jilotepeque and Tajumulco obsidian (Jackson and Love 1991; Love and Jackson 1999). In summary, material ties indicate that Gulf Coast Olmec were connected to the Pacific Coast through trade, but the link between social complexity in the latter and interactions with the former continues to be debated. I examine the Pacific coast as its own cradle of urbanism, providing a brief history of the development of social complexity in this region up to the Middle Preclassic period, when La Blanca became one of the earliest cities in Mesoamerica.

Figure 3. Location of the Olmec Heartland relative to the Pacific Coast. Pacific Coast outline adapted from Chinchilla Mazariegos 2021:Figure 1. Olmec Heartland outline adapted from Pool and Loughlin 2017: Figure 1.

Sociopolitical Complexity and the Test of Time

The earliest archaeological evidence of human presence on the Pacific coast of Guatemala dates to the Archaic period (8000-1900 cal. BCE, date range based on Rosenswig 2015). Neff and colleagues' (2006) analysis of SIP001 and SIP014 sediment cores revealed phytoliths of maize, squash, and arrowroot genus (*Maranta* sp.) dating as early as 3500 cal. BCE. On the Pacific coast of Mexico, burned phytoliths in sediment cores from the Acapetua area demonstrate that inhabitants began to engage in maize horticulture as early as 6500 cal. BP, with progressive emphasis on maize and land clearance over time – evidenced by the pollen, phytolith, and charcoal records from these cores – leading to the emergence of agriculture by 3800 cal. BP (Kennett et al. 2010).

By the Early Preclassic period, the Mazatán area of Chiapas emerged as a major center of occupation and political influence on a regional scale. Paso de la Amada is one of the most well-investigated Early Preclassic sites, and the internal dynamics of the settlement have been reconsidered over time. Lesure and Blake (2002) interpret the occurrence of platform mounds, the largest being Mound 6, across the site as indicative of prestige-based competition by elites. However, Mound 6 is later considered by Lesure (2011) to be a nexus where a combination of residential and ceremonial activities took place at the site. Lesure sidesteps the issue of whether Mound 6 represents an elite or non-elite residence to instead challenge the notion of dichotomic thinking in archaeology, considering Paso de la Amada (Figure 4) as a planned settlement where formal and informal activities variously cultivated social power on individual and/or communal scales.

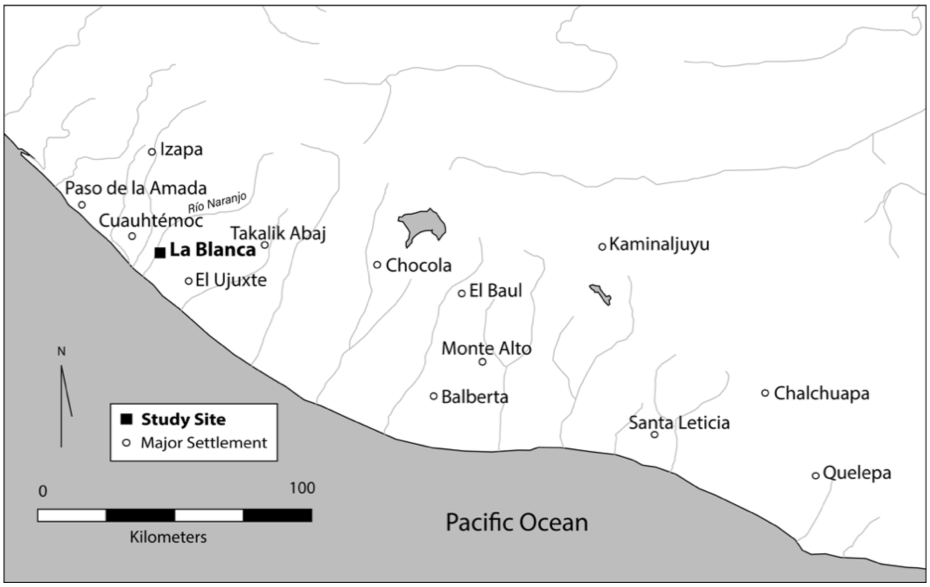

Figure 4. Map of selected Preclassic settlements on the Pacific Coast, including those mentioned in text.

Settlement in the Mazatán extended beyond Paso de la Amada to form what Rosenswig (2011, 2012) refers to as an island of complexity. While occupation at Paso declined by the Cherla phase (Figure 5), other villages in the Mazatán such as Cantón Corralito and Ojo de Agua persisted into the Cuadros (~1325-1150 cal. BCE) and Jocotal phases (~1150-1000 cal. BCE), respectively (Lesure 2011; Rosenswig 2011). This idea of complexity as a nuclear phenomenon is highly applicable to the Pacific coast Preclassic/Preclassic more generally (Chinchilla Mazariegos 2021; Love 2002b, 2011b). Later in time, the rise of the early city of La Blanca in the Middle Preclassic and states such as Izapa, El Ujuxte, and Kaminaljuyu by the Late Preclassic are relatively circumscribed phenomena. While these centers vary in scale, nodes of political power and geographic shifts in these nodes over time can be said to characterize much of the Preclassic period on the Pacific Coast.

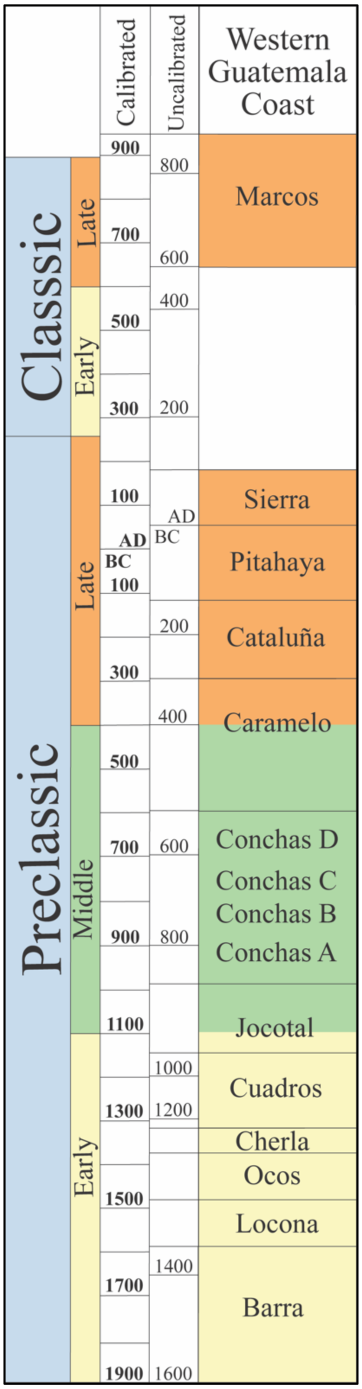

Figure 5. Chronology of the Western Guatemala Coast from the Preclassic to Classic periods. Adapted from Love 2007.

By the start of the Middle Preclassic period (~1000 cal. BCE), the abandonment of sites in the Mazatán and the contemporary growth of settlements in the Río Naranjo area indicates a sea change in the political landscape of the Pacific Coast. Following this large-scale abandonment, the population of the Río Naranjo area dramatically increased and its newfound La Blanca polity grew to an unprecedented 300 km^2 in area (Love and Rosenswig 2022:144). Within this polity, the once small village of La Blanca grew in scale to became one of the earliest cities in Mesoamerica by 900 BCE (Love and Rosenswig 2022). The village of Cuauahtémoc, to the north in Chiapas Mexico, also increased in size during this time despite being outside of the La Blanca polity and thus at a distance from the regional center of power (Rosenswig 2010; Rosenswig et al. 2015). Around the same time as the decline of the La Blanca polity (~600 cal. BCE), the state of El Ujuxte emerged just 12 km to the east (Love 2016a).

Lingering questions regarding the development of sociopolitical complexity on the Pacific Coast center on the identities of those involved, motivation(s) for change, and characteristics of the process (i.e., how it happened). Love (2002b) argues that the history of power dynamics on the Pacific Coast during the Preclassic period is akin to political cycling, where the decline of one center precipitates the growth of another or vice versa. He does not specify a causal impetus for these geographic and political shifts. Instead, the emergence of cities and states is a product of social and cultural influences that are situational and difficult to fully reconstruct. Thus, instead of asking why it happened, a more productive line of inquiry might be to concentrate on tracking how sociopolitical complexity was experienced and (re)shaped over the course of daily life at sites such as La Blanca.

Shifting focus from the impetus for major political events to daily experiences calls attention to the long-term histories of ancient cities. I propose that the investigation of the life of a city, including its rise, florescence, and decline, enhances recognition of the different choices that inhabitants (actors) made over the course of its life. These actors are often organized into residential groups, including neighborhoods. If the life of a city is envisioned as a theatrical production, neighborhoods would serve as collective actors that perform their roles but can also adapt their lines or propose changes to the scripts of other neighborhoods with various possible levels of enforcement. In the next section, I explore the characteristics and challenges of ancient cities as they are experienced over the urban lifespan.

Growing Pains of Early Cities

The specific qualities necessary to classify a settlement as an ancient city is a topic that has been hotly debated (Cowgill 2004; Joyce 2009; Smith 2011a, 2016; Yoffee 2005). Problems have historically existed with using Old World typologies (e.g., Fox 1977) to classify ancient Mesoamerican cities, which poorly fit identifying criteria and functional categories developed based on ancient cities in the Near East or Europe (Chase et al. 1990). Certain scholars, such as Michael Smith (2007), prefer to adopt functional definitions of urbanism that require economic, administrative, or religious influence over an expansive hinterland. On the other hand, demographic definitions emphasize social differentiation, large size, and high population density (Hutson 2016). Monica Smith (2006) has proposed a three-pronged model that combines demographic, functional (external specialization), and Childean (internal specialization) characteristics with the expectation that an urban center would specialize in one arena and invest in the other two to at least some extent.

Following Joyce (2009), I adopt a bottom-up approach to defining urbanism that centers on the analysis of daily life to inform our understanding of this social phenomenon.

In this chapter, I rely on evidence presented by Love (2016a) and others (Chinchilla Mazariegos 2021; Love and Rosenswig 2022) to define the archaeological site of La Blanca as the remains of an ancient Maya city. However, definitional traits do not constitute the only activities that occurred within cities. Inspired by Love (2022) and Rosenswig (2012), I argue that exploring daily life in an incipient city is a more productive method for understanding its internal and external social dynamics than debating its extent of urbanness against a set of predetermined characteristics.

Urban Sustainability

A city is an inherently complex administrative entity. Yet cities pose interesting classificatory challenges to unilineal models of cultural evolution. No matter whether one defines a city as a relatively populous or internally differentiated social entity, it can defiantly manifest aspects of both a chiefdom (e.g., population size) and a state (e.g., classes, bureaucratic infrastructure) as defined by Service (1962) in his classic band-tribe-chiefdom-state model.

Similarly, cities elude expectations of Fried's (1967) ranked and stratified societies. Kinship is a common focus of ranked societies and an essential part of the social fabric of many Mesoamerican cities, but so is an aspect of stratified societies described by Fried (1967:186) as unequal "access to the basic resources that sustain life" among "members of the same sex and equivalent age status." For example, a comparison of modern cities and ancient Mesoamerican cities by Dennehy and colleagues (2016) reveals that inequalities often exist between neighborhoods, sorting out along a spatial rather than economic axis of identity. Cities are also subject to periods of decline and reorganization. This aspect is incompatible with notions that social complexity is a progressive and unilinear process rather than an experiment with ad-hoc fluctuations in settlement size and political management strategies. In his discussion of the concept of chiefdoms, Pauketat (2007) presents a similar critique of the interpretive restrictions imposed by the band-tribe-chiefdom-state and egalitarian-ranked-stratified models. Although a city is not a society, the unsuitability of sociopolitical characteristics of Mesoamerican cities to fit into long-standing categorizations of complexity is a testament to the need for individual consideration and interpretation based on local context.

Cities are transformative social phenomena (Yoffee 2005). They are, however, also politically fragile. In his cross-cultural comparison of ancient cities and states, Yoffee (2005) notes that these complex entities are easily subject to disintegration due to social, environmental, political, or other variables. Maintenance of a city, or urban sustainability, is therefore a difficult balancing act with many moving pieces (e.g., actors, inter-household relationships, exchange networks).

Archaeological research on the topic of urban sustainability has focused on identifying strategies used by inhabitants of ancient cities to aid in coping with modern problems of climate change and resilience. In their cross-cultural and global synthesis of archaeological literature related to peri-urban areas or interfaces (PUI), Simon and Adam-Bradford (2016:67) found that integration of cities and agricultural peri-urban areas enhances stability and long-term resilience. They also call into question the traditional core versus hinterland dichotomy, illustrating that in many cases the divide is neither clear cut nor analytically useful. Instead, in the most integrated examples, households take on different but not necessarily less-connected social and economic roles as distance from the city center increases (Simon and Adam-Bradford 2016). These roles are situationally contingent, with marked variation in the social connectedness of the urban-rural continuum depending on level of integration. Distributed (or low-density) urbanism, often practiced in pre-Columbian Mesoamerica, offers a protective strategy against disintegration especially when unanticipated environmental pressures arise (Isendahl and Smith 2013; Scarborough and Isendahl 2020). Moreover, Feinman and Carballo (2019) note a positive correlation between collectiveness of a settlement, apogee length, and population size in their study of Mesoamerican urban centers. Their findings indicate that settlements with a greater degree of collective governance had greater resiliency. However, more research is needed into the extent of integration in different Mesoamerican urban polities, especially within the centers themselves.

Spatial Organization of Lifeways

The study of urban landscapes focuses on analyzing the configuration of structures and social interactions within cities (Smith 2014). These aspects of urban living have great potential to both reflect the history of the city and shape its future. However, a large part of the focus in urban landscape studies has historically been placed on compact agrarian cities rather than examples of more sustainable, dispersed urbanism (Fletcher 2019). It is in these dispersed cities that "urban growth… encapsulates the rural world in the mesh of the urban network" (Fletcher 2011:285). Thus, on a polity level, dispersed cities such as those of the Maya tend to be integrated and are characterized by ambiguous boundaries that amorphously extend into the hinterland and sometimes evade recognition (Fletcher 2011:292-294).

On a more localized scale, interactions within ancient cities are often structured around meaningful social units that, from smallest to largest, are referred to as households, neighborhoods[1], and districts (Wilk and Rathje 1982; Smith 2010). Districts, as defined by Smith (2010) and Smith and Novic (2012), refer to the top-down spatial units of a city that have an administrative or social identity. As institutional neighborhoods (another term for district, see Smith 2010:140), these optional segments of a city facilitate organization and are recognized by residents. Below districts are neighborhoods, which differ from districts in that they are both a product and expression of face-to-face interactions (Arnauld 2012; Smith 2010, 2011a; Smith and Novic 2012). Neighborhoods are thus a product of bottom-up social interactions rather than top-down decision making (Hutson 2016:72).

Urban planning, in the case of neighborhoods, is an iterative process in which individual actors design their own social spaces that are physically manifested and remapped onto the landscape (Smith 2011b:179). Hutson and Welch's (2021) spatial analysis of wealth disparities at the Classic Maya city of Chunchucmil revealed a high intermixing of households with different degrees of wealth within each of the two neighborhoods studied. This research illustrates that neighborhoods are not necessarily determined by household wealth or status but instead are a product of a potentially wide variety of social reasons for aggregation that are situationally contingent. For example, Blackmore (2011) argues that the Northeast Group neighborhood at the Late Classic Chan site included residents with class-based differences that forged a collective identity through ritual practice.

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[1] The term "barrio," long used in different contexts to refer to residential groups, wards, or neighborhoods has been left off this list intentionally. Smith and Novic (2012) justifiably scrutinize this term for its problematic oversimplification as it has been broadly used to refer to a wide variety of social groupings both ethnographically and emically to Mesoamerican peasants.

Axes of Difference

As the first Mesoamerican cities grew, their inhabitants had to contend with how to interpret and perform their identities within this new social space. One facet of daily life through which aspects of identity can be forged and articulated is participation in the domestic economy. Domestic economy is defined by Hirth (2009:13) as “what households do and how they were organized to meet their physical and social needs.” Hirth (2009:21) goes on to argue that a diversity of tasks is necessary to success in meeting household needs and sustaining exchange relationships. Choosing or not choosing to participate in a task and the degree to which one invests in that task can all result in inter-household differences in daily activities. These choices shape how power is organized at the household and neighborhood scales (Levi 2002). Over the life course of a city, as it emerges, grows, and declines, social and political power dynamics change, sometimes concurrent with or less related to alterations in spatial layout (Lucero et al. 2015).

Status is but one axis of social diversity, or social differentiation, within ancient cities. Hutson (2016:16) identifies social differentiation as one of the defining characteristics of ancient cities. Social differentiation, or heterogeneity among residents (Hutson 2016:11), can manifest in the form of differences in wealth, occupation, authority, ethnic identity, or other factors. One of the most underexplored components of social diversity in ancient cities of the Pacific Coast is relative engagement in different aspects of foodways (e.g., processing, cooking, service, disposal; see Scarry and Reitz 2005; Welch and Scarry 1995) at the household and neighborhood levels. Cities with high social diversity tend to exhibit more long-term resiliency (Hutson and Welch 2021:813), but to understand diversity more fully we must account for other sources of difference besides wealth (Twiss 2012). The exploration of social relationships at the inter-household level is especially useful in certain cases. For example, where spatial differentiation and grouping of households is unapparent or social relationships between households in an apparent cluster are poorly understood. By embracing social difference as including but not being limited to wealth as an axis of differentiation, we can understand if potential neighborhoods: (1) connected households; (2) are distinguishable from other neighborhoods; (3) served a specific function(s) in the maintenance of the settlement; and/or (4) uniquely contributed to the life of the city. I propose that a useful method of looking beyond the question of status while still embracing the concept of social differentiation is to start from a foundation of Bourdieu's theory of social fields.

Social Fields and Fields of Power

Bourdieu's Theory of Social Fields

Pierre Bourdieu's (1972, 1980) path breaking research into identifying social constructs related to the acquisition and sharing of knowledge within communities has had a profound influence on archaeological theory. Although regularly employed are his broad concepts related to the agency-structure dialectic (e.g., practice, habitus, doxa), less discussed are his theoretical contributions to the study of social fields (Bourdieu 1996, 2000, 2004). Social fields are the arenas in which agents (individuals) struggle for symbolic capital within a specific interest group (Hilgers and Mangez 2015; Reed-Danahay 2005:11). These interest groups represent "autonomous power structures, with their own logic and rules, in an ongoing process of differentiation" (Forchtner and Schneickert 2016:296). Bourdieu's (1984, 1993, 1996) examples of social fields tend to revolve around disciplines in the

Western academic canon such as economics, politics, art, and literature. However, archaeologists have variously applied his concept of social fields to study relations of power in the ancient past.

Archaeological applications of Bourdieu's theory of social fields, while fewer in number than those related to his theory of practice or habitus, are nevertheless foundational. In his discussion of the archaeological study of tradition, Chamberlin (2006) frames a social field as a nexus for actors to iteratively build inventories of traditional knowledge. The social field thus serves as a means for actors to unload their embodied knowledge and convert it into symbolic capital (Chamberlin 2006:42). In other words, the social field offers a means through which personal knowledge can be given value, and then incorporated into broader agendas that can extend beyond the individual. These broader agendas could result in personal benefit (e.g., spatial distribution of subsistence responsibilities) or harm (e.g., frequent exploitation of specialist labor to create prestige goods). Laguens (2014) outlines specific examples of social fields in the archaeological record in relation to a regional assessment of inequality among Aguada societies (500-1000 CE) in the Ambato Valley of Argentina. He argues for a link between social differentiation and volume of resources managed but specifies that different social fields contributed to the patterning in resource distribution. While in one of the Aguada groups, architecture and the organization of space contributed most strongly to social inequality, a different social field – ceramic exchange (access to ceramics, including those of high storage capacities) – contributed to social inequality in the second group (Laguens 2014:94). Wilson and colleagues (2020) take a broader, transregional approach to social fields, examining interactions within and beyond the Mississippian Central Illinois Valley in the North American Midwest. They argue that the operation of interregional and inter-group social fields facilitated the early articulation of Mississippianization by around 1000 CE. Collectively, these case studies demonstrate flexibility in applications of the term social field, a flexibility that I draw upon in developing my own specific take on the concept.

I argue that social fields, in relation to Bourdieu's perspective, may represent more discrete arenas of cultural capital pertinent to archaeological analysis through which power is exchanged. Examples of these arenas could include long-distance exchange, prestige goods circulation, movement of raw materials, and the activities involved in foodways. Each aspect of foodways (e.g., collection, cultivation, harvest, processing, cooking, service, discard), for example, represents an interconnected but archaeologically distinguishable social field. I propose that this construct of separate but adjacent social fields is most effective and realistic when different fields related to economics (e.g., prismatic blade circulation, prestige goods economy, communal financing of monumental construction projects) are envisioned as occupying contemporary but distinct social worlds; in Bourdieu's perspective, these archaeologically distinguishable economic fields would have been collapsed into one social field.

Thinking of social fields in the way I have proposed is particularly productive for dissecting social interactions at a local scale. Transformational settings, such as early cities like La Blanca where aggregated living was in its infancy, offer ideal contexts for picking apart relationships of power forged and maintained through different social fields. Differentiating potential networks of knowledge and power is especially helpful in identifying relationships configured within social settings with hundreds (if not thousands) of actors and several centuries of occupational history.

Fields of Power

If we accept the adage that knowledge is power, then social fields, as vessels of knowledge, have an inherent relationship to power. But not all social fields have the same internal power relations. Bourdieu (1996:215) defines the concept of field of power to refer to one social field in which individuals with immense cultural capital within that field could take a dominant position (see also Reed-Danahay 2005:134). However, relations of domination can be more complex than a dominant/dominated binary, with additional levels of internal variation (Hilgers and Mangez 2015:10). While fields of power are subject to dominant/dominated relationships between actors, not all social fields are subject to this organizing principle. In fact, Bourdieu envisions social hierarchy as operating externally to social fields, potentially influencing them, but not dictating relationships between actors in any one social field (Hilgers and Mangez 2015:10). Fields with the most autonomy would logically be the least sensitive to influence by external factors such as hierarchy (Hilgers and Mangez 2015:10).

The relationships between fields of power, social fields, and hierarchy build a complex picture of social differentiation at the settlement or regional levels. In the current study, I focus on analysis of food remains from the incipient city of La Blanca. Here, research by Love and Guernsey (2011) and Love and Rosenswig (2022) comparing densities of prestige goods (e.g., jade) by household offers a sense of social differences and relationships. However, prestige goods production and exchange networks only represent a small range of the social fields that would have operated at La Blanca. Using a theoretical approach that incorporates an understanding of social fields and fields of power opens doors for the analysis of additional household relationships along different social fields, such as those directly related to food.

The current study focuses on the analysis of different activities involved in plant foodways as representing distinct social fields, each which has the potential to operate as a field of power. Mapping social differentiation based on prestige goods may not directly translate to relationships based on aspects of foodways. For example, while certain households may have had greater densities of jade or fine ware ceramics, quantities of prestige goods do not explicitly reflect whether these high-ranking households processed their own food domestically or extracted pre-processed food from other locales. Thus, conducting separate inter-household comparisons of botanical data and prestige good densities can provide different perspectives on intra- and inter-site social relations. Before discussing the current project in greater depth, I present a summary of archaeological research conducted at the La Blanca site.

Archaeology at La Blanca

After the virtual abandonment of sites in the Mazatán region near the end of the Jocotal phase (ca. 1100-980 cal. BCE), the Río Naranjo area (see Figure 4) became a bustling zone of habitation. Certain hamlets first occupied prior to the Conchas phase became more populous during the Middle Preclassic (e.g., La Blanca), whereas other hamlets (e.g., Santa Clara) maintained one to five residences (Love 2002a:29-37). El Infierno and La Victoria represent two of the largest hamlets occupied during this period, with four and five residences, respectively (Coe 1961; Love 2002a). Even the most populous hamlet does not come close to the size of the La Blanca site, with over 100 households identified. Yet La Blanca is best contextualized as a large node within a broader social landscape. This section summarizes archaeological evidence for La Blanca's role as a polity and an urban center. I also summarize all excavations and paleoethnobotanical analyses to date, providing essential context for understanding the role of the current study in providing a unique perspective on daily life at La Blanca.

La Blanca: The Polity

La Blanca's history as a polity began in the Early Preclassic period. Although settlements generally consisted of hamlets during this period, regional surveys conducted by Love have illuminated that it is possible to sort settlements into a two-level hierarchy based on population size (Love 2002a; Love and Guernsey 2011:184). These surveys have revealed that by the Middle Preclassic period (900 BCE), 80 or more settlements existed within the newfound 300 km^2 La Blanca polity (Love and Rosenswig 2022:144). Concurrently, the regional political system of La Blanca became more stratified with three to four levels of regional settlement hierarchy based on population size, including a primary center (La Blanca site), two secondary centers (La Zarca and El Infierno), hamlets (e.g., La Victoria), and single residences (Love 2002a:36). Love and Rosenswig (2022) recently combined their survey data from Pacific Mexico and Guatemala and identified a three-tiered settlement hierarchy for the Middle Preclassic period. Their demographic analysis revealed that 39% of the regional population lived at La Blanca (primary center), 8% inhabited secondary centers, and 54% resided at other settlements in the hinterlands (Love and Rosenswig 2022:152).

Exchange relationships between the settlements in the La Blanca polity are not fully understood, partially due to fewer excavations of hinterland households as opposed to those at the main center. Love and Guernsey (2011) suggest that the founding of the La Blanca polity could represent an episode of coercive resettlement based on evidence of population aggregation in the Río Naranjo area and demographic decline in the Mazatán and Río Jesus areas by the Middle Preclassic. Monumental construction projects at the urban center of La Blanca, including a 25-meter-tall mound (Mound 1) and two acropolises provide evidence of shared investment or subjugation of its inhabitants. Love (2016b) and Guernsey (2020) have separately argued that Mound 1 is likely a communal construction, embodying a space where the ancestors would have dwelled; fill from the mound significantly includes hundreds of handheld figurines used in domestic rituals (see below, this chapter). It is presently unclear to what extent residents of the hinterland would have participated in or financed (e.g., through tribute to feed the laborers/elites) any construction projects at the city center. The two secondary centers, La Zarca and El Infierno, each have one large mound (~15 m in height; Love 2002a:43-44), potentially imitating Mound 1 at the main center. However, it is not possible to do more than hypothesize the functions of these mounds until excavations have been undertaken.

In sum, by the Middle Preclassic, the La Blanca polity contained over 80 settlements of different sizes. However, the extent of extraction or subjugation of hinterland settlements by the main center cannot be determined until more excavations have been undertaken at hinterland sites. The primary center, in contrast, has been subjected to decades of systematic excavations that have produced insights into the complex relationship between material economy and ideology in the early city.

La Blanca: The Urban Center

The political center of the La Blanca polity is represented by an archaeological site that shares its name. The La Blanca site (Figure 6), measuring over 300 ha in area (Love and Guernsey 2011), has been excavated intermittently from the 1970s to 2017.[2] The earliest investigations, led by Guillermo Folgar, focused on salvage excavations of Mound 1 prior to a highway being constructed through it from 1972-1973. Much of the mound, and other mounds on the site, became damaged in the process but construction strata of Mound 1 have been identified below the current ground level. Analysis of material recovered during the 2017 excavations of these strata is ongoing. Mound 1, constructed of rammed earth, stood over 25 meters tall and measured 150 by 90 m at its base (Love and Rosenswig 2022:147). Although monumental in size, Mound 1 likely served the community—as a vessel for the ancestors to dwell—rather than representing a symbol of its subjugation (Guernsey 2020; Love 2016b). Mound 1 is one of the most prominent features of the central residential area of the site, which Love refers to as the Central District (Love and Rosenswig 2022). The Central District also featured two raised platforms, the East and West Acropolis. The East Acropolis included mostly elite residences and one earthen mound (Mound 5) possibly constructed for either public or ceremonial activities (Love and Guernsey 2011). The West Acropolis is characterized by larger mounds on top of which public buildings (with likely ceremonial uses) would have been constructed (e.g., Mound 2) and a possible E-group consisting of Mound 6 plus three shorter mounds to the east (Love and Guernsey 2011).

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[2] Three archaeologists have led excavations at La Blanca. Guillermo Folgar directed salvage excavations of Mound 1. Edwin Shook uncovered domestic remains in the southern portion of the site, around the area referred to by Michael Love as the Esquivel group. Michael Love has directed all fieldwork at La Blanca since the 1980s with a focus on identifying and excavating households.

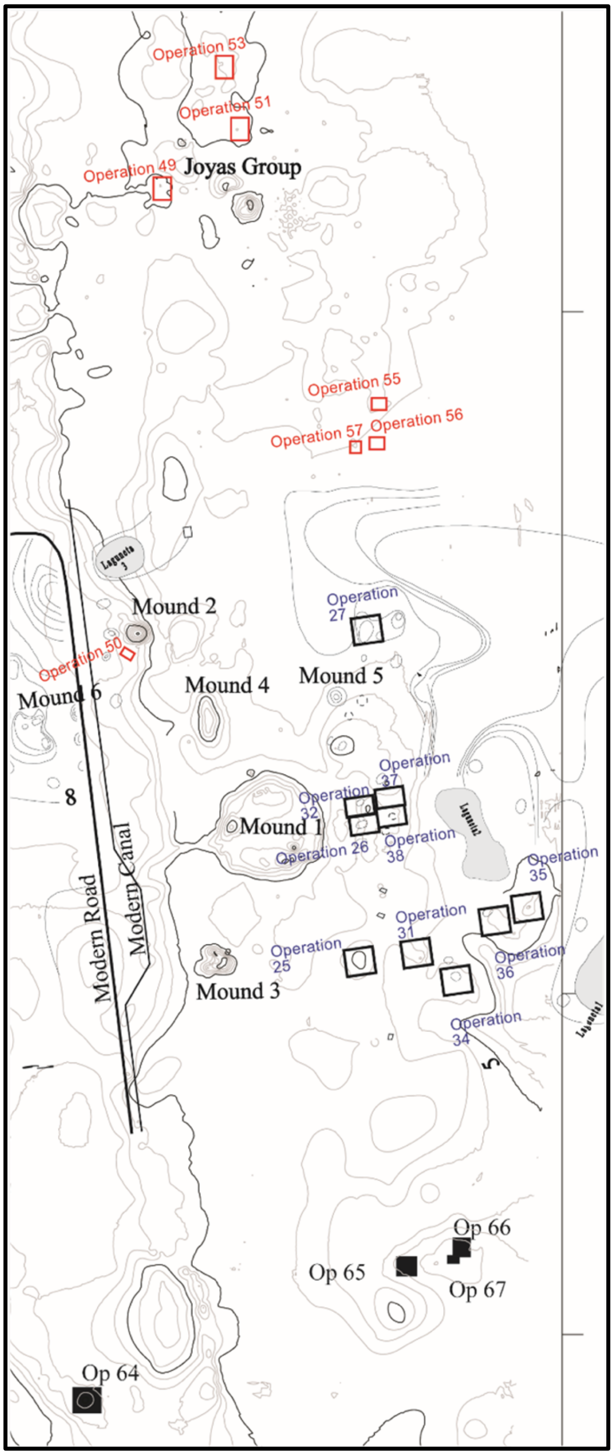

Figure 6. Plan map of excavations at the La Blanca site. Produced by Michael Love. Blue text = Central District excavations. Red text = Joyas Group excavations. Units filled in black = Esquivel District (left, Op 64) and Vacas District (Ops 65-67).

While E-groups have long been understood as sacred geography (Aimers and Rice 2006), at La Blanca the orientation of the entire site put its inhabitants into conversation with the natural and spiritual worlds. The alignment of the site's central axis with the Tajumulco volcano, the tallest peak in Central America, represents an explicit reference to the ancestral realm. Volcanoes are the homes of the ancestors among the Maya, vantage points from where they can protect the second soul of a living person (see Chapter 3). Volcanic areas of the Guatemalan highlands also served as key sources of obsidian during the Preclassic period. Jackson and Love (1991; see also Love and Jackson 1999) linked obsidian from La Blanca to the Tajumulco, Ixtepeque, San Martin Jilotepeque, and El Chayal sources on the volcanic belt that runs along south-central Guatemala.

The Central District is surrounded by residences that Love organizes into the Joyas, Esquivel, and Vacas groups (Love and Rosenswig 2022:147). Excavations of the Joyas, Esquivel, and Vacas groups proceeded during the 2016-2017 field seasons; most of the macrobotanical and microbotanical samples analyzed in this dissertation derive from these excavations. Based on the expansive nature of household placement, Love and Rosenswig (2022) understand La Blanca as an example of dispersed urbanism, comparing it to similar examples from elsewhere in the neotropics (Fletcher 2011). Dispersed urbanism, also known as low-density urbanism (Isendahl and Smith 2013), is a hallmark of early Mesoamerican cities. Although dispersion could be associated with low integration and high household autonomy, Lucero and colleagues (2015) argue that dispersed cities are typically highly integrated. Dispersion of households across the landscape also offers greater economic sustainability for farmers in the outer reaches of the city (Lucero et al. 2015). These farmers would have been less dependent on receiving tribute than those living in integrated centers and thus they would have been better prepared to fulfill their own subsistence requirements (if necessary) as local activities scaled down with the city's decline.

Households and Social Relationships. Pedestrian surveys by Love have identified at least 100 houses at the La Blanca site (Michael Love, personal communication 2021). Twenty-one of these houses have been excavated. Each Operation, or excavation area, represents at least one excavated structure or construction project[3] (see Figure 6). Apart from Operation 25, which is likely a public building (Michael Love, personal communication 2021), and Operation 50, representing construction fill as part of the Western Acropolis, all Operations are situated in residences. Excavation of one or more 2 x 2 m units, or SubOperations, took place in each Operation.

Household differentiation in artifact assemblages and architecture at La Blanca provides the earliest evidence of inter-household social stratification at a settlement on the Pacific Coast (Love 2016a). Love and Guernsey (2011) consider aspects of economy and ideology in presenting their comparative analysis of household status at La Blanca. They argue that quality of house construction and quantity of jade are the best criteria for social differentiation. Of these criteria, Love and Guernsey (2011:179) determined that jade quantity is the most reliable indicator of household rank. Jade has been recovered from nearly all excavated households, but their analysis determined that the highest ranking households have significantly higher densities of jade than other residences. This pattern suggests that jade served as a means of acquiring private wealth at the site. Other prestige

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[3] An entire structure has never been excavated due to the large size of buildings and high degree of labor investment required for excavation (intact Middle Preclassic contexts are often not encountered until ≥1 m in depth).

goods, fine paste ceramics, mica jewelry, and decorated earspools, are typically concentrated in the highest ranked households, though the difference is not statistically significant. They also found that the highest-ranking residences tend to be rebuilt over time (multiple floors) and were more thoughtfully constructed. These houses have prepared floors as opposed to the rammed earth floors, perhaps just trampled down by footsteps, that characterize lower-ranked households. Finally, Love and Guernsey (2011) note that in terms of ideology, representations of certain supernatural beings (e.g., were-jaguar, glyphlike motifs) are limited to high-ranking residences, suggesting a relationship between wealth, status, and power.

Social status at La Blanca took on not only economic, but also political and spiritual meanings that tie into the development of an ideology of rulership among Preclassic Maya societies of the Pacific coast. Love and Guernsey (2011) and Love and Rosenswig (2022) argue that relative household rank is the most appropriate measure of social stratification at La Blanca. Operation 32, located in the Central District, is the highest ranked residence at the site with the highest jade density (Love and Guernsey 2011:179). This residence also features a large quatrefoil (Monument 3), which is the earliest known quatrefoil and one of the earliest earthen monuments in Mesoamerica (Love and Guernsey 2007). The quatrefoil symbolizes a portal to the underworld and is associated with elite authority among the Maya during later periods (Guernsey 2020:32-33). Operation 32, therefore, would have served as more than just a secular domicile for the wealthy. This residence exemplifies that (1) political, economic, and spiritual power were intertwined by the Middle Preclassic period; and (2) symbols of elite power appear in households and less so in public spaces that are dominated by monumental architecture (e.g., Mound 1, East and West Acropolises, possible

E-group). However, civic architecture built by the community could have also served as a visible symbol of the organization of power at La Blanca if construction was initiated and managed by actors of high social status.

While the distribution of prestige goods among households provides evidence for social differences based on status, the study of figurines illuminates social linkages between households. Handmade, ceramic figurines with anthropomorphic and/or zoomorphic features are ubiquitous among households at La Blanca (Guernsey 2020). Arroyo (2002) found in her analysis of La Blanca figurines that most of the human figurines are female, but it was difficult to determine the gender of certain figurine fragments (e.g., arms, legs). Most figurines have open mouths, and some have red pigment applied to their mouths (Guernsey 2020:70). For the current study, I collected residues from the mouths of a subset of these figurines, with starch grains and phytoliths from these residues discussed in Chapters 4 and 5.

The relationship between figurines and social status is complex. Ronsairo (2016) identified that figurines appear in greater densities in high-ranking residences at La Blanca.[4] The distribution of figurines, however, does not appear to be a product of a formal circulation system deployed by elites as a propaganda tool. Neither production techniques nor figurine types sort out along status lines (Guernsey and Love 2019:8). Guernsey and Love (2019) found that Shriner figurines, for example, occurred in comparable percentages across all households included in their study. The role of figurines in the lives of La Blanca

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[4] High-ranking residences also typically yielded greater quantities of faunal and material remains (e.g., obsidian, ceramics, jade) during excavation in comparison to lower-ranking households.

residents is more related to their use and fragmentation than their distribution across households.

Nearly all figurines found in Preclassic assemblages, including but not limited to La Blanca (e.g., La Victoria, Chalcatzingo), are fragmented (Guernsey 2020:85). Guernsey (2020) argues that figurine fragmentation represents part of an intentional process that contributed to the articulation of personhood (Guernsey and Love 2019), development of Mesoamerican conceptions of destiny, veneration of ancestors, and the forging/maintenance of social identities across household lines. Coe (1961:255) described the task of refitting figurine fragments from La Victoria as "absolutely impossible." Thus, in addition to inter-household exchange, the breakage and exchange of parts of the human form may have even been undertaken on inter-settlement or regional scales that would further complicate efforts at refitting.

Figurines represented a medium for the ongoing articulation of social bonds between individuals at the early city of La Blanca. Practices of fragmentation and exchange of figurine parts occurred alongside status-based differentiation of households through other exchange networks that resulted in the uneven distribution of prestige goods. In other words, the circulation of figurines and prestige goods can be understood as operating along different social fields. Foodways also have the potential to have been practiced in a comparable way at the La Blanca site, operating along different social fields than those used to exchange prestige goods. However, before analyzing food in this way, it is important to first summarize the history of previous paleoethnobotanical research at the La Blanca site.

History of Paleoethnobotanical Research. A research team from the University of Missouri (led by Deborah Pearsall) analyzed macrobotanical samples collected from the La

Blanca site during the 2003-2004 field seasons (Pearsall et al. 2016). Four hundred thirteen soil samples from Operations 34-38 were floated by the field team for macrobotanical remains and then analyzed by Pearsall and her students; 225 handpicked samples from these contexts were also analyzed. Megan O'Brien, a member of Pearsall's team, traveled to La Blanca in the summer of 2005 to collect residues from 102 artifacts (Operations 29-32, 34-38) for starch grain and phytolith analysis. All artifacts sampled for microbotanical remains were washed by the field team in shared basins prior to residue collection. Seven sediment samples were also analyzed for phytoliths to gain a sense of background vegetation and deforestation practices.

Macrobotanical results demonstrate a promising degree of preservation, considering the humid, hot conditions and alternating wet-dry seasons of the Pacific coast. Maize kernels are the most prevalent taxa by count after wood; no cupules of maize were identified (Pearsall et al. 2016:26-27). Other plants in the macrobotanical assemblage included guava (*Psidium guajava*), bean (*Phaseolus* sp.), tentative palm family (Arecaceae cf.), and fruit/nut rind fragments of varying thickness (Pearsall et al. 2016:27).

Maize was the most widely identified phytoliths in artifact residues. The team found maize phytoliths on 31 of the 96 artifacts with analyzed residues, generally one to two maize phytoliths per artifact (Pearsall et al. 2016:6-7). Twenty-four of the sampled artifacts had palm family (Arecaceae) phytoliths, including one metate fragment (Pearsall et al. 2016:8). Aside from Panicoid and palm phytoliths, Pearsall and colleagues (2016:7-8) identified seed phytoliths from arrowroot (*Maranta arundinacea)*, leaf phytoliths of lobster-claw (*Heliconia* sp.), and phytoliths of custard apple family (Annonaceae), squash genus/family (*Cucurbita* sp., Cucurbitaceae), coco plum family (Chrysobalanaceae), sedges (*Scirpus* sp*., Cyperus* sp*.,* *Carex* sp.), and ebony family (Ebenaceae) from the artifacts. Phytolith sediment samples yielded a low number of arboreal plants (Areceae and Chrysobalanaceae) and mostly Panicoid grasses, with maize present in all but one of the seven samples (Pearsall et al. 2016:17-18). Pearsall and colleagues (2016:21) argue that the sediment assemblage suggests "an open landscape with arboreal elements, in which cultivated and useful plants dominated."

Starch grains consistent with maize were found on 41 of the 102 artifacts analyzed (Pearsall et al. 2016:10-11). Chili pepper (*Capsicum* sp.) starch was also recovered from five artifacts, along with one possible manioc (*Manihot esculenta* cf.) granule. Pearsall and colleagues (2016:12) noted in their report that "around 40% of both base and body sherds lacked starch" and about 40% of this assemblage had evidence of maize starch. Thus, 80% of the pottery assemblage either had maize or lacked starch entirely; similarly, 90% of grater bowls had either starch granules consistent with maize (30%) or lacked starch entirely (60%).

Initial work by Pearsall and colleagues provides a solid foundation for the current study. The team established that soil samples, artifacts, and sediments collected from the La Blanca site yielded identifiable remains of food plants. Carbonized seeds, starch granules, and phytoliths paint a picture of La Blanca as a cultivated landscape. One of the limitations of the team's study is that all artifacts analyzed for starch and phytolith residues were washed prior to sampling, as microbotanical analysis was not anticipated at the time of excavation. Prior washing in water is not always an exclusion factor for starch analysis as even washed museum artifacts can display evidence of granules with signs of anthropogenic damage (Barton 2007). However, washing of the sampled artifacts did not involve: (1) hand washing prior to artifact washing (to remove possible contaminants from recently consumed food); (2) provisions to prevent eating while washing artifacts; or (3) drainage/cleaning of basins between artifacts. Given the typical foods eaten in the area (e.g., maize), the risk of contamination is high regardless of the provisions taken in the lab by team members.

The current study involved more rigorous protocols to control for potential contamination, including training of all field technicians in types of artifacts to select for microbotanical analysis and how to handle them (e.g., always remove with a clean trowel, double bag, send back to climate-controlled laboratory by end of day). I personally supervised botanical collection during every field season at La Blanca from 2016-2017. In addition to being available for consultations on when and where to take flotation samples, I collected microbotanical samples from artifacts in a designated area of the field house where food was prohibited.

The current study provides a unique perspective on food remains from La Blanca that builds on foundational research by Pearsall and colleagues (2016). Whereas Pearsall and colleagues focused on landscape reconstruction, I use food as a medium for investigating inter-household social relations at La Blanca over the course of the early city's history. Using the wider array of household assemblages excavated since 2005, it is now possible to go beyond the Central District to compare foodways at a neighborhood scale. Additional radiocarbon dates (see Chapter 7) now permit finer-grained temporal comparisons of food-related activities over the course of the city's beginnings, growth, and decline.

Bridging Social History, Food, and Urban Sustainability at the Early City of La Blanca

The social fabric of a city is multifaceted in terms of its various types of social differentiation and wide-ranging potential contributions of larger entities (i.e., districts and neighborhoods) to the city's resilience. Social diversity on the Pacific Coast has most often been analyzed in terms of status, but there are other types of relationships that can be observed through spatial analysis of archaeological remains. Bourdieu's construct of social fields presents opportunities for the exploration of inter-household differences and neighborhood relations through the analysis of plant remains. Previous research at the incipient city of La Blanca has provided the foundational knowledge necessary for more specifically examining inter-household relationships in terms of different steps in the processing, cooking, and disposal of food. My plant data assess relationships not only between households, but also between neighborhoods, which I identify in Chapter 6. In the next chapter, I continue to set the scene by discussing the ecological context of the Pacific Coast and the unique benefits of paleoethnobotanical analysis for increasing the resiliency of indigenous plants in the face of future climate change.

CHAPTER 3: RECONSTRUCTING PRECLASSIC ECOLOGIES OF THE PACIFIC COAST

Available native flora directly impacts food selection by human residents. In arable landscapes, locally available foods offered a more practical means of regular subsistence for ancient Mesoamericans with fewer labor costs than, for example, transportation of food over long distances (Drennan 1984; Lentz et al. 2015; Webster 2002). Before interpreting archaeological plant data from La Blanca, it is important to consider the types of foods available in the immediate vicinity. In addition, critical consideration must be given to the overall floristic composition of the Río Naranjo area even in relation to other areas of the Pacific Coast. This chapter reviews available evidence for reconstructing ecologies of the Pacific coast of Guatemala and the Río Naranjo area more specifically, while also reflecting on aspects of Maya ethnobotany that relate to the region of study.

Modern Environmental Conditions on the Pacific Coast of Guatemala

Climate and Geography

The climatic conditions of Guatemala vary depending on location. Although all areas of the country have wet and dry seasons, there are notable differences in elevation, temperature, and rainfall even within the same geopolitical department. For example, within the department of San Marcos there are three distinct climatic regions (Figure 7; see also McBryde 1947). The regions mapped in Figure 7 as *Pacifico* (Pacific), *Bocacosta* (Piedmont), and *Occidente* (West) roughly correspond with the colloquial regions recorded by Shook (1965) as *tierra caliente* (0-1,000 m), *tierra templada* (1,000-1,900 m), and *tierra* *fría* (>1,900 m). The municipality of La Blanca (20 m asl), in which the archaeological site is located, is positioned within the *tierra caliente* region of San Marcos. The average annual temperature for the *tierra caliente* region is >23 °C, with ranges for *tierra templada* and *tierra fría* being 17-23 °C and <17 °C, respectively (Shook 1965:180). In the Pacific and Piedmont regions of San Marcos (see Figure 7), the warm air from the Pacific is cooled after reaching the Piedmont, creating a rain belt ~300-800 m asl. The coast thus tends to be warmer and drier than the areas of the Piedmont that are in the rain belt. For example, La Blanca has high annual temperatures and only received 1,000-1,500 mm of rainfall in 2011 (Biota S.A. and the Nature Conservancy 2014:24). In comparison, the Piedmont town of El Carmen (129 m asl) is also in the San Marcos department but received >4,500 mm of precipitation, partly a consequence of being located at higher elevation (Biota S.A. and the Nature Conservancy 2014:24).

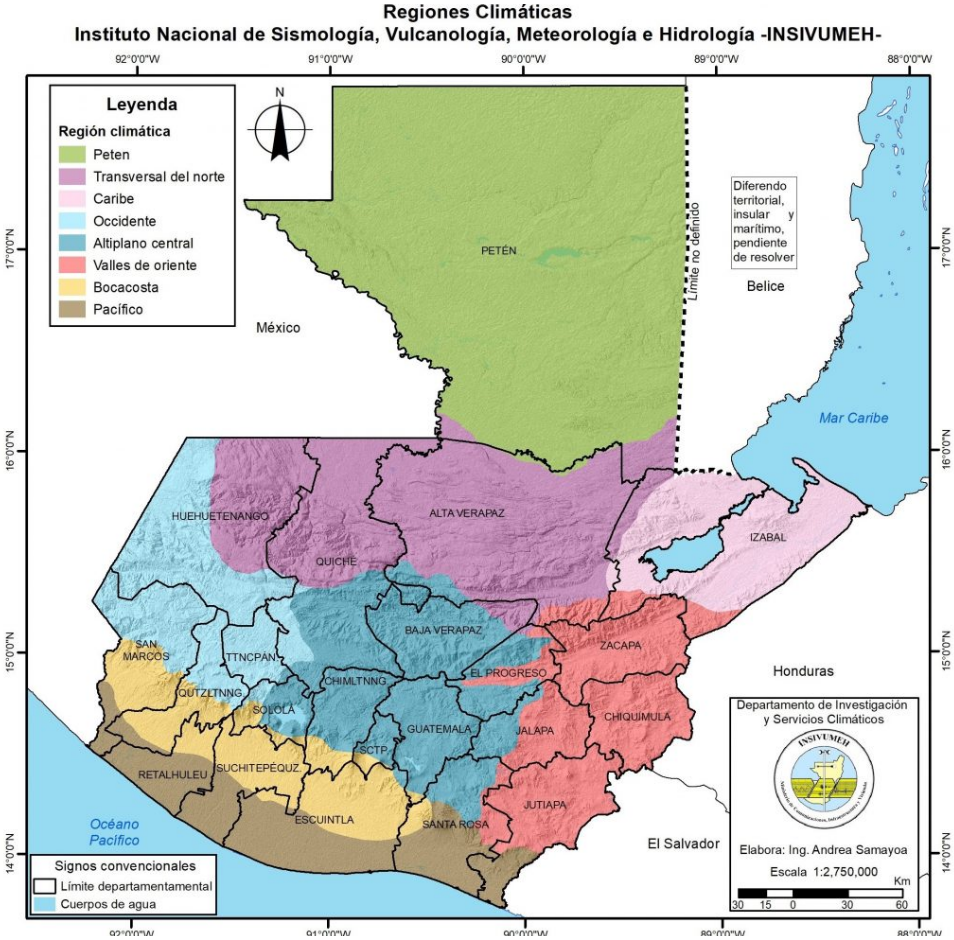

Figure 7. Climate Regions of Guatemala. Produced by the Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (2022).

The Maya lowlands are not the only low-lying areas of Guatemala. Much of the Pacific Coast consists of lands below 1,000 m in altitude (Biota S.A. and the Nature Conservancy 2014:Figure 2). Areas between 1,000 and 2,000 m asl make up a smaller portion, with the smallest portion of lands ranging from 2,000 to 3,000 m asl. These highest elevation areas are in the northeastern portion of the region, including volcanic mountains to the south of Lake Atitlán.

The volcanos of Guatemala are organized along a ridge of mountains that run northeast to southwest along the south-central portion of the country. However, the effects of volcanic activity and the impacts of these volcanoes on daily life are not limited to the central highlands. On January 18, 1902, a severe earthquake followed by the eruption of the Santa María volcano led to the destruction of homes and villages down to the lowest altitude areas of the San Marcos department (Anderson 1908; Eisen 1903). The volcanoes of Guatemala typically go several years between eruptions (Eisen 1903; see also Williams 1960).

Relationships with volcanoes hold special significance in the Mayan ritual canon as they are the places where ancestors dwell (Morgan 2002:191). From this vantage point, the ancestors can protect the second soul of a living person, which resides inside a non-human (e.g., animal, atmospheric) form (Pitarch 2012). Ancestor veneration is a central component of ancient Maya ceremonialism, with ancestors appearing in pictorial and figural representations that exist within the spaces of the living on Maya sites (Guernsey 2012, 2020; McAnany 2013). Orientation of the Central District of the La Blanca site with respect to the Volcano Tajamulco is just one example of how volcanoes and ancestors played a central role in ancient Mayan ceremonial life, even from afar.

Economically, volcanic areas served as key sources of obsidian for ancient inhabitants of the Pacific Coast. Obsidian, an igneous rock, is useful for producing blades including the prismatic blades that coincide with the emergence of social hierarchy on the Pacific coast (Jackson and Love 1991). Love and Jackson (1999) conducted comparative analyses of obsidian from the La Blanca site (900-500 BCE) and probable modern sources along the volcanic belt. Their studies identified that the obsidian used at La Blanca derives from the El Chayal, Ixtepeque, San Martín Jilotepeque, and Tajumulco sources located in the uplands (Figure 8). Although the remainder of this chapter will focus on Pacific lowland flora, Love and Jackson’s findings serve as a reminder that exchange relationships between the central uplands and Pacific lowlands are longstanding, dating back to at least the Archaic period (see Voorhies 1976).

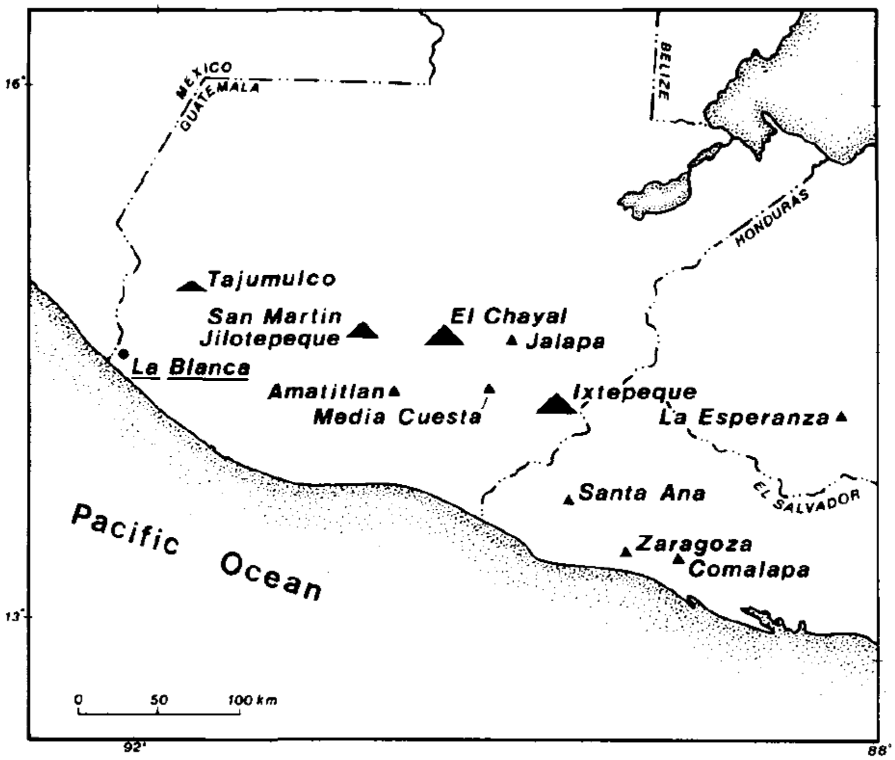

Figure 8. Obsidian sources in Guatemala. Adapted from Jackson and Love 1991.

Biomes and Land Management

The modern floristic composition of Guatemala is affected by not only the factors of rainfall, temperature, and elevation discussed previously, but also the development of industrialized agriculture. Small-scale agriculture has been the main food production strategy for most of Guatemala’s history, even before its designation as a country (Calderón et al. 2018). However, industrial agriculture has taken a dominant role in the past seventy years. The introduction of synthetic fertilizers into the Guatemalan highlands during the 1950s and 60s (Carey 2009:285) coincided with growing foreign investment into agricultural production in Guatemala. The United Fruit Company (now Chiquita Brands International) invested heavily in land to grow bananas for the American and European markets. Other companies followed suit, creating expansive plantations to grow coffee, sugarcane, maize, and other cash crops (Dosal 1993). In 1954, the Central Intelligence Agency of the United States funded an authoritarian coup of the democratically elected president, Jacobo Arbenz (Bernal 2020). Part of the motivation for U.S. involvement came from Arbenz's push to nationalize fruit plantations, lowering potential for foreign profits. Success of small-scale agriculture became further hampered by the decades long Guatemalan Civil War (1960-1996) involving the genocide of indigenous peoples across the country.

Initiatives to support small-scale agriculture have increased in recent years. Local farmers started the *Campesino a Campesino* (CAC) movement in the 1980s to promote exchange of agricultural innovations and knowledge between farmers, even across national borders (Altieri and Manuel Toledo 2011:601; Holt-Giménez 2006). However, efforts to increase the sustainability of local food systems and long-term resilience to climate change remain hampered by the landholding power of large multi-national corporations such as Dole and Chiquita (Siddiqui 1998). Although their food is produced mostly for export, these corporations persist through not only providing funding for farmers, but also jobs (especially for men) in rural areas of the country.

I argue that a legacy of industrialized agriculture has altered the native biomes of Guatemala, particularly on the Pacific coast. I begin by describing modern ecological conditions and then reflect on ways in which these conditions differ from our current understandings of environments during the pre-Columbian period and the Middle Preclassic more specifically.

Currently, Guatemala has twenty distinct forest cover zones (Figure 9). Broadleaf forest, or temperate rainforest, is the most expansive forest type with its destruction partially prevented by national and international conservation efforts. One of the emptiest parts of the forest cover map is the Pacific coast, for which most of the land is coded as “No Forest” (Figure 10). Red mangrove forests dot the edges of this coast, but most of the land is devoid of forest cover until reaching rubber tree groves in the piedmont. Agricultural fields, some affiliated with large corporations, are prevalent throughout these coastal areas. The predominance of agricultural fields, mostly growing crops desirable for export, raises questions about the environmental composition of the Pacific coast before the introduction of industrialized agriculture. What types of flora are native to the region? Do these plants signify more of a cleared or forested landscape? To answer these questions and more, I turn to environmental findings generated by ecologists and archaeologists.

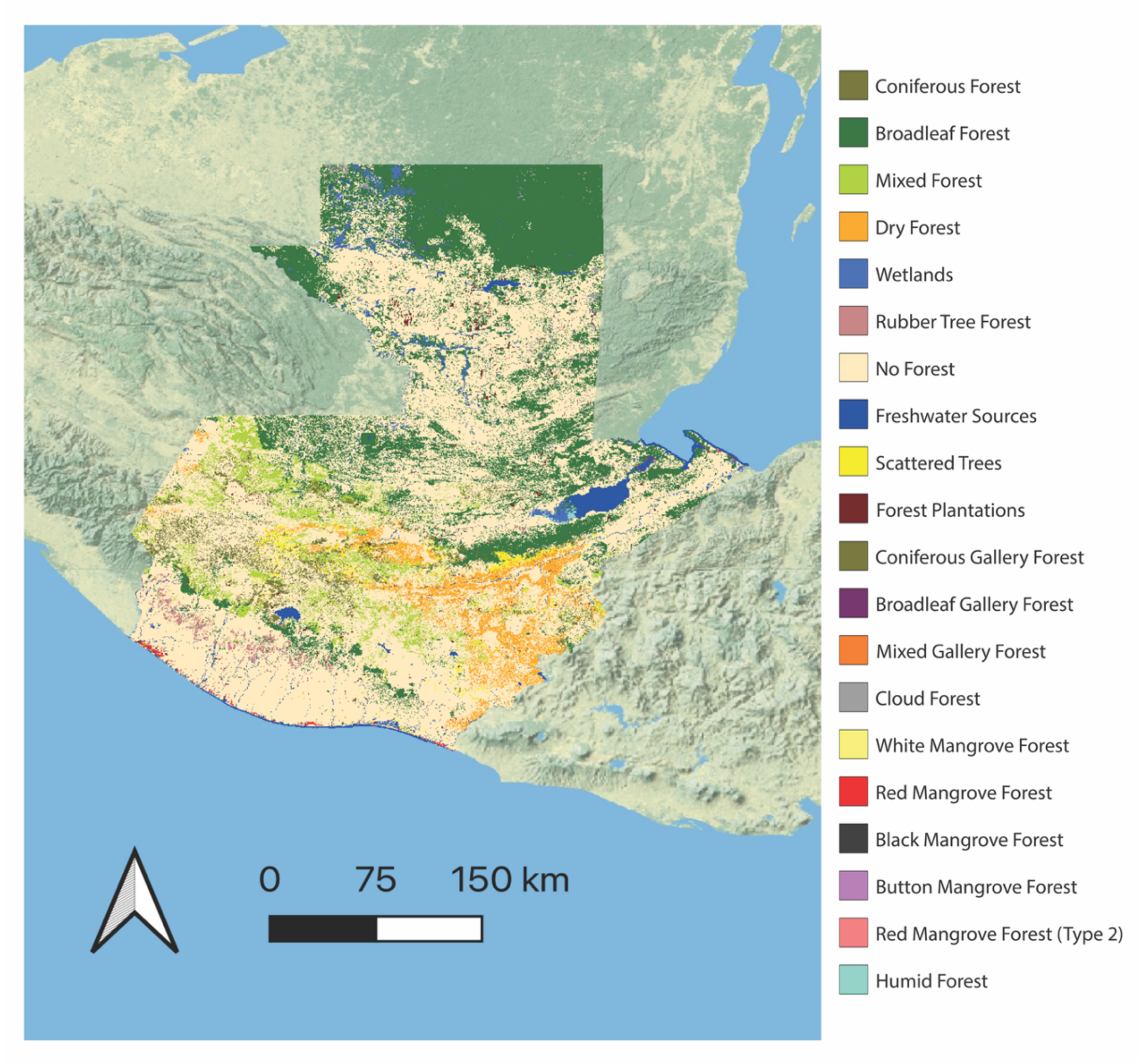

Figure 9. Map of ecological zones in Guatemala as of 2012. Ecological data is derived from the Guatemala Forest Cover database published by Global Forest Watch (2015) with a Creative Commons license.

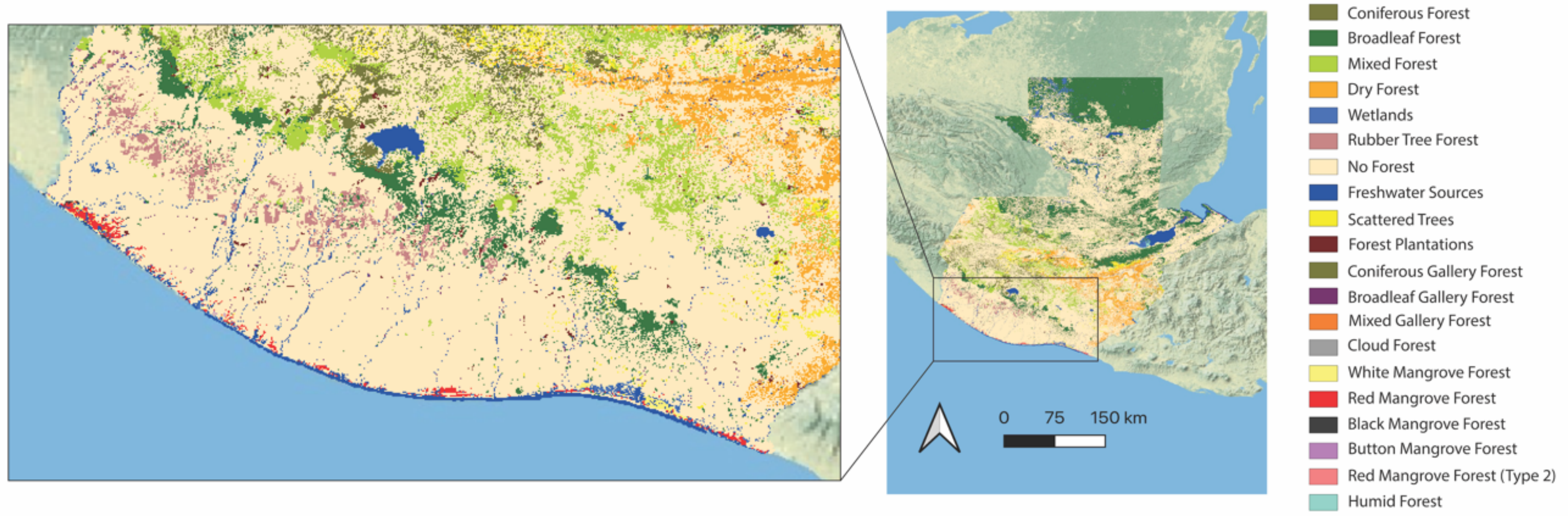

Figure 10. Map of ecological zones on the Pacific Coast of Guatemala as of 2012. Ecological data is derived from the Guatemala Forest Cover database published by Global Forest Watch (2015) with a Creative Commons license.

Approximating Ecological Conditions During the Middle Preclassic

Environmental Surveys

Assessment of forest composition provides a good starting place for reconstructing the landscape of the Pacific Coast prior to the introduction of industrialized agriculture. Although only a small portion of wild vegetation remains (see Figure 10), satellite imagery and on-the-ground field assessments of soil moisture have allowed the Guatemalan Instituto Nacional de Bosques (2001) to map forest ranges according to the Holdridge (1947, 1967) life zone system. The resulting ranges, presented in Figure 11, demonstrate that a narrow band of dry forests runs along the Pacific coast of Guatemala. This finding is groundbreaking as it demonstrates that this area is not naturally characterized by cleared landscapes. Instead, patches of mangroves along the coast are abutted by dry forest ranges that become increasingly more humid as elevation rises.

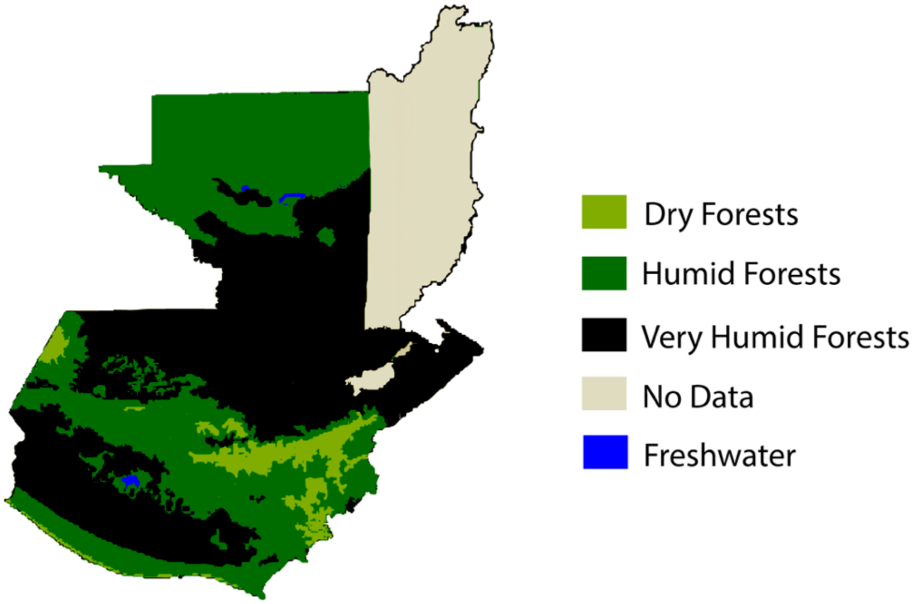

Figure 11. Map of Native Forest Ranges of Guatemala. Adapted from data published by the Guatemalan Instituto Nacional de Bosques (2001:Figure 5).

Dry tropical forest constitutes the second largest biome in Guatemala in terms of area (Instituto de Investigación y Proyección sobre Ambiente Natural y Sociedad (IARNA) 2018:50). Over two million hectares, or 19.21%, of Guatemalan land is composed of dry forests (IARNA 2018:50). This forest type is at especially high risk for further destruction. Although dry forests represent 15.9% of land in Mesoamerica, only 3.3% of this land had protected status in 2010 (DeClerck et al. 2010).

Ecological surveys and curated collection inventories document many plant species native to the dry forests of Pacific coast. I organized these data by location and elevation, resulting in a list of taxa that are native to <1000 m elevation areas of the San Marcos/Retalhuleu departments and the Pacific coast, if metadata did not specify department (Appendix A). Plants range from tall trees that produce edible fruits (e.g., coyol [*Acrocomia Mexicana*]), to shrubs (e.g., *chiltepe* [*Capsicum annuum* var. *glabriusculum*]), and herbs with uses as food and/or medicine (e.g., *kekeshte* [*Xanthosoma robustum*]). Indeed, the soils of the Pacific coast lowlands of Guatemala are among the most fertile in the country (Villar Anléu 2008:25).

Most of the biodiversity once recorded for the dry forests of the Pacific coast is unfortunately absent today, with Villar Anléu (2008:49) describing the introduction of industrialized agriculture as having transformed the region into "*una típica sabana* [a typical savannah]"; climate models designed by Imbach and colleagues (2010) similarly classify the Pacific coastal plain of Guatemala as having a Savanna Dry Tropical forest type. Cash crops historically grown here, including cotton, sugar cane, plantains, and bananas, require clearance of vast tracts of land that have only left isolated trees behind (Villar Anléu 2008:49). Sharer and Traxler (2006:32) echo the sentiment that current trees are merely a "relic" of what once was, with native cultivars playing a much smaller role in local economies than agricultural plantation crops (Bukasov 1963:41). For this reason, it is important to look to descriptions of ecologies predating the mid-twentieth century boom in foreign agricultural investment into Guatemala.

Historical and Archaeological Insights

Historical records describing the plants native to the San Marcos coastal plain (<1000 m) illustrate a landscape that differs markedly from the relative savannah of today. The catastrophic eruption of the Santa María volcano on October 24, 1902 provided an impetus for documenting the ecology of the Pacific coast in the wake of the disaster. Sediment from the eruption raised the heights of riverbeds across the Pacific coastal plain and beyond, causing water to cover some trees up to their crowns (Kuenzi et al. 1979; Schneckenberger 1952). Other plants remained visible. In his record of the landscape following the 1902 eruption, Schneckenberger (1952) recognized several native trees: *chichicaste* (*Chichicaste grandis*), *guamuche* (*Pithecellobium dulce*), *hule* (*Castilla elastica*), *guayacán* (*Guaiacum sanctum*), *pino cimarrón* (*Pinus* spp.), *huicicil* (species unknown), *laurel negro* (*Cordia megalantha*), and *manglares* [mangroves] (possibly *Rhizophora mangle*, *Laguncularia racemosa*, *Avicennia germinans*, and/or *Conocarpus erectus* (Merce 2015)). His observations are consistent with the interpretation of the region as offering access to coastal wetland and, on the opposite end of the spectrum, more drought tolerant species.

Archaeological studies help to identify environmental changes in the Río Naranjo region that occurred prior to, during, and following the Middle Preclassic period. Although modern and historical botanical surveys provide greater taxonomic detail, they are less specific to the period of study. Research by Neff and colleagues (2006) analyzes long-term changes in climate and forest cover on the Pacific coast of Guatemala through elemental analysis of sediment cores, pollen identification, and calculation of a phytolith aridity index (Chloridoid grasses / (Chloridoid + Panicoid grasses)). These researchers found that a drying interval during the Early Preclassic gave way to wetter conditions by 2,800 cal. BP (~850 BCE; Neff et al. 2006:397). Interestingly, stability in these wetter conditions coincided with the intensification of maize agriculture on the Pacific coast during the Middle Preclassic (Love 1999). However, the sediment core (MAN015) informing results presented by Neff and colleagues (2006) did not come from a locale of major habitation during this period. Thus, their indications of a growth in forest species during the Middle Preclassic do not help to inform our understanding of the extent of deforestation at the La Blanca polity. The team's data indicate, however, that wet conditions persisted until a slight disruption between 2,600 and 2,400 cal. BP (~650-450 BCE), coinciding with the drop in population density at La Blanca by around 500 BCE. This drier interval offers one possible explanation for the city's decline (Neff et al. 2006).

Humans also appear to have made meaningful changes to biomes adjacent to the La Blanca polity. Although the polity's reach did not extend into the mangrove-estuary zones along the coast, they may have nevertheless contributed to its maintenance. Neff and colleagues (2018) conducted survey and excavations of coastal mangroves to the south of Izapa. The research team found evidence for a shift in anthropogenic uses of the mangroves by the end of the Early Preclassic period. Whereas inhabitants previously used the groves for subsistence and salt production, evidence for clearance decreases over the Early Preclassic, demonstrated by an increase in mangrove pollen by around 1000-800 BCE. By the Middle

Preclassic period, this area appears to have transitioned to being exclusively used for salt production with increased demand potentially coming from the burgeoning city of La Blanca. Another possibility presented by the researchers is that locals could have overexploited mangroves during the Early Preclassic period, leading to a need to allow for new growth in the subsequent era. The environmental context gleaned from extant records and studies provides an important backdrop for exploring what ancient inhabitants of the Pacific Coast did with subsistence plants following acquisition. I explore this topic through the investigation of foodways.

Pacific Coast and Maya Foodways

In the context of the current study, foodways (Scarry and Reitz 2005; Welch and Scarry 1995) refers to the various activities through which people processed, cooked, and disposed of food in their everyday lives. Much of our ethnographic evidence for these activities comes from the northern Maya lowlands, with far fewer records for the Pacific Coast. The relative dearth of the ethnographic record for the Pacific Coast is partly a consequence of the Guatemalan Civil War (November 13, 1960-December 29, 1996). De facto President Efrain Ríos Montt's (1982-1983) scorched-earth policy resulted in the genocide and victimization of indigenous Guatemalans during the war. Identifying or presenting as indigenous led to entire families being kidnapped, imprisoned, or murdered. Divisions within indigenous communities resulting from the war still threaten to pull them apart, while hesitancy in personally declaring indigenous affiliation persists (Ybarra 2012). It is for these reasons and more that the municipality of La Blanca does not fit the mold of the stereotypical "anthropologist's paradise," where indigenous people continue to engage in traditional practices in much the same way that they have for hundreds of years. Few people in the La Blanca Municipality identify as Maya today (0.553% according to the 2018 Census, see Instituto Nacional de Estadística Guatemala 2022).

Gaining an ethnographic perspective on plant use on the Pacific Coast requires looking farther afield to more well-recorded regions like the northern Maya lowlands. Whenever possible, I identify the regional source of each line of evidence. In this section, I provide a general summary of Maya plant use practices to set a foundation for understanding archaeological results from La Blanca. In integrating accounts from areas outside of the Pacific Coast, my intention is to present a more thorough literature review without forging direct analogies between practices that refer to a range of different time periods, places, and societies.

Collection of Wild and Domesticated Plants

Wild plant collection among the Maya involved not only gathering of resources growing without intervention, but also cultivation of these resources to encourage growth for different purposes. For example, members of the palm family (Arecaceae) have edible fruits and their wood is also used in construction (McKillop 1996). Virtually every part of the palm plant has evidence of anthropogenic uses (Balick 1984; Lentz 1993). As part of Fedick's (2017) extensive and ongoing study of Maya food plants, he has identified 215 trees, 106 shrubs, 104 herbs, 55 vines, 13 lianas (long-stemmed woody vines), 11 succulents, and five grasses with subsistence uses. Although not all these plants are wild, the range of plant types in this list illustrates that Maya peoples found food in forests, grasslands, and disturbed areas.

Tubers, rhizomes, and other underground storage organs are historically underrated Maya food sources. Plants that produce edible tubers and root structures known to have been used by inhabitants of the northern Maya lowlands include but are not limited to species of manioc (*Manihot esculenta* and *M. utilissima*), *malanga* (*Xanthosoma violaceum* and *X. yucatanense*), sweet potato (*Ipomoea batatas* and *I. dentata*), yam (*Dioscorea bartlettii, D. convolvulacea, D. polygonoides*, and *D. trifida*), arrowroot (*Maranta arundinacea*), canna (*Canna indica* and *C. tuerckheimii*), *lerén* (*Calathea allouia*), and wild *Calathea* (*Calathea* sp.; Fedick 2017; Morell-Hart et al. 2021). All the above genera except for *Canna* are native to southwestern Guatemala (see Appendix A). Wild potatoes (*Solanum* spp.) also grow in the Piedmont of Guatemala (see Figure 7 and Appendix A), adjacent to the Pacific Coastal Plain (Spooner et al. 1998). Although different plants vary in their root structures, I will collectively be referring to this category as “tubers” for the sake of simplicity.

Tubers have played an important role in feeding both modern and ancient societies of Central America. In his study of *Calathea* use in southwestern Guatemala, Murcia Tello (2015:3) notes that tubers are eaten by modern people either alone or with other foods like beans, *recado* (Mayan curry), or *caldo* (a thin soup with a meat-based broth). Fedick (2017:166-167) notes that tubers besides *Calathea*—manioc, arrowroot, and canna—have a history of being ground and then dried by Maya peoples to aid in storage and transport. Certain root crops such as *malanga* are even prized by indigenous residents of the Pacific Coast (McBryde 1947:140).

Archaeological case studies trace the use of tubers among the Maya into the ancient past (Cagnato and Ponce 2017; Chen et al. 2022; Morell-Hart et al. 2021; Sheets et al. 2012; Simms 2014). All contexts, however, date to the Classic period (~250-900 CE). Some of the strongest evidence for the use of manioc as a staple crop comes from the site of Cerén in El Salvador. Here, excavations by Sheets and colleagues (2012) uncovered evidence for sloping, elevated beds, with tubers and stalks being preserved on these beds under Loma Caldera eruption debris. Cagnato and Ponce (2017) also detected starch granules consistent with domesticated manioc in residues from grinding stones and ceramic sherds at the Late to Terminal Classic period site of La Corona in northwestern Petén, Guatemala. In contrast with earlier conceptions of tubers as a last resort resource, both previously mentioned studies provide strong evidence that the Maya chose to adopt tubers as staple crops. There is also evidence to suggest that root crops played an important role in beverages among the Maya. Chen and colleagues (2022) identified starch granules of manioc, unidentified tubers, and maize in a large polychrome cylinder from the Copan site in Honduras (Classic period), with the starches showing evidence of grinding and fermentation consistent with their use in prepared beverages. Use of other underground storage organs besides manioc has also been documented. For example, Simms (2014) found arrowroot starch granules on grinding tools from the Terminal Classic period site of Escalera al Cielo. These starches appeared in such abundance that she proposes they functioned as a staple crop. Tubers have even been identified in areas situated at the crossroads of different Maya regions, like northwestern Honduras. In their analysis of paleoethnobotanical data from several sites, Morell-Hart and colleagues (2021) document the identification of *lerén*, sweet potato, and manioc starch granules in artifact residues from Classic-period contexts.

Root crops had the potential to yield unique benefits for Mesoamerican farmers facing new challenges and uncertain conditions. Fedick and Santiago (2022) note that tubers of Central America are particularly drought tolerant. Manioc, malanga, and sweet potato can all survive short-term droughts, and manioc can persist through extreme droughts lasting several years in duration (Fedick and Santiago 2022). The same three root vegetables—manioc, malanga, and sweet potato—can also help to ensure food security. If left in the ground, each plant will continue to grow and produce (Drucker and Fox 1982). Maturation rates vary, with sweet potato producing at three months, manioc in eight months, and malanga in two to three years (Drucker and Fox 1982). Once started, manioc could produce indefinitely, as Drucker and Fox (1982:183) note:

> If cuttings are replanted each time the daily few plants are dug (and a little fertilizer, in the form of mulch, etc., is added to restore the soil), the plot will continually produce. Drucker once calculated that 0.5 hectare, thus handled, would continue to cycle indefinitely, meeting a fair-sized family's starch needs.

This infinite cycling would likely not be possible for all root crops as deterioration rates vary among species (Drucker and Fox 1982). Nevertheless, collection of wild roots and planting of domesticated species offers the prospect of serial harvesting (i.e., staggered harvests), a strategy for coping with food insecurity that also distributes labor costs across a longer harvesting season (Galt 1976:102; see also Melton 2018).

Field and Forest Management

Several models have been proposed to characterize how Maya peoples managed their agricultural fields; most archaeological discussions have focused on the Classic period. Prior to the 1970’s, slash-and-burn or swidden farming served as the primary model based on ethnographic observations of farming by Maya peoples of the Chiapas and the Yucatán

(Robin 2006:410). Robin (2006) notes that by the 1970s, a greater body of evidence for agricultural intensification among the Classic Maya caused narratives to diverge from this central model. Since then, an array of models has been presented, each of which proposes a different extent of anthropogenic landscape change (Lentz et al. 2015).

Some models of Maya agriculture include only one type of landscape management, such as the *milpa* (or *kool*), *conuco* (or *pach pakal*), chinampa, and fixed-plot models. *Milpa* agriculture typically involves growing maize, beans, and squash in upland soils, with fallow periods in between planting episodes (Salazar et al. 2012). Ethnographic research conducted in Xocén, Yucatán, Mexico by Salazar and colleagues (2012) reveals that the *milpa* is combined with *conuco*, another management system. *Conuco* involves cultivating root crops such as manioc, sweet potato, *malanga*, arrowroot, and jicama (*Pachyrhizus erosus*) in flatter soils of the plains (Salazar et al. 2012). Chinampas, or floating gardens, have a long-term history of use in the Basin of Mexico, but Siemens (1996) has argued that they are less applicable to understanding Maya wetland agriculture than once thought. The dams that chinampas depend on to maintain water levels are absent from raised-field systems in the lowlands, complicating the year-round cultivation that is a characteristic of the chinampa system (Siemens 1996). Yet, instead of regulating seasonal changes in water levels, Maya people more likely took advantage of these fluctuations to grow more wetland species at wetter parts of the year (Siemens 1996). One can imagine that this strategy would have been particularly effective in an area like La Blanca, with its annual wet-dry cycle and scattered lagunetas in the present day. Reuse of fields with short fallow periods characterizes the fixed-plot model presented by Lentz and colleagues (2014) to describe management strategies at Late Classic Period Tikal in Petén, Guatemala. However, ethnographic research conducted by Robin (2006) among the Lacondon Maya of Chiapas indicates that even when fixed plots are used, there is no evidence of an infield-outfield system of agricultural field arrangement.

Agriculture, however, is not the only means by which Maya peoples made anthropogenic changes to their landscapes that supported food procurement. Fedick (1996) argues that Maya peoples managed the mosaic of resources at their disposal, including agricultural and foraged foods from a range of disturbed to forested landscapes. Lentz and colleagues (2015) have more recently used archaeological, ecological, ethnographic, and geographic datasets to build on this foundation by presenting a multicomponent land use model for Classic-period Tikal in Guatemala and Cerén in El Salvador. Their model conceives of the Classic Maya as having "managed forests, dooryard gardens and orchards, extensive agricultural plots, and zones of intensive agriculture irrigated from a series of reservoirs" (Lentz et al. 2015:178); note that reservoir irrigation would not have been possible or necessary in all areas of Mesoamerica due to differences in rainfall. Earlier, Pyburn (1998:268) proposed that, instead of any single agricultural system, a combination approach is most realistic:

> No single system will ever characterize all ancient Maya subsistence, even at a particular time, much less for 2000 years. Farmers can practice some swidden, some canalization of fields, some fertilization, some tree and root cropping, and some full-time craft production, all within the same household.

It is this diversification that is essential to the maintenance of food security in many Maya societies. Pyburn (1996) even argues that a decrease in diversification in context with growing agricultural intensification contributed to the collapse of Classic Maya societies in the Lowlands.

One of the most widely recognized ways in which Maya people diversified their landscape use is through the creation and maintenance of agroforestry systems. Although one of the possible causes historically put forward for the collapse of Classic Maya societies is mismanagement of forests through deforestation, ancient Maya people are now considered to have carefully and intentionally managed their forests (Fedick 2010). Even when using slash-and-burn methods, modern Maya peoples of Petén keep sapote (*Manilkara* sp., *Pouteria* sp.) trees but cut other species with less economic value when clearing land for fields (Lundell 1937). Ethnographic research among the Maya of Belize published by Levasseur and Olivier (2000) identifies that the *milpa* system (agriculture), cacao (*Theobroma cacao*) tree management, and home gardens are used in combination to meet the subsistence needs of households and communities.

Gender

A final exercise to consider when seeking to understand Maya foodways is asking who was responsible for which part of the process. Rather than conceiving of Maya farmers as a homogenous category, it is more productive to consider how different genders fit into the broader picture of subsistence procurement. Some aspects of the gendered experience that can be considered archaeologically and ethnographically are identification of which genders performed what tasks, use of private versus public space, and relative participation in production versus consumption (Hendon 2006). Joyce (1992) argues that Classic Maya sculpture depicts men and women as being linked in a system of complementary dualism.

Instead of one gender being seen as more prestigious than the other, both played different but equally valuable roles in Maya society. Ethnographic research by O’Connor (2010) in Quintana Roo, Mexico supports Joyce’s (1992) argument, attesting that the complementary dualism between men and women reinforces the interdependence between households; however, it is important to note that this archetype represents a tidy conception of relationships between men and women and the reality is likely more complex.

Considering the relationship between gender and food production elaborates how the different roles of Maya men and women are performed in aspects of daily life. Production of food and textiles are key aspects of women’s identity, while men typically tend to be farmers, hunters, and warriors (Hendon 1997). Yet Hendon’s (1997) study of gendered use of space at the Classic period site of Copan found that domestic and public space was not restricted by gender. A separate study by Robin (2006) of archaeological data from the Chan Nòohol site in Belize reached the same conclusion. Certain activities are also shared across genders. Ethnographic research among the Lacondon Maya in Chiapas indicates that planting, tending, and harvesting agricultural products is a collaborative effort between men and women (Helmuth 1977:426; Robin 2006). Closer to the regional and temporal context of La Blanca is Guernsey’s (2016) analysis of supernatural beings linked to maize in Late Preclassic iconography from Izapa. She argues that “maize god” imagery may in fact not represent a man or even one deity, with aspects of the deity’s identity being tailored to support local politico-religious agendas (Guernsey 2016:344). However, men are clearly depicted as rulers (and thus members of the elite) in Izapan style iconography (Guernsey 2006:115). These rulers would have played important roles as middlemen between the heavens and the earth, a role that became cemented through public rituals carried out in various parts of the Izapa and El Ujuxte polities during the Late Preclassic (Love 2016a; Rosenswig and López-Torrijos 2018).

Human Ecosystems of the Middle Preclassic Pacific Coast: Summarizing the Evidence and Missing Pieces

The purpose of this chapter is not to comprehensively summarize the relationship between the Maya and their environment. Rather, my goal is to provide readers with a mixture of localized and broader context with which to approximate the human ecosystem of the Pacific coast of Guatemala during the Middle Preclassic period to the best of our current knowledge. In the ecological literature, a human ecosystem can be defined at virtually any spatial scale of analysis, but the same basic components of critical resources (natural, socioeconomic, cultural) and a human social system apply to all cases (Machlis et al. 1997). I have outlined the natural resources native to the study region (the Río Naranjo drainage), while also acknowledging the deleterious impact that industrialized agriculture has had on many of these plant populations. I have also pieced together the results of studies conducted within the Pacific Coast region and the northern Maya lowlands to provide a fuller perspective on how ancient inhabitants of the Pacific Coast may have used the plants at their disposal. I propose that gender is important to consider in reconstructing human ecosystems, especially as Maya people tend to have more complementary gender roles than Western societies. Both Maya men and women could be farmers, with women steering food production.

Climate change has presented unique challenges for the future of floristic diversity in the Río Naranjo area. The biodiversity crisis in Guatemala is currently so dire that solutions often focus on mitigating damage rather than financing efforts to cultivate native species threatened by increased land clearance for agriculture (EPIQ 2003). Fragmented habitats, or habitat islands, like those on the Pacific coast are particularly vulnerable to the effects of climate change as natural range expansion is not an available adaptive strategy if surrounding land is regularly cleared (Vreugdenhil et al. 2002:33). Forging linkages between habitats, and avoiding habitat islands, is presented by Vreugdenhil and colleagues (2002:33) as one of the best possible strategies for mitigating the impacts of climate change in Mesoamerica. More diverse and expansive forests connected to different nearby habitats (e.g., other forest types, estuaries) have better resilience to climate change than their less diverse, expansive, and connected counterparts (Noss 2001). Archaeological analysis of plant material is uniquely positioned to provide historical insights into local ecology and anthropogenic plant management on the Pacific Coast that could potentially help to correct for habitat islands. In this region, efforts at environmental protection and restoration face a situation where current conditions better represent agro-industrial rather than native ecosystems. Before offering possible solutions for enriching climate change resilience on the Pacific coast, I present the methods used by the current study to collect and analyze archaeobotanical remains.

CHAPTER 4: LA BLANCA AS A CITY IN MOTION: ANALYZING THE DATASETS

Examination of botanical remains for the current study involved a three-pronged approach. Microbotanical analysis involved the identification of starch granules and phytoliths recovered from artifact residues. Soil samples were analyzed for carbonized macrobotanical remains. Lastly, a selected portion of these remains were submitted for radiocarbon dating. This chapter discusses the procedures used to collect and analyze these various datasets. I end with a discussion of the Exploratory Data Analysis approach employed in the statistical analyses (Chapters 5-8).

Field and Laboratory Procedures

Collection

All botanical samples were collected during fieldwork conducted at La Blanca between 2016 and 2017. Sample collection was a collaborative process; although I designed microbotanical and macrobotanical recovery methods prior to fieldwork, I discussed these methods with all members of the excavation crew prior to breaking ground. This consistent understanding allowed samples to be collected from the field under appropriate circumstances (e.g., upon encountering features or grinding equipment) and with appropriate sanitation measures (e.g., removal of artifacts for microbotanical analysis with a clean trowel that had been washed in water and subsequently dried, no eating within or near units).

Microbotanical Samples. Stringent procedures were applied during the collection of starch and phytolith samples to limit the potential for contamination. As each residue sample was subject to both starch and phytolith analysis (see Extraction section below), strict collection protocols required for limiting starch contamination had to be applied universally. No food was allowed near or within excavation units. Each artifact selected for microbotanical analysis was pedestalled during excavation and then removed using a clean trowel washed in water. All personnel were instructed to make minimal contact with the artifact using the cleaned trowel, quickly double bagging the artifact and adhering soil in plastic. The sample bag was immediately closed to limit the potential of airborne starch contamination (see Laurence et al. 2011) and transported to the microbotanical laboratory at the field house in twice-daily intervals (during lunch and at the end of the workday). After arrival, each bag was stored indoors away from sunlight and processed within a few days to prevent moisture in the soil and high interior temperatures leading to starch gelatinization in the bag (Li et al. 2004). Features with artifacts sampled for microbotanical remains are summarized in Table 1.

Table 1. Features Containing Artifacts Sampled for Microbotanical Remains.

Object	Rasgo	Op	Sub	Description	Period	Phase/Subphase
29 (131)	97	34	2	Ceramic concentration	Middle Preclassic	Conchas B or C
42 (145), 44 (139), 49	240	50	3	Intrusive pit	Middle Preclassic	Conchas C
47, 57	266	57	1	Trash pit	Middle Preclassic	Conchas D[a]
50	255	55	4	Trash pit	Middle Preclassic	Conchas C or Conchas D
56	254	50	3	Floor	Middle Preclassic	Conchas C
58	258	55	2	Trash pit	Middle Preclassic	Conchas C
61, 62, 63, 64	278	57	5	Trash pit	Middle Preclassic	Conchas D
70, 73	269	57	3	Artifact concentration	Early part of Late Preclassic[a]	Conchas mixed with LPC[a]
71	271	57	5	Trash deposit	Middle Preclassic	Conchas D
75, 76, 79, 80, 82, 85, 86	295	64	1	Pit	Middle Preclassic	Conchas D
78	291	64	3	Pit	Middle Preclassic[a]	Ceramics not analyzed
84	297	65	2	Ceramic/lithic concentration	Late Classic	-
87	299	65	5	Offering (bowl with top)	Late Classic	-
97	303	66	1	Burnt floor	Middle Preclassic	Conchas B or C
100	306	66	4	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)
106, 107	308	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)
108	312	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)
110	314	66	5	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)
111	325	67	3	Ceramic concentration	Middle Preclassic	Conchas D
112	324	66	3	Lithic concentration	Middle Preclassic	Conchas (subphase unspecified)
113	326	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)
114	335	37	8	Floor	Middle Preclassic[a]	Ceramics not analyzed

[a] Hypothesized based on comparisons with levels of same Op in similar depth ranges.

A small portion of the overall sample consisted of washed artifacts excavated prior to the 2016 field season (Table 2). Artifacts washed in shared basins are susceptible to contamination from starches or phytoliths that were once attached to other artifacts. However, it is still possible to derive meaningful results from washed and curated artifacts if potential sources of contamination are carefully considered (Barton 2007; Ciofalo et al. 2020). Barton's (2007) study of starch residues on museum artifacts from the tropics curated in the Australian Museum (Sydney, Australia) and the Pitt Rivers Museum (Oxford, England) revealed a direct relationship between taxa of starch granules recovered from each artifact and its recorded function(s). In a more recent study, Louderback and colleagues (2015) collected starches from ground stone tools that were subject to collection immediately following excavation, collection with a dry brush following washing and curation, and collection with a sonicator following washing and curation. Although each treatment method yielded progressively fewer starches, the authors considered environmental contamination to be a "minor or non-existent problem" (Louderback et al. 2015:538) based on comparisons of starches in sediment versus sonicated samples and lack of starches on plastic bags used in artifact storage.

Table 2. Artifacts Sampled for Microbotanical Remains

Object	Operation	SubOperation	Nivel	Elemento	Rasgo	Artifact Description	Date Collected	Notes
4	49	2	-	-	217	Mano	5-Feb-16	N 6.91; W 7.19
6	50	1	-	-	226	Grinding stone	22-Feb-16	-
9	50	1	-	-	226	Sherd	22-Feb-16	-
10	50	2	-	-	227	Sherd	23-Feb-16	Found interior up; 40 S of N wall; 150 E
11	50	2	-	-	227	Metate	23-Feb-16	10 S of N wall; 142 E
12	50	2	-	-	227	Mortar	23-Feb-16	Found worked surface down; 25 S of N wall; 140 E
13	50	1	-	-	240	Sherd	1-Mar-16	#1 in profile drawing; from complete or nearly complete vessel; soil inside of vessel taken as flotation sample
18	51	1	16	-	232	Sherd	25-Feb-16	Found interior up; base of a vessel found on top of a house floor; one sherd from the vessel selected for analysis
19	51	3	10	-		Metate	2-Mar-16	Found in flotation sample; exposed to very little water; soil still adhering to artifact
21	53	1	10	-		Metate	8-Mar-16	-
23	53	4	-	-	244	Grinding stone	10-Mar-16	-
25[a]	37	2	11	-	-	Human face vessel	1990	Artefactoa 184; SM.90.37.2-11-184; washed and labeled (nail polish and white pen) before processing; sed 2 and 3 only
26 (143)[a]	32	3	5	-	-	Jaguar face vessel	1990	Artefactoa 31; SM.90.32-3-5-31; washed and labeled (nail polish and white pen) before processing; sed 2 and 3 only
27 (137)[a]	32	4	16	-	-	Jaguar face vessel	1990	Artefactoa 52; SM.90.32-4-16-52; washed and labeled (nail polish and white pen) before processing; sed 2 and 3 only
28[a]	32	2	8	-	-	Human face vessel	1990	Artefactoa 22; SM.90.32-2-8-22; washed and labeled (nail polish and white pen) before processing; sed 2 and 3 only
29 (131)[a]	34	2	-	-	97	Human face vessel	1990	Artefactoa 7; SM.90.34.2.R97.7; washed and labeled (using nail polish and white pen) before processing; sed 2 and 3 only
30	55	4	8	-		Metate	17-Mar-16	-
34	55	3	8	-		Metate	17-Mar-16	Sample from 2 fragments of the same metate, broken during excavation
38	55	4	-	-	249	Grinding stone	21-Mar-16	-
41	50	3	-	-	240K	Sherd	24-Mar-16	Nearly complete jar; vessel #1 keyed to drawing; depth = 1.95 m
42 (145)	50	3	-	-	240K	Rim sherd	24-Mar-16	Rim sherd from lip of a neckless jar; depth = 1.95-2.05 m
43	50	3	-	-	240K	Mortar	24-Mar-16	Fragment of a bowl mortar; depth = 1.95-2.05 m
44 (139)	50	3	-	-	240P	Sherd	24-Mar-16	Fragment of a very large olla; dpeth = 2.05-2.?
45	55	3/5	-	-	251A	Metate	24-Mar-16	Entire metate; depth = 1.16-1.22 m
46	55	3/5	-	-	251A	Mano	24-Mar-16	Entire mano; depth = 1.16-1.22 m
47	57	1	-	-	266A	Plate rim sherd	14-Apr-16	-
48	57	1	-	-	266A	Flaring rim jar sherd	14-Apr-16	-
49	50	3	-	-	240X	Stone ball	n.d.	-
50	55	4	-	-	255D	Bowl rim/base	29-Mar-16	-
52	50	3	-	-	240P	Vessel base	28-Mar-16	Associated soil sample
56	50	3	-	-	254	Stone ball	23-Mar-16	147bd

Object	Operation	SubOperation	Nivel	Elemento	Rasgo	Artifact Description	Date Collected	Notes
57	57	1	-	-	266	Vessel base	14-Apr-16	1.40-1.50 m; associated soil sample
58	55	2	-	-	258	Vessel rim/side portion	29-Mar-16	1.35-1.40 m
59	56	3	-	-	263	Mano	14-Apr-16	-
61	57	5	-	-	278	Mano	18-Feb-17	Depth = 179; N: 15, W: 11
62	57	5	-	-	278	Grinding stone	17-Feb-17	Depth = 169; N: 70, E: 55
63	57	5	-	-	278	Vessel rim/side portion	17-Feb-17	Depth = 170; S: 22, E: 32
64	57	5	-	-	278	Rim sherd	17-Feb-17	Depth = 168; S: 0, W: 112
66	57	3	9	B	-	Vessel rim/side portion	8-Feb-17	Depth = 130; N: 1.74 m, E: 0.56 m
69	57	3	9	B	-	Figurine head	8-Feb-17	Depth = 128; N: 195, E: 38
70	57	3	-	-	269E	Rim sherd	7-Feb-17	Depth = 100-110
71	57	5	-	-	271I	Vessel rim/side portion	14-Feb-17	Depth = 155; N: 150, E: 160; Artifact #1 in drawing
73	57	3	-	-	269	Figurine head	4-Feb-17	Depth = 85; X: 28, Y: 165
75	64	1	-	-	295B	Grater bowl	15-Mar-17	Depth = 280-290
76	64	1	-	-	295B	Vessel base	15-Mar-17	Depth = 280-290
77	64	3	-	-	291A	Vessel rim/side portion	9-Mar-17	Depth = 224.5; N: 170, E: 140; Artifact #2 in drawing
78	64	3	-	-	291A	Vessel base	9-Mar-17	Depth = 215.5; N: 176, E: 150; Artifact # 1 in drawing
79	64	3	-	-	295	Vessel base	14-Mar-17	Depth = 224.5; N: 170, E: 140; Artifact #2 in drawing
80	64	1	-	-	295E	Complete vessel	21-Mar-17	Depth = 310-320; pulled from S Profile; N: 0, W:106
82	64	1	-	-	295C	Grinding stone	16-Mar-17	Depth = 290-300
84	65	2	-	-	297	Grinding stone	25-Mar-17	Depth = 79; N: 158, W: 56
85	64	1	-	-	295B	Grinding stone	15-Mar-17	Depth = 280-290
86	64	1	-	-	295C	Grinding stone	16-Mar-17	Depth = 290-300
87	65	5	-	-	299	Vessel rim/side portion	27-Mar-17	Depth = 44
88	66	1	-	-	300	Vessel base	27-Mar-17	Depth = 80-90
89	66	1	9	-	-	Grater bowl	27-Mar-17	Depth = 80-90
90	66	1	-	-	300A	Recycled tool fragment	28-Mar-17	Depth = 90-100
93	65	5	7	-	-	Bark beater	23-Mar-17	Depth = 90-100
95	66	1	15	-	-	Stone ball	31-Mar-17	Depth = 140-150
97	66	1	-	-	303	Stone ball	31-Mar-17	Depth = 144-150
99	66	1	11	-	-	Figurine head	28-Mar-17	Depth = 100-110
100	66	4	-	-	306	Miniature vessel	3-Apr-17	Depth = 90-97
106	66	3	-	-	308	Metate	4-Apr-17	Depth = 97-105
107	66	3	-	-	308	Metate	4-Apr-17	Depth = 90-97
108	66	3	-	-	312	Stone ball	5-Apr-17	Depth = 99-105
110	66	5	-	-	314	Metate	6-Apr-17	Depth = 65
111	67	3	-	-	325E	Vessel rim/side portion	12-Apr-17	Artifact #4 in profile drawing; check drawing for depth
112	66	3	-	-	324	Metate	10-Apr-17	Depth = 134-137
113	66	3	-	-	326B	Miniature mano	13-Apr-17	Depth = 157-167
114	37	8	-	-	335	Mortar	15-Jul-17	Depth = 154; Artifact #6 in plan drawing of Rasgo 335
115	41	8	-	-	354	Vessel rim/side portion	31-Jul-17	Depth = 475; visible in profile drawing

Object	Operation	SubOperation	Nivel	Elemento	Rasgo	Artifact Description	Date Collected	Notes
116[a]	32	9	12	B	-	Stone ball	1-Aug-17	-

[a] Washed before sampling

Most artifacts sampled for the current study were subject to collection of three sediments, each of which grew successively closer to embedded archaeological residues. This three-sediment method follows standard procedures outlined by Pearsall (2015). Washed artifacts (recovered before the 2016 field season) were only subject to collection of two sediments in cases for which no adhering sediment (Sediment 1) was present. Starch-free nitrile gloves (Fisherbrand Nitrile Gloves and Fisherbrand Comfort Nitrile Gloves) tested in-house and verified to be free of starch were worn, and a fresh piece of lab-designated plastic wrap was applied to the working tray. The plastic wrap was replaced between artifacts, while gloves were replaced between samples. All toothbrushes used for collection were also replaced between samples, either with sterile ones or toothbrushes that had been sterilized. Sterile toothbrushes were preferred over sterilized toothbrushes in all cases; sterilized toothbrushes were only used when supplies became limited. Sterilization procedures involved soaking each toothbrush in designated bowls under the outdoor overhang, away from the kitchen or any live plants. Toothbrushes were soaked in household-grade bleach (NaClO) at high temperatures (38-40°C) for three or more days. After soaking, toothbrushes were retrieved using starch-free gloves, thoroughly rinsed in distilled water, and laid on a tray covered with fresh plastic and clean Kimwipes to completely dry on a shelf in the microbotanical field laboratory.

Collection of sediments from artifacts proceeded in the following manner. The first sediment was collected with a sterile/sterilized dry manual toothbrush with the objectives of (1) removing surface sediments to allow access to less superficial residues and (2) assessing potential contaminant taxa and extent of contamination (particularly from on-site plantain fields). Using the toothbrush, Sediment 1 was transferred directly from the artifact to a sterile 15 mL centrifuge tube. A maximum of 5 mL was collected to limit time spent on extraction.

Sediment 2 was collected using a sterile/sterilized manual toothbrush moistened with distilled water. The toothbrush was used to lightly scrub the target use surface of the artifact (e.g., grinding surface, vessel interior). A wash bottle was then used to transfer the contents of the toothbrush to a sterile 50 mL centrifuge tube. This process was repeated until the tube was filled to about 45 mL to prevent spillage during shipping. Ideally, caps would have been loosened to allow for as much water evaporation as possible or tubes would have been centrifuged to separate the supernatant water from the starches, phytoliths, soil and other material in the sediment. However, two factors interfered with this theoretical ideal; humidity levels at the field laboratory were too high to allow for substantial water evaporation through cap loosening and the field laboratory was not equipped with a centrifuge. Yet studies have shown that storage of modern and archaeological starches in room temperature water has no significant effects on starch morphology for up to eight years (Henry et al. 2009; Louderback et al. 2015). In the La Blanca assemblage, the lack of universal signs of partial to complete gelatinization in identified starches indicates that water temperatures did not reach 50°C during shipping or storage at the field house. Storage of liquid sample tubes on a shaded, indoor shelf in the field house and subsequent storage of these samples in an air-conditioned laboratory immediately upon arrival at the University of California, Santa Barbara helped to keep water temperatures low. Caps for all liquid samples were fastened securely with duct tape prior to shipping. Artifact residue samples were shipped to the UCSB-ISL via DHL with all appropriate Export Permissions from the

Ministerio de Cultura y Deportes de la República de Guatemala and a Soil Permit issued by the United States Department of Agriculture.

Sediment 3, also a liquid sample, was collected via two techniques. The first technique involved moistening a sonicating toothbrush with distilled water. This technique provides the most specific sampling as the collector can choose exactly which surface of the artifact to sample, allowing one to target specific use surfaces of interest. Using a sonicating toothbrush proved to be essential when sampling the mouths of figurines (Figure 12) as any offerings would have been most likely been stored or smudged in the mouth rather than rubbed over the entire surface of the head and body. All sediments taken from figurines (Sediments 1-3) were sampled in this manner. A sonicating toothbrush was also preferred for manos with one clearly worked side, metates, vessel interiors, mortar fragments, recycled tools, and any other artifacts for which sonicating in a tank would make results less specific or would not be possible (in cases where artifact dimensions exceeded the size of the tank).

Figure 12. Sampling the mouth of a figurine for microbotanical remains using a moistened sonicating toothbrush.

Sonicating in a tank (Branson 1800) was the second technique used to collect Sediment 3. Use of a tank is ideal for small artifacts where the entire surface demonstrates evidence of use (e.g., palm-size groundstone balls commonly found in Conchas phase contexts). The selected artifact was placed in a plastic bag and subsequently filled with enough distilled water to completely submerge the artifact. The bag was then closed and clipped to the side of the tank filled with water. Every artifact was sonicated for at least 15 minutes or until residues appeared to be fully dislodged. After sonicating, the bag was removed and the water inside the bag was poured into a sterile 50 mL centrifuge tube. If less than 45 mL of water was collected, a wash bottle filled with distilled water was used to wash the bag clean until 45 mL of total volume was collected.

Macrobotanical Samples. Soil samples designated for macrobotanical analysis were collected from every excavation level—either arbitrary (10 cm in depth) or cultural—of all units and features (Table 3). Samples were acquired using the bulk strategy (d'Alpoim Guedes and Spengler 2014), where soil is collected from specific locations and samples are processed independently rather than being aggregated after collection as is the case with scatter sampling, another popular sampling strategy (Farahani 2020). Generally, 10 L of soil was collected from each context, with smaller contexts yielding smaller samples. Soil samples were bagged in plastic and transferred to the flotation area, where the volume of each sample was measured before processing by placing each bag in a bucket with graduated markings.

Table 3. Features with Collected Flotation Samples.

Rasgo	Op	Sub	Description	Period	Phase/Subphase	Depth (cm)	Excavation Year	Notes
1	25	3	Possible posthole	Middle Preclassic	Conchas C	140-150	1985	No associated floor; likely not a domestic structure
5	25	3	Series of house floors	Middle Preclassic	Conchas A	218-230	1985	
27	26	5	Trash pit	Middle Preclassic	Conchas D	70 initial	1985	Associated with Rasgo 22 and Rasgos 25-26
32	26	5	Trash pit	Middle Preclassic	Late Conchas B-Early Conchas C	227 initial	1985	
34	27	2	Trash pit	Middle Preclassic	Conchas C	161-171	1985	
36	27	1	House floor	Middle Preclassic	Conchas B to Conchas C	218-238	1985	
39	27	2	Pit	Middle Preclassic	Late Conchas B-Early Conchas C	160-200	1985	Possible well
59	32	7	Earthen wall	Middle Preclassic	Conchas C	130-140	2004	
214	49	5	Floor	Late Middle Preclassic	Conchas E	50-60	2016	
217	49	2	Burnt daub/clay scatter	Late Middle Preclassic	Conchas E	110-120	2016	
218	49	1	Floor	Late Middle Preclassic	Conchas E	90-95	2016	
220	49	5	Floor	Late Middle Preclassic	Conchas E	60-70	2016	
225	50	1	Floor	Middle Preclassic	Conchas D	154-170	2016	Burned
226	50	1	Artifact concentration	Middle Preclassic	Conchas D	159-165	2016	Embedded in Rasgo 225
228	51	1	Floor	Late Middle Preclassic	Conchas D	110-120	2016	
229	51	1	Floor	Late Middle Preclassic	Conchas D	125-130	2016	
230	51	1	Floor	Late Middle Preclassic	Conchas E	130-135	2016	
232	51	1	Vessel contents	Late Middle Preclassic	Conchas E	140-158	2016	Vessel on top of floor (Rasgo 233)
233	51	1	Floor	Late Middle Preclassic	Conchas E	140-155	2016	
236	50	2	Ceramic concentration	Middle Preclassic	Conchas C	125-163	2016	Above Rasgo 225 (floor)
238	50	2	Fill lens	Middle Preclassic	Conchas C	159-163	2016	Under Rasgo 225
240	50	1	Intrusive pit	Middle Preclassic	Conchas C	165-285	2016	Contemporary with Rasgo 225
241	50	1	Intrusive pit	Middle Preclassic	Conchas C	269-310	2016	Begins at Rasgo 225 level; directly below Rasgo 226; extensive rodent activity
244	53	4	Trash pit/ceramic and lithic concentration	Late Middle Preclassic	Conchas E	70-80	2016	
245	55	2	Ceramic concentration	Middle Preclassic	Conchas D	50-58	2016	
249	55	4	Artifact concentration (sheet midden?)	Middle Preclassic	Conchas D	100	2016	

Rasgo	Op	Sub	Description	Period	Phase/Subphase	Depth (cm)	Excavation Year	Notes
251	55	3	Artifact concentration (with metate)	Middle Preclassic	Conchas D	100-110	2016	
253	55	2	Floor	Middle Preclassic	Conchas D	100-110	2016	
254	50	3	Floor	Middle Preclassic	Conchas C	155	2016	
255	55	4	Trash pit	Middle Preclassic	Conchas C or Conchas D	130	2016	Exterior; continuation of Rasgo 249A
256	55	2	Floor	Middle Preclassic	Conchas D	100-110	2016	Continuation of Rasgo 253
257	55	2	Ceramic concentration	Middle Preclassic	Conchas D	120-130	2016	
258	55	2	Trash pit	Middle Preclassic	Conchas C	135-140	2016	Exterior; named Rasgo 257 in previous level
260	56	2	Ceramic concentration	Middle Preclassic	Conchas C or Conchas D	92-100	2016	
261	56	2	Ceramic concentration	Middle Preclassic	Conchas C or Conchas D	100-110	2016	
263	56	3	Floor	Middle Preclassic	Conchas (subphase unspecified)	80	2016	
264	57	1	Floor	Middle Preclassic	Conchas D	87-90	2016	Portions burned
266	57	1	Trash pit	Middle Preclassic	Conchas D [a]	140-150	2016	
268	57	1	Floor	Middle Preclassic	Conchas C? (uncertain due to low numbers)	158-210	2016	Portions with taxcal
269	57	3	Artifact concentration (exterior trash pit?)	Early part of Late Preclassic [a]	Conchas mixed with LPC [a]	85-90	2016	
270	57	5	Pit	Middle Preclassic	Conchas D	110-120	2016	
271	57	5	Trash deposit	Middle Preclassic	Conchas D	96-155	2016	Below Rasgo 270
273	57	5	Trash deposit	Middle Preclassic	Conchas D	107-114	2016	Below Rasgo 270
274	57	3	Floor	Middle Preclassic	Conchas D	160-165	2016	Same level as Rasgos 268 and 275
275	57	3	Intrusive pit	Middle Preclassic	Conchas D	160-200	2016	Same level as Rasgos 268 and 274; lined with sherds
278	57	5	Trash pit	Middle Preclassic	Conchas D	165-185	2016	Exterior; Rasgo 271 is within this large pit
300	66	1	Ceramic concentration	Middle Preclassic	Conchas C	90-110	2017	
301	66	1	Ceramic concentration/burnt earth	Middle Preclassic	Conchas B or C	118-130	2017	Two levels below Rasgo 300
302	66	2	Trash pit	Middle Preclassic	Conchas (subphase unspecified)	80-90	2017	Exterior
305	65	5	Ceramic concentration	Middle Preclassic	Conchas C	164-180	2017	

Rasgo	Op	Sub	Description	Period	Phase/Subphase	Depth (cm)	Excavation Year	Notes
306	66	4	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	90-97	2017	
309	66	4	Ceramic concentration/stones	Middle Preclassic	Conchas (subphase unspecified)	No data	2017	
310	66	4	Ceramic concentration/burnt clay	Middle Preclassic	Conchas (subphase unspecified)	No data	2017	
311	66	1	Ring of burnt earth	Middle Preclassic	Conchas (subphase unspecified)	210	2017	
314	66	5	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	65-120	2017	
315	66	4	Barro, ash, and ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	110-120	2017	Level below Rasgos 309 and 310
317	66	4	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	130-137	2017	Level below Rasgo 315
318	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	105-115	2017	
321	66	4	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	140-147	2017	Level below Rasgo 317
322	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	125-127	2017	
325	67	3	Ceramic concentration	Middle Preclassic	Conchas D	69-150	2017	
326	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	140-147	2017	
327	67	1	Ceramic concentration	Middle Preclassic	Conchas D	84-130	2017	
329	66	3	Ceramic concentration	Middle Preclassic	Conchas (subphase unspecified)	170-180	2017	
330	37	8	Trash pit	Middle Preclassic	Prob. Conchas D	61-111	2017	
332	37	8	Trash pit	Middle Preclassic	Prob. Conchas D	70-100	2017	
334	37	8	Floor	Middle Preclassic	Prob. Conchas C	130-150	2017	Above Rasgo 335

Note: Op 37 Sub 8 phases estimated using Op 37 Sub 1 as a proxy.

[a] Hypothesized based on comparisons with levels of same Op in similar depth ranges.

Soil samples with carbonized remains must be subject to flotation before they are ready for macrobotanical analysis. Flotation involves exposing a soil sample to water, agitating it lightly, and collecting the floating (light fraction) and sunken material (heavy fraction) for analysis (White and Shelton 2014). Flotation was conducted on site during the 2016-2017 excavations at La Blanca as irrigation systems for plantain fields (fed by underground wells) provided easy connection of hoses to active water taps. Following a SMAP-style design (Watson 1976), a kitchen-size trash can was used as a flotation tank with a PVC pipe attached to one of the narrow sides.[5] This pipe provided a conduit for transfer of floating material (light fraction) to a plastic, vented shelf supported by four legs and lined with chiffon. For collection of heavy fractions, the chiffon was replaced by standard window screen mesh with 1.59 mm (1/16 inch) openings (Figures 13-14). All samples were then dried before bagging; light fraction samples were dried in the sun on a clothesline, while heavy fraction samples were dried in the plastic shelves used in flotation. Processed flotation samples were hand-carried by project staff during return trips to the United States and subsequently shipped to the Integrative Subsistence Laboratory at the University of California, Santa Barbara. All appropriate permissions from the Ministerio de Cultura y Deportes de la República de Guatemala were secured prior to export.

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[5] A similar SMAP-style flotation set up was used during the pre-2016 excavations.

Figure 13. Renato Juarez and Jose Aldana transfer heavy fraction material from the flotation tank to the window screen mesh on the plastic shelf below.

Figure 14. Renato Lopez and Jose Aldana clean heavy fraction material after transfer.

Laboratory Contamination Controls

Starch granules and phytoliths were extracted from artifact residues in the wet laboratory facilities of the Integrative Subsistence Laboratory at the University of California, Santa Barbara (UCSB-ISL). Standard procedures for surface and equipment cleaning were regularly carried out to reduce the risk of microbotanical contamination. All surfaces used in extraction and analysis (including all desks, trays, tables, and equipment surfaces) were sterilized weekly. A dedicated sponge was used weekly to apply a 5% solution of lye (i.e., sodium hydroxide (NaOH)) and distilled water to these surfaces, after which they were rinsed with distilled water and left to dry before the next use (following Henry 2020). The same brands of starch-free nitrile gloves used in sample collection consistently tested negative for starch and thus were also used during cleaning, sterilization, extraction, and analysis. No food or drinks are allowed in the UCSB-ISL space reserved for deflocculation and extraction of microbotanical remains.

All laboratory consumables (e.g., glass slides/cover slips, glass Pasteur pipettes) and reusable tools (e.g., metal toothpicks, tweezers, mason jars used to hold supplies) were sterilized prior to use. Laboratory consumables were not reused, while metal toothpicks were sterilized between each artifact residue sample. Sterilization of these materials involved submerging them in distilled water within a laboratory-designated pressure cooker (InstantPot Duo 6 Quart) set to high pressure for two hours (following Crowther et al. 2014). The pot was then drained, and the materials transferred to an uncapped, sterilized jar placed under the fume hood until the contents were completely dried.

Risk of airborne contamination was reduced through control slides and air filtration. While the UCSB-ISL was being used for sample extraction, glass slides that had been sterilized in-house were periodically placed in the fume hood and on the countertops. These slides were then examined under the microscope to test for airborne starch and phytolith contaminants. In addition to periodically analyzing control slides, the laboratory space used for most of the slide mounting (described below) was equipped with a continuously running three-stage True HEPA air purifier (Winix D360). This model of air purifier is capable of filtering particles as small as 0.003 µ and cleaning a 40.41 m^2 room in 15 minutes; the laboratory space used for slide mounting measures approximately 11.04 m^2.

Due to travel restrictions imposed by the COVID-19 pandemic, any slide mounting occurring after March 2020 was conducted in a room of my residence that was designated as laboratory space upon move-in. Surface, equipment, and consumable contamination protocols used during extraction in the UCSB-ISL were maintained in this new space. Moreover, the door to the space always remained closed during periods when microbotanical lab work was being conducted. No food was ever allowed in the room and no beverages were allowed on the work surfaces. The glass stages of all microscopes used during analysis were cleaned with the same lye solution used to clean surfaces, at least weekly or more often as needed.

Extraction

Steps in the extraction of microbotanical remains followed standard protocols of the UCSB-ISL (Appendix B). These protocols employ the “piggyback” method of microbotanical extraction (Chandler-Ezell and Pearsall 2003), which allows for the extraction of starch granules and phytoliths from the same sample. Starch granule and phytolith samples were produced for every artifact residue (sediment) subjected to extraction.

Prior to extraction, a specifically designed process was used to deflocculate all artifact residue samples and remove most of the clays. This preprocessing method was developed to solve a problem noted after early attempts at extracting microbotanical remains from La Blanca artifact residues using standard procedures of the UCSB-ISL. Starch granules were notably absent from these initial samples, a pattern that Ruth Dickau and I hypothesized to be the result of starch granules being attached to clays present in the soils and then gelatinizing and disintegrating upon contact with the high-strength acids used in chemical pretreatment for phytolith extraction.

The preprocessing protocol we created is summarized below (a comprehensive list of steps can be found in Appendix C). First, the contents of each sample were wet-sieved through a 250-micron steel screen and passed through a glass funnel into a new 50 mL centrifuge tube (Figure 15). If the new tube became filled with liquid, it was centrifuged for two minutes at 1000 rpm after which the supernatant was decanted. The sieving process was then repeated until the entire contents of the original tube had been transferred into the new tube. The sieve and funnel were thoroughly cleaned with 0.1% alconox solution and then rinsed in distilled water between samples. After sieving, 20 mL of 0.1% alconox solution was added and, after a quick swirl to mix the contents, each tube was placed in a rack on an orbital shaker set to 200 r/min and left on overnight (for 15+ hours). The next morning, the tubes were centrifuged at 1000 rpm for 2 minutes and decanted into the sink. They were then rinsed in distilled water and centrifuged, a process that was repeated at least twice or until the supernatant water column became transparent.

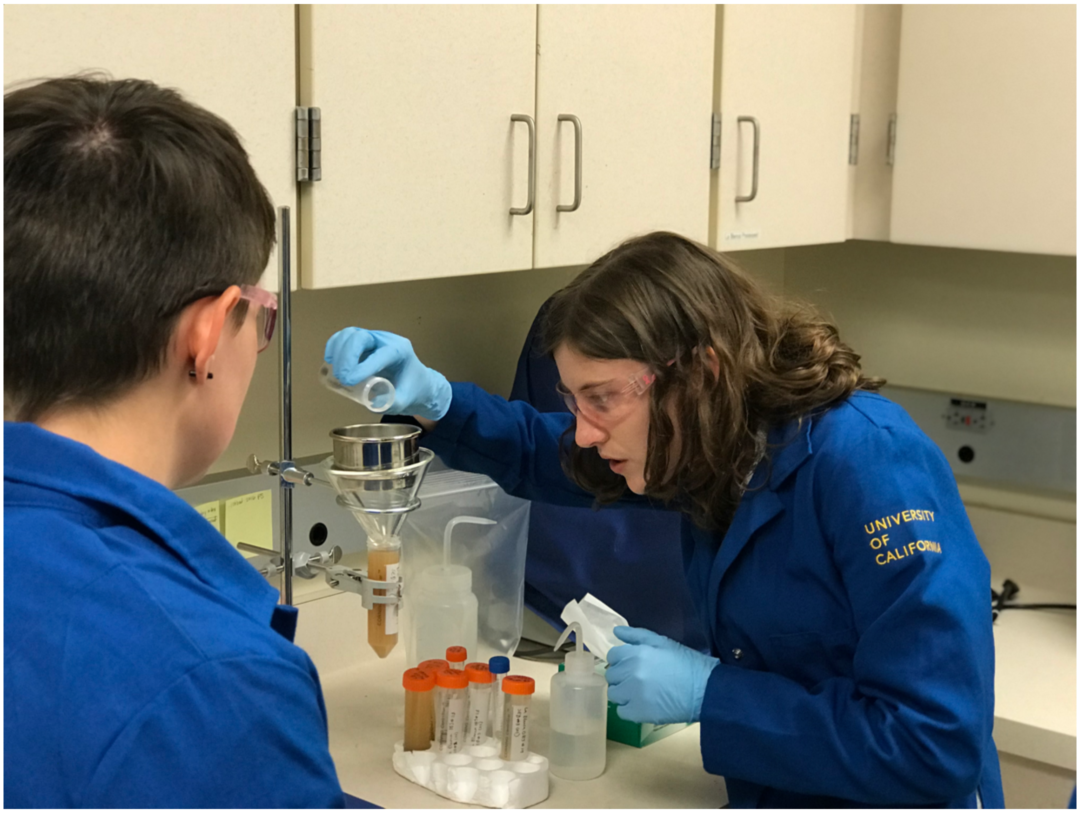

Figure 15. Laboratory setup for preprocessing steps used to remove clays from La Blanca artifact residue samples.

Following preprocessing and extraction steps, each starch and phytolith extract was completely dried in a laboratory-designated benchtop muffle furnace (Thermolyne F48025-60). Starch extracts were dried at 40°C, while phytolith extracts were dried at 60°C. After drying, all samples were placed in a covered microcentrifuge rack and then in a UCSB-ISL cabinet reserved specifically for samples from the La Blanca site, where they were stored until slide mounting.

Analysis

Microbotanical Samples. Visual identification of starches and phytoliths requires mounting extracts on glass slides and examining these slides under a high-powered microscope. Slide mounting procedures are fully described in Appendix D and summarized here. A few drops of mounting medium were added to each dried extract to facilitate slide mounting; every extract was mounted in its entirety. Mounting media allow for the rotation of three-dimensional microfossils during analysis. Starch extracts were mounted using either a mixture of glycerin and water (1:1 ratio) or immersion oil, each of which has an ideal refractive index at room temperature; phytolith extracts were mounted using immersion oil only. The chosen media are among the best choices for mounting microfossils on glass slides as evidenced by their widespread use in recent studies (e.g., Cagnato et al. 2021; De Lucia and Scott Cummings 2021). After a mounting medium was added, a metal toothpick was used to suspend the dried material in the medium through incorporating the mixture and gently breaking up any clumps. A few drops of the mixture were then added to each slide, covered with a sterilized glass cover slip, and sealed along the sides with clear nail polish. Prepared slides were examined under the microscope immediately to prevent any drying out of the mounting medium that might inhibit rotation of the microfossils.

Identification was conducted using a Brunel SP 400 (50-600x) microscope equipped with incident/transmitted light illumination systems, brightfield/darkfield capabilities, a polarizing filter, and a Leica FLEXACAM C1 camera. All starch and phytolith samples were examined under transmitted light but lighting conditions and scanning procedures differed by microfossil type. Starch sample slides were scanned at magnifications of 100-200x; Sediment 1 slides were scanned at 100x to expedite processing. Scanning was conducted using a low level of polarization. This level was low enough to contribute to birefringence in native starches and starches with a lower extent of damage, while not preventing the visualization of granules with little to no birefringence (the latter due to initial morphology or damage by natural/cultural factors). All identified starches were photographed under both non-polarized and polarized lighting conditions. Phytolith slides were scanned at 200x magnification under non-polarized lighting. This study focused on the identification of phytoliths from potential domesticates as arboreal and non-maize grass phytoliths have less potential to comment on food-related uses. Thus, only potentially diagnostic domesticate phytoliths were identified, photographed, and counted.

Macrobotanical Samples. Processed flotation samples were size sorted prior to analysis according to standard methods used on the Gulf Coast of Mesoamerica, where preservation conditions are similar (VanDerwarker 2006). Each light fraction or heavy fraction sample was passed through a series of brass sieves with mesh sizes of 2.0 mm, 1.4 mm, and 0.7 mm. A pan was attached to the bottom of the 0.7 mm sieve to collect any material less than 0.7 mm in size. Each size group (>2.0 mm, 1.4 mm, 0.7 mm, and <0.7 mm) was bagged separately. Heavy fractions exceeding 500 g in weight were subsampled before sieving. Subsampling was done by either pouring the sample back and forth into a slotted berry basket placed on top of two side-by-side plastic bins (in the field) or using a riffle splitter (in the UCSB-ISL lab). If the 50% subsample still exceeded 500 g in weight, it was then subsampled again using the same technique. Only one randomly selected subsample was sieved and sorted from each subsampled heavy fraction.

Light and heavy fractions were subject to the same set of procedures for identification of plant remains. All plant remains were removed from the greater than 2.0 mm size fraction; seeds were counted, weighed, and identified taxonomically, but wood was only weighed. Wood was not removed from the 1.4 mm, 0.7 mm, and <0.7 mm fractions. However, all seeds were counted, weighed, and identified taxonomically. Identifications were made using low-powered stereoscopic microscopes (10-40x). The comparative collection at the UCSB-ISL, which contains a wide variety of plants native to Mesoamerica, and reference texts with plant ranges and/or seed photographs (Villar Anléu 2008; Henderson et al. 1995; Lentz and Dickau 2005; Martin and Barkley 1961) aided in making identifications. Amber VanDerwarker verified my identifications and consulted on the identification of unidentified specimens.

Plant specimens were identified to the lowest taxonomic level possible (e.g., family, genus, species). In some cases, "cf." (Latin: *confer*) is used to indicate identifications that are tentative and could not be confirmed either due to poor preservation or a lack of comparative images/specimens. Specimens marked as "Unidentified" had potentially diagnostic characteristics, yet an identification could not be determined at this time (usually due to a poor match with available comparative images and specimens). "Unidentifiable" specimens could not be identified further due to issues with fragmentation and lack of diagnostic characteristics.

Radiocarbon Dates. Eighteen maize kernels from flotation samples were selected for radiocarbon dating (Table 4). This analysis was conducted by the W.M. Keck Carbon Cycle Accelerator Mass Spectrometer Facility at the University of California, Irvine. Samples were treated with acid-base-acid (1N HCl and 1N NaOH, 75°C) prior to combustion. $\delta^{13}C$ values were measured to a precision of <0.1‰ relative to standards traceable to PDB, using a Thermo Finnigan Delta Plus stable isotope ratio mass spectrometer (IRMS) with Gas Bench input. Results of radiocarbon dating and $\delta^{13}C$ measurement are discussed in Chapter 7.

Table 4. Proveniences of Maize Kernels Submitted for Radiocarbon Dating.

Lab Number	Op	Sub	Nivel/Rasgo	Depth (m)	Flotation Catalog No.
255118	26	5	R32	-	26.5.0.32.1
255119	32	4	N19	1.8-1.9	32.4.19.0.1
255120	32	6	N16	1.5-1.6	32.6.16.0.1
255121	32	6	N17	1.6-1.7	32.6.17.0.1
255122	32	8	R59	-	32.8.0.59.1.1
255123	49	1	R218 (above floor)	-	49.1.10.218.3
255124	55	2	R245A	0.8-0.9 m	55.2.0.245.1
255125	56	2	R261	1.0-1.1 m	56.2.0.261.1
255126	57	1	R266A	1.4-1.5 m	57.1.0.266.2
255127	57	3	R269B	1.0-1.1 m	57.3.0.269.3
255128	65	5	R305	1.64-1.7 m	65.5.0.305.2
255129	66	2	R302	0.8-0.9 m	66.2.0.302.1
255130	66	3	R322	1.25-1.27 m	66.3.0.322.1
255131	66	4	R321	1.40-1.47 m	66.4.0.321.1
255132	66	7	R314D	1.1-1.2 m	66.5.0.314.4
255133	67	1	R327B	1.1-1.2 m	67.1.0.327.3
255134	67	3	R325	0.69-0.80 m	67.3.0.325.1
255135	67	3	R325C	1.0-1.1 m	67.3.0.325.4

The Statistical Approach

Data-directed research benefits from an analytical approach that recognizes the variance within datasets. Exploratory Data Analysis (EDA; Tukey 1977) is a statistical technique in which the analyst uses a wide range of tests to evaluate patterning in datasets and construct interpretations based on revealed patterns. EDA envisions statistical analysis as an opportunity for hypothesis development in addition to hypothesis testing (Behrens 1997). In this way, I use EDA as an overarching framework for exploring botanical, spatial, and temporal patterning at La Blanca, evaluating relationships between patterns, testing the significance of these patterns, and interpreting the results. Theory still guides the selection of statistical tests, but a key benefit of EDA is that testing is not limited to the confines of null hypotheses built from theory. Results derived from EDA have the power to support, refine, or refute the premises of initial theoretical frameworks while also taking the research in new directions.

Anatomy of a Box Plot

The box plot is a statistical technique used for assessing the spread of a distribution, organization of values within that distribution, and relationships between distributions (Frigge et al. 1989). As box plots are regularly incorporated into the EDA presented in this dissertation, it is necessary to provide a brief description of the key interpretive features. All box plots were created using SYSTAT 12; described symbology and calculations match the program defaults.

The box portion of the plot, otherwise known as the interquartile range (Figure 16), diagrams between 25 and 75% of the distribution. Lower and upper limits are marked by the hinges on either end of the box. The area between the upper and lower hinges is referred to as the interquartile range. All box plots presented in this dissertation are notched (McGill et al. 1978), meaning that the median of the distribution is indicated by a notch in the box. The entire notched area of the box represents a confidence interval around the median (Benjamini 1988). This confidence interval is useful when comparing distributions as medians can be determined to be statistically different if the notched areas of two boxes do not overlap (Benjamini 1988). The whiskers, or lines attached to either side of the box, represent the area of the distribution that falls within the calculated inner fences. Minimum and maximum hinge values are labeled in Figure 16. Inner and outer fences are calculated as follows, with Hspread representing the interquartile range:

Lower inner fence = lower hinge-(1.5*(Hspread))

Upper inner fence = upper hinge+(1.5*(Hspread))

Lower outer fence = lower hinge-(3*(Hspread))

Upper outer fence = upper hinge+(3*(Hspread))

Values between the inner and outer fences are considered outliers and graphed as asterisks (see Figure 16). Far outliers, or values that fall outside either of the outer fences, are plotted as open circles.

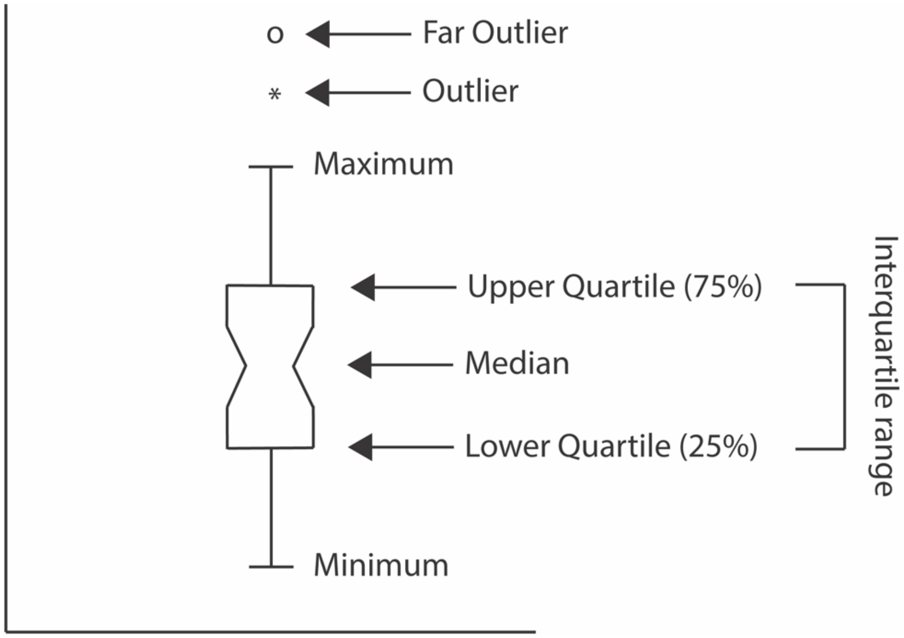

Figure 16. Parts of a box plot.

Exploratory statistical analysis of botanical results, radiocarbon dates, and other datasets has great potential to reveal meaningful patterning. Basic botanical patterns are presented in Chapter 5. In Chapters 6 and 7, a variety of statistical approaches will be used to test relationships between space and time. Chapter 6 investigates the potential for neighborhoods, or house groupings, at the urban center of La Blanca and then uses botanical data to evaluate the defining characteristics of each neighborhood. I consider the relationship between food production and space to investigate how different areas of the site contributed to urban sustainability, food security, and the survival of the city. In tandem, I acknowledge and evaluate the possibility that household groups may have produced food autonomously. Adopting this strategy would mean choosing to manage any risk of shortages at the household or neighborhood, rather than city, level. Chapter 7 considers La Blanca as a lived space by evaluating trends in food production over time. Adding a temporal dimension to the analysis of botanical data from households provides a unique contribution to Middle Preclassic archaeology on the Pacific Coast. Here, domestic data are sparse, and temporal comparisons at the subphase level between botanical data from the same household are often impossible. Yet before implementing these analytical approaches, it is necessary to first understand the basic botanical results.

CHAPTER 5: MAKING FOOD AND SOCIAL CONNECTIONS

Dining is a shared experience that leaves behind many different types of material traces. The integration of macrobotanical and microbotanical approaches goes beyond food disposal to also offer information regarding food preparation and cooking practices. These practices are essential components of foodways, which include gathering, planting, harvesting, processing, cooking, serving, and ultimately disposal (Nelson et al. 2020; Scarry and Reitz 2005; Welch and Scarry 1995). Its regularity of use makes the study of food ideal for taking a close look into how social relationships are forged, maintained, and renegotiated. For La Blanca, the botanical analysis of domestic contexts pursued by the current study offers an opportune perspective on the building blocks of this early city's economy. This chapter discusses the types of plants used by La Blanca residents based on botanical data from domestic contexts. I then explore how different technologies are used to process food plants and which types of plants are subject to different processing techniques. Considering our limited knowledge of native plants and their uses on the Pacific Coast, archaeological data has great potential to provide critical insights toward developing a better understanding of native ecologies.

Basic Botanical Results

Identification of plant remains focused on the analysis of macrobotanical, starch, and phytolith samples collected from Conchas phase (900-500 BCE) contexts at the La Blanca site. Although samples were identified as dating to the Conchas phase in the field based on cursory analysis, I used Michael Love's (personal communication 2022) most recent ceramic results to verify that all samples with identified plant material dated to some portion of the Conchas phase. For discussion of change over time, see Chapter 7.

Analysis of macrobotanical, starch, and phytolith samples produced a diverse taxa list (Tables 5-7). This list includes typical (e.g., maize) and more surprising plant findings (e.g., wild potato) that widen our current perspectives on the breadth of Middle Preclassic plants used for subsistence. To allow for integrative discussion of results obtained through these different methods, I organize my overview by major plant categories: field crops/cultigens, tree crops, nuts, root crops, wild tubers, and miscellaneous taxa. Identified plants are consistent with the interpretation that the site was regularly occupied for extended periods of time during which labor was invested in resources with delayed and immediate returns (e.g., maize and nuts, respectively).

Table 5. Macrobotanical Taxa Identified in La Blanca Samples.

Number of samples[a]	169
Number of features[a]	64
Soil volume (L)[a]	1598
Plant weight (g)	23.41
Wood weight (g)	13.13

Common Name	Scientific Name	Count
Field Crops		
Bean	*Phaseolus* sp.	2
Maize cf.	*Zea mays* cf.	1
Maize cupule	*Zea mays*	37
Maize cupule cf.	*Zea mays* cf.	4
Maize kernel	*Zea mays*	996
Maize kernel cf.	*Zea mays* cf.	18
Squash rind cf.	*Cucurbita* sp. cf.	1
Squash/gourd	Cucurbitaceae	1
Squash/gourd cf.	Cucurbitaceae cf.	2
Tree Crops		
Avocado	*Persea americana*	4
Avocado cf.	*Persea americana* cf.	4
Coyol	*Acrocomia mexicana*	129
Coyol cf.	*Acrocomia mexicana* cf.	6
Green sapote	*Pouteria viridis*	3
Sapote	*Pouteria* sp.	165
Sapote cf.	*Pouteria* sp. cf.	3

Nuts		
Oreomunnea	*Oreomunnea* sp.	1
Oreomunnea cf.	*Oreomunnea* sp. cf.	2
Walnut	*Juglans* sp.	17
Walnut cf.	*Juglans* sp. cf.	17
Walnut family	Juglandaceae	6
Miscellaneous		
Beak-sedge	*Rhynchospora* sp.	1
Bean family	Fabaceae	1
Bean family cf.	Fabaceae cf.	1
Bec	*Ehretia tinifolia*	3
Beilschmiedia	*Beilschmiedia* sp.	45
Canegrass cf.	*Eragrostis* sp. cf.	5
Grass family	Poaceae	1
Horse purslane	*Trianthema portulacastrum*	33
Jointvetch cf.	*Aeschynomene* sp. cf.	3
Mallow family cf.	Malvaceae cf.	2
Mexican copperleaf	*Acalypha mexicana*	1
Mexican poppy cf.	*Argemone mexicana* cf.	1
Mustard family cf.	Brassicaceae cf.	1
Nutshell/palm	Juglandaceae/Arecaceae	12
Palm family	Arecaceae	3
Palm family cf.	Arecaceae cf.	4
Paspalum cf.	*Paspalum* sp. cf.	1
Pereskia	*Pereskia* sp.	1
Pereskia cf.	*Pereskia* sp. cf.	53
Piscidia	*Piscidia* sp.	1
Purslane	*Portulaca* sp.	4
Scleria	*Scleria* sp.	1
Sedge	*Cyperus* sp.	32
Tick Clover	*Desmodium* sp.	1
Unidentified	-	72
Unidentified seed	-	2
Unidentified seed fragment	-	2
Unidentifiable	-	86
Total	-	1792

[a] Does not include analyzed samples with <0.01g of plant weight

Table 6. Starch Taxa Identified in La Blanca Samples.

Common name	Scientific name	Count	Ubiquity
Field cultigens			
Maize	*Zea mays*	3	8.11%
Maize cf.	*Zea mays* cf.	7	13.51%
Bean family	Fabaceae	2	2.70%
Root crops			
Arrowroot	*Maranta arundinacea*	16	21.62%
Arrowroot cf.	*Maranta arundinacea* cf.	4	5.41%
Calathea	*Calathea* sp.	2	2.70%

Calathea cf.	*Calathea* sp. cf.	2	5.41%
Malanga	*Xanthosoma* sp.	1	2.70%
Manioc	*Manihot esculenta*	1	2.70%
Manioc cf.	*Manihot esculenta* cf.	2	5.41%
Sweet potato cf.	*Ipomoea batatas* cf.	1	2.70%
Yam	*Dioscorea* sp.	4	10.81%
Root crop	-	9	16.22%
Wild tubers			
Wild Calathea cf.	*Calathea* sp. cf.	1	2.70%
Wild potato	*Solanum* sp.	40	13.51%
Wild potato cf.	*Solanum* sp. cf.	8	10.81%
Wild yam	*Dioscorea* sp.	4	10.81%
Miscellaneous			
Calathea/Wild yam	*Calathea* sp./*Dioscorea* sp.	3	8.11%
Unidentified (granules estimated)	-	63	0.00%
Unidentified (bell-shaped)	-	1	2.70%
Unidentified (damaged)	-	3	2.70%
Unidentified	-	68	48.65%
Unidentifiable (heat damaged)	-	22	2.70%
Unidentifiable (damaged)	-	1	8.11%
Unidentifiable (definitely torn, possibly gelatinized)	-	1	2.70%
Unidentifiable	-	12	21.62%

Note: Unidentified starches also found in Sediment 1 of Object 47 (plate rim sherd) but were too numerous to count accurately. Ubiquity calculated based on artifacts.

Table 7. Phytolith Taxa Identified in La Blanca Samples.

Common name	Scientific name	Count	Ubiquity
Root crops			
Manioc secretory cell cf.	*Manihot esculenta* cf.	1	6.25%
Miscellaneous			
Palm family	Arecaceae	3	18.75%
Grass family (short cell, bilobate)	Poaceae	1	6.25%
Grass family (cross body)	Poaceae	1	6.25%
Grass family (rondel)	Poaceae	2	12.50%
Sedge family cf.	Cyperaceae cf.	1	6.25%
Unidentified (amorphous silica/epidermal)	-	1	6.25%
Unidentified (epidermal platelet)	-	1	6.25%
Unidentified (silicified tracheid/epidermal)	-	1	6.25%
Unidentified	-	15	75.00%

Field Crops & Cultigens

All three long-standing field crops of Mesoamerica, maize (*Zea mays*), bean (*Phaseolus* sp.), and squash/gourd (Cucurbitaceae) are present in the La Blanca macrobotanical assemblage. Identified starches in this category include maize and members of the bean family (Fabaceae). For starches, the heading "field crops" is replaced with "field cultigens" as the bean family starches could potentially derive from wild species. Wild beans could have certainly been cultivated alongside maize plants but were maintained differently than domesticated beans planted as regular crops (e.g., *Phaseolus* sp.). For example, wild beans may not have been intentionally planted. Thus, the broader category of "field cultigens"—anything that may have been cultivated, or tended, in fields—is adopted in this case.

Maize has the highest raw counts of these three cultigens, which is particularly interesting as only 20 years ago the possibility of Middle Preclassic maize intensification on the Pacific Coast was controversial (Blake et al. 1992). Maize findings from the Middle Preclassic site of Cuauhtémoc (Rosenswig et al. 2015) and even earlier evidence of maize slash-and-burn agriculture at Archaic sites in the Soconusco (Kennett et al. 2010; Neff et al. 2006) has effectively settled this debate. However, the extent to which maize was used across a large sample size of domestic contexts and in different Conchas subphases remains underexplored. Analysis of maize remains from the La Blanca site bolsters the current knowledge base by exploring spatial patterning in maize use/processing across one of the most populous and expansive examples of population aggregation in Middle Preclassic Mesoamerica.

Beans (*Phaseolus* spp.) are too low in abundance to statistically analyze the counts (n = 2) but are nonetheless interesting. Directly dated remains from Oaxaca indicate that common bean (*Phaseolus vulgaris*) was domesticated in Mesoamerica by the Early Preclassic period (~2300-2100 cal. BP.; see Kaplan and Lynch 1999; Rodriguez et al. 2016). However, beans do not appear to have been intensively cultivated on the Pacific Coast until the Late Preclassic period, when they became much more abundant in the archaeological record at sites such as El Ujuxte (Pearsall et al. 2016). Bean fragments from La Blanca (n = 2) reported in the current study provide important evidence that (1) beans were incorporated into subsistence in the Río Naranjo area as early as the Middle Preclassic period, but (2) did not become a major part of foodways until the Late Preclassic period. Squash evidence in the La Blanca macrobotanical assemblage is scant, with many identifications being tentative. Despite the low counts of beans and squash, they can be incorporated with maize counts to assess broader investment in field versus tree cultivation (discussed further in Chapter 6).

Tree Crops

Modern-day visitors to the area of the La Blanca site would mostly encounter cleared land dedicated to industrialized agriculture. However, the pre-industrial landscape would have included arboreal species native to the dry forest environment (see Chapter 3). These trees would have provided critical fuel and food to ancient inhabitants. Botanical data from La Blanca support the presence of several food-producing arboreal species with a long history of tending and management by humans in Mesoamerica.

Tree crops identified in La Blanca macrobotanical samples include avocado (*Persea americana*), coyol (*Acrocomia mexicana*), green sapote (*Pouteria viridis*), and sapote

(*Pouteria* sp.). Although sapotes are widely considered to be native to Mexico, they are also native to the Pacific coast of Guatemala (Núñez-Colín et al. 2017:Figure 2). Each tree type (avocado, coyol, and sapotes) produces fruits composed of an endosperm surrounded by an edible pulp. For palms like coyol, the portion of the fruit that preserves archaeologically is the endocarp, a hard shell between the endosperm and the flesh/mesocarp (see McKillop 1996:Figure 17.2). The endosperm of coyol is edible, serving as a source of food and oil (Williams 1981:249-250).

Interpretations of the role of palms in ancient Maya societies vary widely. In his analysis of plant remains from the Copán Valley, Lentz (1990, 1991) considers coyol to have been a famine or second choice food in times of scarcity. While there is evidence that it was used in this way in the form of a hot beverage (Tozzer 1941:200), it is also commonly grown in Maya kitchen gardens today (Lentz 1990) and used as an occasional snack (McKillop 1996:288) or to make wine (Balick 1990). The purposeful cultivation of these palms is perhaps best embodied by their continued and consistent presence on Maya archaeological sites, even if few palms are present in the surrounding landscape (McKillop 1996). Certain palm specimens from La Blanca could only be identified to the family level (see Table 5) so the possibility remains that residents could have also cultivated palms more typically used among the Maya for other purposes (McKillop 1996), such as a source of oil (*Bactris major*) or housing thatch (*Orbignya cohune*).

Although tree fruits such as avocado, green sapote, and sapotes in general are typically considered foods, there is evidence that they also had medicinal and other economic uses among the Maya. Kunow’s (2003) ethnographic research among the Yucatec Maya revealed that avocado flesh can serve as a skin treatment by boiling with onion. The leaves of the plant can be boiled in water to produce a cure for diarrhea, while a drink made from boiled bark is a treatment for rheumatism (Kunow 2003). Boiling seeds in water can produce a beverage used to treat diarrhea and bladder problems (Roys 1931). Woods of the sapote family (Sapotaceae) are ideal for construction, but sapotes can also be used as a source of gum and latex (Zidar 2022). Oil from sapote seeds can be used medicinally as a skin ointment, to promote hair growth, or as a solution for cardiovascular problems (Morton 1987:401; VanDerwarker 2006:85). A medicine to treat parasites can be produced by brewing tea from sapote berries (Reining et al. 1992), and the resin is a topical treatment for burns or other types of wounds (Schlesinger 2001). Boiled and roasted seeds can be combined with either corn or cacao to make beverages such as pozole and chocolate, respectively (VanDerwarker 2006:85). Alternatively, seeds from some species can be dried and then used for flavoring (Williams 1981:301).

Nuts

Several nut taxa were identified in the La Blanca macrobotanical assemblage. This finding was completely unexpected as nut trees are rarely encountered in the Río Naranjo area today. However, as demonstrated in Chapter 3, when discussing the Preclassic Pacific Coast, the present provides a poor approximation of past environmental conditions. While most land is now cleared for agriculture, many native arboreal species that thrive in dry forests are native to the Pacific Coast (see Chapter 3), including plants that yield edible seeds such as walnuts.

Two walnut species are native to Central America (Stone 2009), Guatemalan walnut (*Juglans steyermarkii*) and nogal (*Juglans olanchana*, synonym: *Juglans guatemalensis*

W.E. Manning). These species have been recovered from contexts in upland southwestern Guatemala near the departments of Guatemala, Alta Verapaz, Baja Verapaz, Chimaltenango, Sacatepéquez, Quiché, Huehuetenango, and Sololá (MacVean 2009; Stone et al. 2009; Vivero et al. 2006). Walnuts grown in Guatemala today are mostly planted (Stone 2009), but wild specimens have been collected as far south as Nicaragua (Stone 2001). Guatemalan walnut (*J. steyermarkii*) typically grows at an altitude of ~1100-2200 masl (IUCN 2022; Stone et al. 2009). Fewer wild voucher specimens have been found for nogal, but those that have been recovered place it at around ~1150 masl (Manning 1957). Both species are currently considered endangered on the International Union for Conservation of Nature Red List of Threatened Species (2022). To provide a sense of context for the pace of habitat destruction, less than twenty years ago nogal was only listed as Near Threatened on The Red List of Trees of Guatemala using the IUCN criteria (Vivero et al. 2006).

Oreomunnea is another edible nut genus identified in the La Blanca assemblage. Two species of *Oreomunnea* are native to Guatemala, *O. americana* (called *nogal*) and *O. mexicana* subsp. *mexicana* (also called *nogal*; see Grantner 2005; Plants of the World Online 2022). *O. mexicana* grows throughout the country at altitudes from ~600-2000 m but tends to grow best at ~1000-1700 masl (Gonzaléz-Espinosa et al. 2012; Stone 1972, 2009). *O. americana* has been found growing in Baja Verapaz at ~1600 masl (Lundell 1978), but this species has been subject to less research since Lundell's initial identification in the 1970s. *O. mexicana* grows best in very humid conditions, typically perched on steep hillsides or ridges blanketed in fog (Stone 1972:312). Interestingly, Chiapas, a coastal state in Mexico that is part of the Pacific Coast region, may offer ideal growing conditions for *O. mexicana* as "the presence of this tree… has been long suspected and even reported but so far it has not been proven" (Gonzaléz-Espinosa et al. 2012:39). *O. mexicana* has been virtually cleared from agricultural states in Mexico (e.g., Veracruz) and is at especially great risk of endangerment and extinction as it would struggle to tolerate the drier conditions expected from future climate change (Gonzaléz-Espinosa et al. 2012).

Finding nuts at La Blanca sheds valuable light on forest conditions and exchange relations in the Middle Preclassic period. All identified genera currently grow at higher altitudes (~1000-2200 masl, collectively) than the current modern elevation of the La Blanca site (~20 masl). Specimens derive from undisturbed domestic features (255, 268, 330, 332) securely dated to the Conchas C and/or D subphases. Thus, it seems likely that these nuts were collected during foraging forays to higher elevations or exchange with groups living in those elevations. Although it is impractical to exchange large amounts of food across long distances and steep descents, small amounts of nuts could have been acquired from far-away locations and brought home for consumption. Nuts can serve as a vital source of immediate food that could be necessary to supplement site yields, however the small quantities suggest that these nuts were more likely emblematic of a forged relationship with far-flung neighbors. Low recovery also presents the possibility that nuts served as a specialty item used rarely and never in high amounts.

The recovery of nuts from La Blanca uniquely supports the argument that Middle Preclassic peoples of the Pacific coast had more dietary diversity than has been detected previously. Analyses of plant remains produced by inhabitants of contemporary sites on the Pacific Coast (e.g., Cuauhtémoc, Rosenswig et al. 2015) and other coastal Preclassic period regions, such as the Gulf Coast, have only yielded small amounts of acorn (e.g., Terminal Formative occupation of Bezuapan, VanDerwarker 2006:89). Thus, in addition to exploring the use of more expected agricultural and arboreal resources (e.g., maize and tree fruits, respectively), it is important to remain aware of local patterning in biodiversity. Plant taxa that are currently endangered or have fallen out of use may not be reflected in the local environments or foodways, but they nevertheless had the potential to be integrated with a more diverse suite of resources in the past.

Root Crops

Tubers, such as potato (*Solanum* spp.) and yam (*Dioscorea* spp.), are rich in vitamins, minerals, protein, and calories (Baah et al. 2009; Navarre et al. 2009; Rexen 1976; Schnorr et al. 2015). However, their contributions to ancient diets have been traditionally underrated, particularly on the Pacific Coast. Contributing to this disparity are two factors. First, there is poor preservation of tubers in the macrobotanical record because they are largely consumed in their entirety and any discarded peels are subject to being easily fragmented beyond recognition in the carbonized record. Second, fewer microbotanical than macrobotanical studies have been conducted for Preclassic sites on the Pacific Coast, thus presenting fewer opportunities to identify tubers. Large sample sizes that represent a wide variety of features and/or sites offer more opportunities for detecting rare taxa than their smaller counterparts (Popper 1988).

A notable exception is previous starch and phytolith research conducted by Pearsall and colleagues (2016) on artifacts from the La Blanca and El Ujuxte sites. Their analysis of starch granules in La Blanca artifact residues revealed maize and chili pepper (*Capsicum* sp.), but root crops[6] are only represented by one tentatively identified manioc (*Manihot* sp.

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[6] I use "root crop" to refer to tubers considered to be cultivated or domesticated, classifying tubers collected from the wild as "Wild Tubers." I acknowledge that wild tubers

cf.) granule; arrowroot (*Maranta arundinacea*), however, is identified in the phytolith assemblage. No starch granules from root crops were identified in El Ujuxte (500 BCE-100 CE) artifact residues processed by the team. It is important to remember that all artifacts considered in the 2016 report were washed before residue collection (as starch analysis was not anticipated), with shared wash basins likely contributing to the ubiquitous presence of maize starches in every artifact category designated by the researchers (Pearsall et al. 2016).

Based on extant evidence, it may be tempting to conclude that Preclassic inhabitants of the Pacific Coast deprioritized tubers (which can provide much needed sustenance at any time, see Dine et al. 2019) as maize would have been capable of producing large harvests and multiple harvests per year (see McBryde 1947) that could meet the needs of this growing incipient city. However, my own results have already begun to question the notion of virtual maize dependence at La Blanca. I have identified foraged resources, such as walnuts, coyoles, and sapotes, that made major contributions to subsistence in addition to maize. Adding to this list of non-maize resources are a variety of domesticated root crops with starch granules and phytoliths discovered in La Blanca artifact residues.

Root crops I have identified in La Blanca artifact residues include arrowroot (*Maranta arundinacea*), *Calathea* sp., yam (*Dioscorea* sp.), manioc (*Manihot esculenta*), and *malanga* (*Xanthosoma* sp.). Sweet potato (*Ipomoea batatas* cf.) starches were also tentatively identified. Another tentatively identified taxa is a phytolith that plausibly represents a secretory cell of manioc. The wide variety of root crops found in processing, cooking, and serving equipment at La Blanca exceeds any expectation, especially

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can be maintained by humans and thus cultivated. However, in botanical studies "cultivated tuber" is typically used to refer to tubers regularly planted by humans but lacking morphological markers of domestication.

considering the rigorous contamination control procedures used in this study (see Chapter 4).

Tubers are not unusual in the archaeological record of Central America. Cagnato (2016) has also questioned the notion of tubers as famine foods. Her analysis of archaeobotanical remains from two lowland Classic Maya sites, El Perú-Waka' and La Corona, revealed manioc, canna (*Canna* sp.), possible jicama (*Pachyrhizus erosus*), and possible sweet potato on ground stone and ceramic artifacts. Based on the abundance of these starches, Cagnato argues that tubers played a more central role in Maya diets than is traditionally acknowledged. Further south, Sheets and colleagues (2012) have offered convincing evidence that manioc served as a staple crop for residents of Classic-period Cerén. I argue that this all-too-common narrative of tubers as a marginal resource be rejected for the Middle Preclassic Pacific Coast, a much earlier context further from the Maya heartland. Here, root crops played a central role in the diverse suite of resources, including but not limited to maize, that quite literally fueled the city of La Blanca. In a later section of this chapter, I will demonstrate that these root crops played a central role in food processing, but for now I turn to discussion of the wild tubers exploited by La Blanca residents.

Wild Tubers

In contrast to tubers of domesticates, which I refer to as root crops, wild tubers do not demonstrate morphological signs of having been intensively managed by humans. Signs of domestication are often apparent in starch granule morphology, depending on the species and extent of damage. For example, the main domesticated species of yam in the Neotropics, *Dioscorea trifida*, consistently produces cunate granules with an eccentric and closed hilum, straight distal edge, and visible lamellae (Piperno 2006). The granule is somewhat compressed in profile. In contrast, starch granules from wild species of *Dioscorea* are not evenly cuneate with a straight distal edge, but many still retain a celt or axe shape (Piperno and Holst 1998:Figure 4). Several granules in the La Blanca assemblage fit this shape profile (Figure 17a-b).

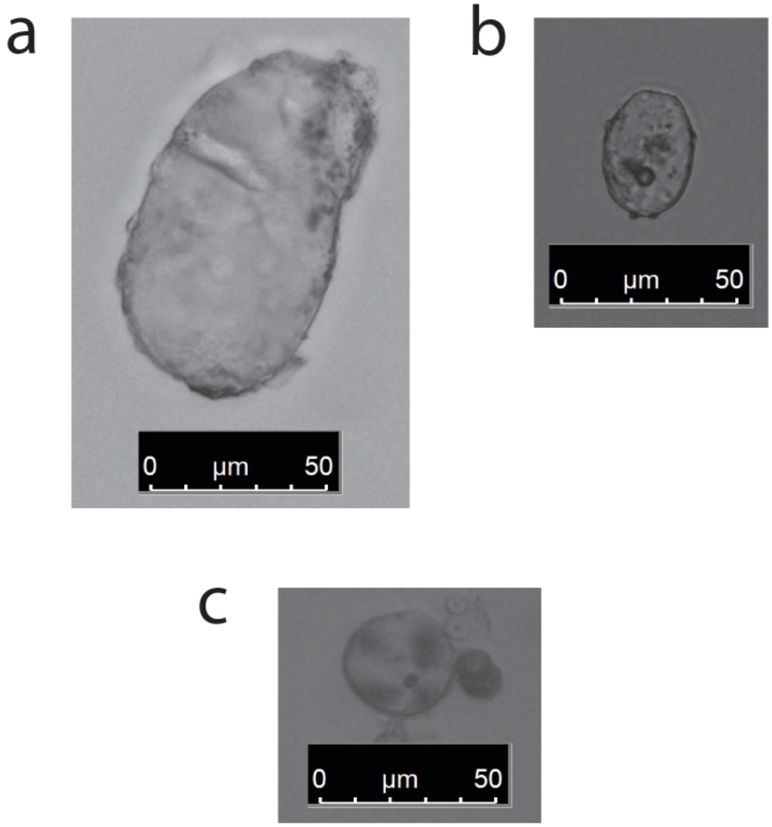


Figure 17. Wild tuber starch granules identified in La Blanca artifact residues: (a-b) Wild yam (Record # 276, 280); (c) Wild *Calathea* cf. (Record # 296).

Lerén (*Calathea allouia*), or the domesticated form of *Calathea*, is more difficult to identify than *D. trifida*. *Calathea macrosepala* has been recovered from the Piedmont areas of the San Marcos department (see Appendix A) but additional wild and/or domesticated species of *Calathea* could be native to the Pacific Coast as a systematic survey has yet to be conducted. A great diversity of Marantaceae and *Calathea* species exists in the Neotropics, leading to specimens consistent with *Calathea* to only be identified to genus even in guides of comparative modern specimens (Págan-Jímenez 2015). However, Págan-Jimenez and colleagues (2016) identified wild *Calathea* starch in archaeological residues from Ecuador by using modern specimens as a guide. The starches they sampled from the rhizome of wild *Calathea* spp., collected from Santo Domingo de los Tsachilas in Ecuador are:

> Mostly triangular with some variants. A pronounced convex margin is common at the distal section with a narrower proximal section. Hilum is closed and eccentric, hardly observable. General size range is from 3.5 to 28.3 µm with a mean size of 13.6µ (±7.02). Lamellae consist of regular and very smooth concentric rings. No fissures were noted and the Maltese cross is eccentric, mainly a cross shape with straight arms or wavy arms in a few occasions. No pressure facets were registered [Págan-Jimenez et al. 2016:Appendix E].

One starch granule from the La Blanca assemblage has morphological features matching this description (see Figure 17b), specifically its roughly triangular shape, eccentric hilum, and size which falls toward the high end of the observed range (27.85 x 29.37 µm). However, this identification could not be made with confidence or to species because reliably filtering out other possibilities within Marantaceae and *Calathea* is difficult. Making these identifications requires collaborating with a botanist who has expert knowledge of other possibilities on the local landscape as there are numerous species belonging to Marantaceae or *Calathea* that grow in the Neotropics and possibly on the Pacific Coast.

In summary, starch granules consistent with morphological features of wild yam (*Dioscorea* sp.) and tentatively wild *Calathea* (*Calathea* sp. cf.) are present on manos, metates, figurine mouths, and ceramic vessels from the La Blanca site. Thus, not only did La Blanca residents choose to grow domesticated root crops, but they also collected tubers from wild species to incorporate into meals. Bolstering this finding is another subset of tuber starches in the La Blanca assemblage that matches expectations for potato (*Solanum* sp.), which is discussed separately below to provide detail on the source, taxonomy, and domestication status.

Speciating Potato Starches. Artifact residues from La Blanca contained forty starch granules consistent with potato and eight granules tentatively identified as potato (*Solanum* sp. cf.). Most of these starches originated from Object 47, a plate rim sherd, but two grinding stones, a vessel base, a vessel rim/side, and a miniature vessel also contained potato starch granules (Appendix E). Small, wild potatoes are native to the uplands of Guatemala (*Solanum agrimonifolium*, *S. bulbocastanum*, *S. clarum*, *S. demissum*, *S. morelliforme*) and Mexico (*Solanum* spp.; Hijmans and Spooner 2001; Spooner et al. 1998).

Non-native potatoes also have a history of use in Central America. The introduction of cultivated Andean potatoes, *Solanum tuberosum*, into the region has traditionally been considered to have postdated European contact. More specifically, the introduction of *S. tuberosum* into Central America has been considered to have been a product of European colonists relocating potatoes from South America to Europe, and then back to Central and North America. However, recent genetic studies (Spooner et al. 2010; Zhang et al. 2010) comparing Central American potatoes, *S. tuberosum*, and cultivars from North America (Ozette, Kasaan, To-Le-Ak, Maria's) indicate that a purely post-Columbian origin story is unlikely. In addition to sharing genetic markers with Andean cultivars, certain *S. tuberosum* collections from Mexico and Central America contain the 241-bp plastid DNA deletion which is found in 81-86% of Chilean but only 5-6% of Andean landraces based on studies by Hosaka (2004) and Spooner and colleagues (2007). Although the timing of *S. tuberosum*'s entry into Central America is a topic deserving of future research, it is presently clear that humans transported *S. tuberosum* landraces from both the Andes and other parts of Chile into Central America before European contact.

The notion that both *S. tuberosum* and wild potato species (e.g., *S. agrimonifolium*, *S. bulbocastanum*, *S. clarum*, *S. demissum*, *S. ehrenbergii*, *S. hjertingii*, *S. morelliforme, S. pinnatisectum*, *S. stoloniferum*, *S. verrucosum*) could have been present in Central America by the time of the La Blanca occupation affects the speciation of potato starch granules from this assemblage. Wild potatoes of Mexico and Guatemala (see species list above) are largely considered edible but small, not necessarily a first-choice food (Spooner et al. 1998). Potatoes of *S. tuberosum* would have undergone years of human-mediated selection before arriving in Central America, making tubers of this species larger. Distinguishing whether La Blanca residents selected *S. tuberosum* or wild tubers thus offers tantalizing clues as to whether wild tubers served as food in a time and place that had many other available options.

Archaeological starch granules are most easily speciated when viewed alongside comparative specimens. Staff at the USDA/ARS U.S. Potato Genebank sent me a combination of curated and lab-cultivated fresh tubers representing eleven species of potato (Table 8). Collection locations for all modern specimens are depicted in Figure 18, though in some cases the collection location falls outside of the species' native range. The sample set includes species that are not native to the study area: domesticated (*S. tuberosum, S. tuberosum* ssp. *andigenum*)/cultivated (*S. phureja*) potatoes from the Andes and wild potato from southwestern North America (*S. jamesii*). Sampled species from Mesoamerica include wild potatoes native to northern, central, and Pacific Mexico (*S. hjertingii*, S. *ehrenbergii*, *S. pinnatisectum*, *S. stoloniferum*, *S. verrucosum*) and the east-central uplands of Guatemala (*S. bulbocastanum*, *S. demissum*). Wild potatoes native to Guatemala have been collected from the Baja Verapaz, Chimaltenango, Guatemala, Huehuetenango, El Progreso, Quetzaltenango, Quiché, Sacatepéquez, Sololá, Totonicapán, and San Marcos departments (Spooner et al. 1998). Notably, the La Blanca site (20 m in altitude) is located in the San Marcos department but wild potatoes grown here are typically found at higher altitudes of 1350-3800 m (Spooner et al. 1998:Table 1).

Table 8. Metadata for Comparative Wild and Cultivated Potatoes Sent by the USDA/ARS U.S. Potato Genebank.

Lab Name	Accession	Name	Taxonomy	Origin	Source Date	Elevation	Habitat
jam	PI 605370	BMPF 072	*Solanum jamesii* Torr.	New Mexico, United States	9/15/98	2200	Under pines and junipers on E-facing slope above roadway.
hjt	PI 251065	HAW 1357	*Solanum hjertingii* Hawkes	Coahuila de Zaragoza, Mexico	-	2100	Scrub forest, rich soil under Mahonia trifoliata, Pinus cembroides and Juniperus monosperma.
blb	PI 283096	HAW 1719	*Solanum bulbocastanum* Dunal	Oaxaca, Mexico	-	-	Shaded by trees in loose humus-rich soil.
cph	PI 597678	HJT 95-7	*Solanum ehrenbergii* (Bitter) Rydb.	Querétaro, Mexico	8/28/95	2100	Zone of Bursera, Jatropha dioica, minosoid scrub, and large candelabran cactus. W and SE facing slopes and ledges of lava rocks.
pnt	PI 184774	HAW 1105	*Solanum pinnatisectum* Dunal	Guanajuato, Mexico	9/16/49	2000	In a maize field, very dry soil.
Criolla	-	Criolla (2x cultivated)	*Solanum phureja*	Columbia	-	-	-
sto	PI 161170	COR 14246	*Solanum stoloniferum* Schltdl.	Hidalgo, Mexico	11/8/47	-	In gravelly soil along the roadside.
ver	PI 275255	HAW 1527	*Solanum verrucosum* Schltdl.	Michoacán de Ocampo, Mexico	-	2950	Among bushes and herbs on the edge of a Abies forest, W of the road.
dms	PI 230589	RDD 178	*Solanum demissum* Lindl.	Ciudad de México, Mexico	-	3000	-
Early Gem	-	Early Gem (modern cultivar)	*Solanum tuberosum*	-	-	-	-
Andean	PI 281034	WAC 911	*Solanum tuberosum* L. subsp. andigenum (Juz. & Bukasov) Hawkes	Mexico	-	-	-

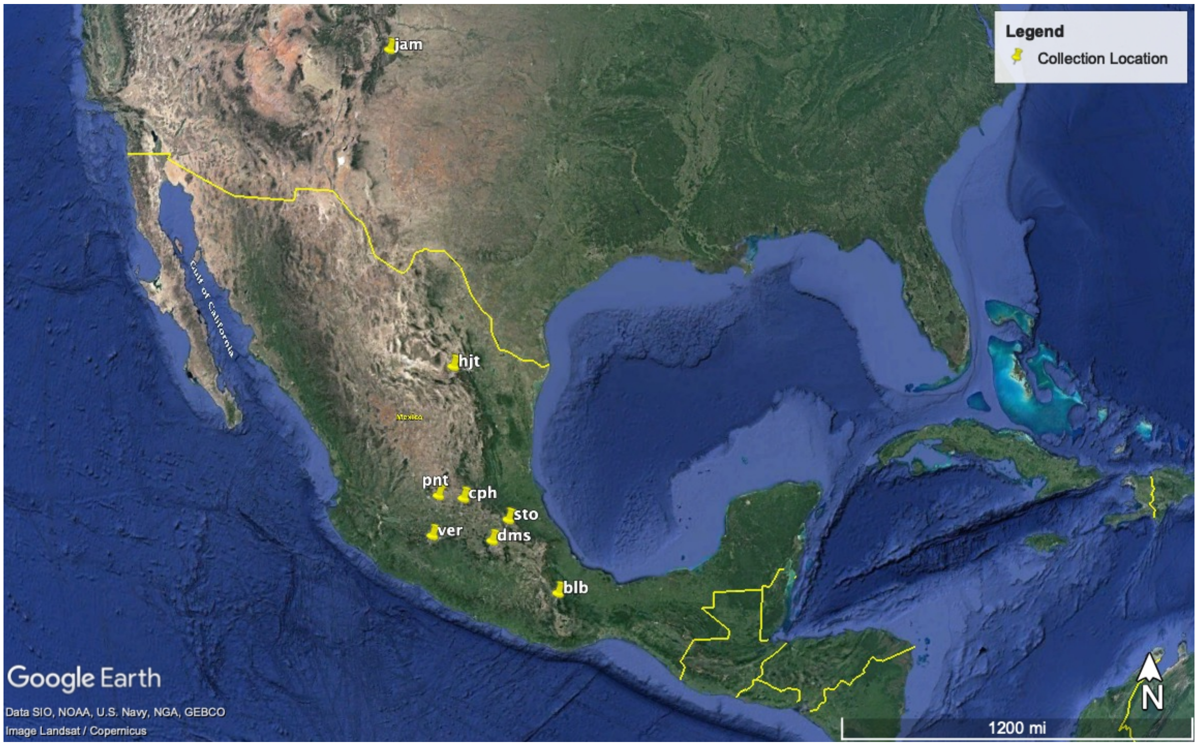
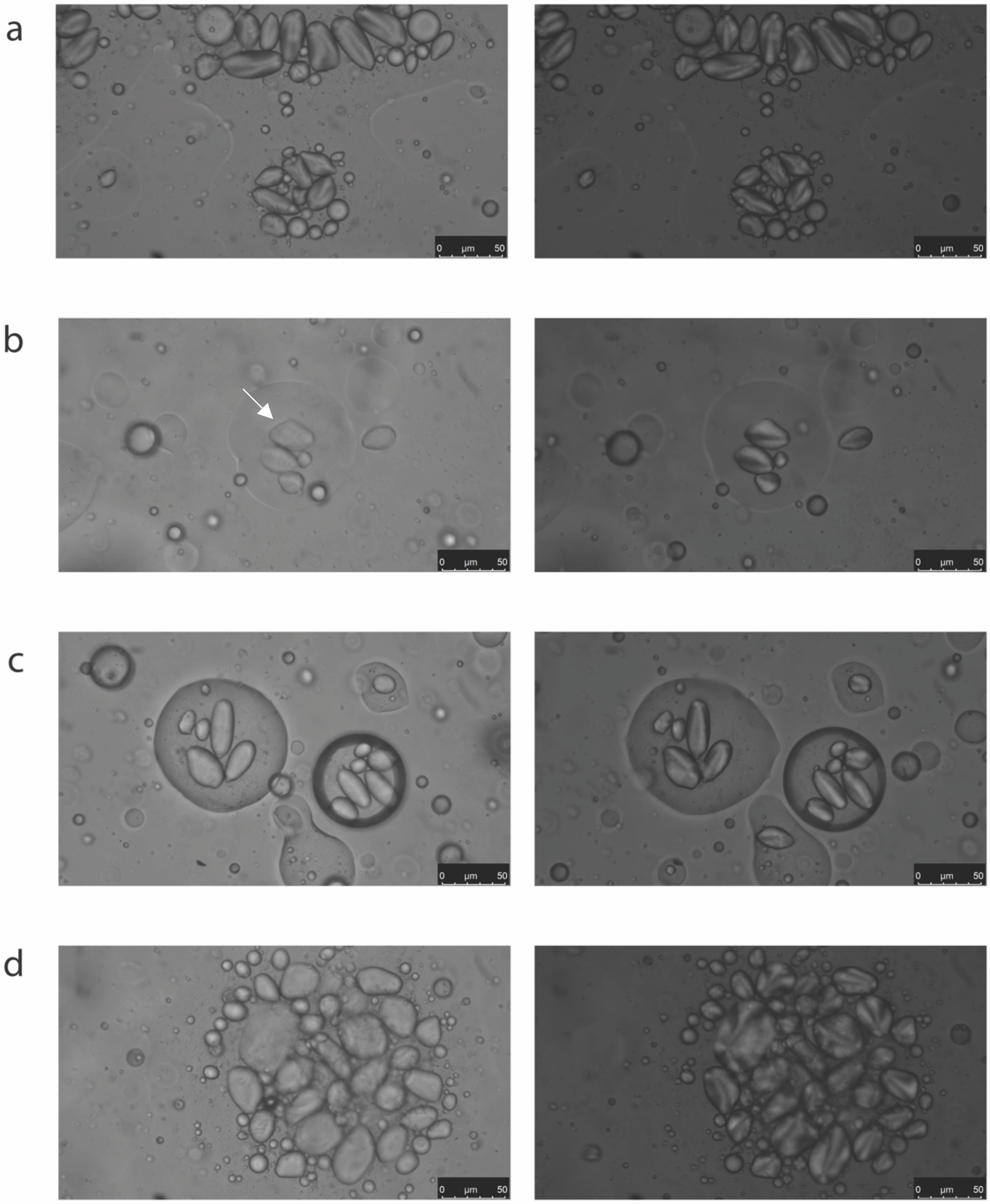


Figure 18. Map of collection locations for several potatoes sent by the USDA/ARS U.S. Potato Genebank and sampled for comparative starch analysis. Note that collection locations do not necessarily correspond to native ranges of the sampled specimens.

My collection and analysis of starch granules from modern comparative specimens followed standard procedures. A small portion of each tuber was removed with a sterilized dissection probe and transferred into a microcentrifuge tube. A few drops of 1:1 glycerin to water solution were then added. The mixture was swirled with a sterilized metal toothpick and the suspension was pipetted onto glass slides for analysis. Contamination controls followed procedures outlined in Chapter 4. All comparative and archaeological micrographs generated by the current study are hosted under the La Blanca Botanical Data (2020 NSF) project on The Open Scientific Framework (https://osf.io).

Micrographs illustrate marked variability in size within starch assemblages from all sampled potatoes, while shape appears to be a better diagnostic indicator of species (Figure

19). Starch granules of *S. tuberosum* tend to be ovate, with some specimens being narrower or wider than others. Although granules may be slightly distended in one direction or the other, the angle between the maximum limit of distention and the two ends tends to be <90 degrees. In contrast, the same measurement is usually >90 degrees on any distended starch granules of the sampled wild potatoes from Central America.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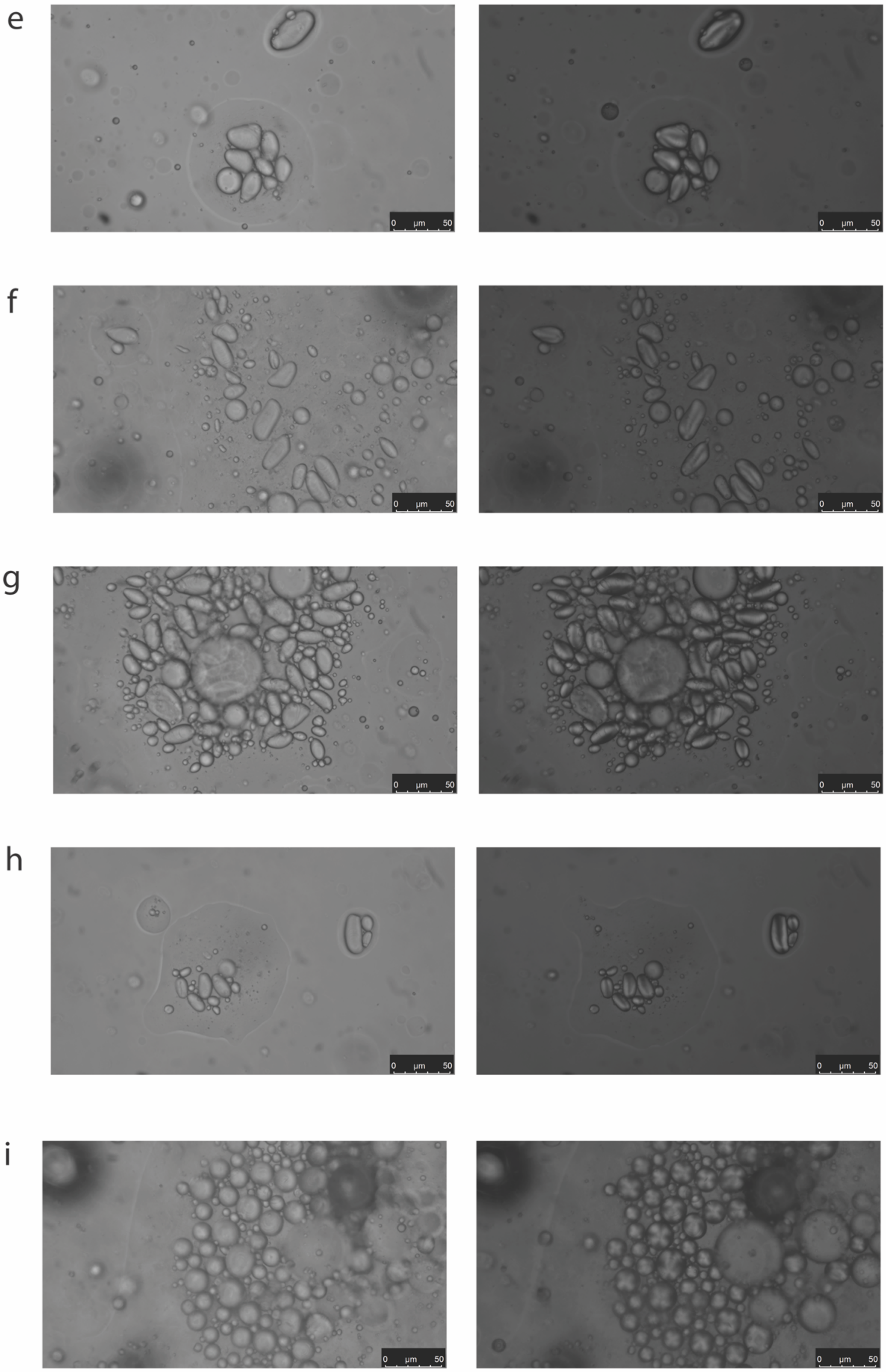
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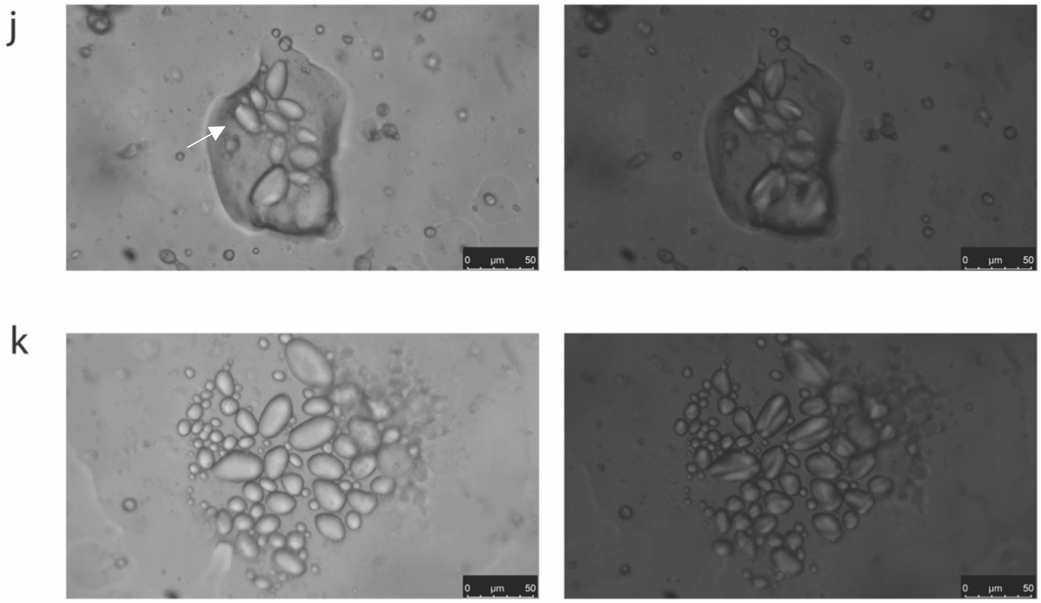


Figure 19. Comparative potato starches from USDA samples: (a) hjt (*Solanum hjertingii*); (b) blb (*Solanum bulbocastanum*); (c) cph (*Solanum ehrenbergii*); (d) pnt (*Solanum pinnatisectum*); (e) sto (*Solanum stoloniferum*); (f) ver (*Solanum verrucosum*); (g) dms (*Solanum demissum*); (h) jam (*Solanum jamesii*); (i) Criolla (*Solanum phureja*); (j) Andean (*Solanum tuberosum* subsp. *andigenum*); (k) Early Gem (*Solanum tuberosum*). Arrows in (b) and (j) indicate triangular-shaped starches.

Although variation in granule shape is present in every species, each species has one or more characteristic shapes. *S. tuberosum* and *S. bulbocastanum* both produce triangular-shaped starches (see arrows in Figures 19b and 19j), but those of the former are more regular than those of the latter. Triangular starches in *S. bulbocastanum* have less straight, more irregular edges with slight undulations along them. *S. ehrenbergii* produces elongated ovate granules with some measuring over 50 µm in length. Nearly all *S. phureja* starches are spherical. *S. demissum* is one of the most variable assemblages, including tear-drop shaped, triangular, and large ovate starches. *S. hjertingii* matches or exceeds the variety of shapes present in *S. demissum*, with wedge-shaped, ovate, and spherical starches. While starch size is not a good predictor for Central and South American landraces, the only North American potato sampled, *S. jamesii*, produces comparatively smaller starches. *S. pinnatisectum* starches are generally large, often presenting as wide ovals with blurry internal morphology. *S. stoloniferum* produces spherical starches that are around the same dimensions as those seen in *S. demissum*. *S. verrucosum* produces distinctive rectangular-ovate starches that resemble parallelograms; similar starches were not found in any of the other comparative assemblages.

I consider the potato starches from La Blanca to represent wild potatoes native to Central America (*Solanum*, species unspecified) based on characteristics of the La Blanca potato starch assemblage as a whole and uncertainty surrounding the timing of the entry of Andean potatoes into Central America. Some of the potato starches identified in the La Blanca assemblage closely match those produced by *S. bulbocastanum* (native to the Huehuetenango and Baja Verapaz departments of Guatemala) and *S. pinnatisectum* (native to central Mexico). For example, several starches collected from a plate rim sherd (Object 47) have a triangular shape and somewhat undulating edges, with the angle between the maximum limit of distention and the two ends being less than 90 degrees. Based on observations, these starches resemble those produced by *S. bulbocastanum* (Figure 20a). One starch with a triangular shape (see Figure 20b) has straight edges but a more centric hilum than observed in *Solanum tuberosum*. This starch most closely matches *S. pinnatisectum* as this species produces triangular-shaped starches with straight sides and the most centric hilum of the triangular starches encountered in this study. An example of a starch most consistent with *S. pinnatisectum* comes from the interior of a miniature vessel (Object 100). This starch is especially large and does not have many visible lamellae but, like starches from *S. pinnatisectum*, its size and the poor visibility of internal morphology do not appear to be a product of damage (Appendix F).

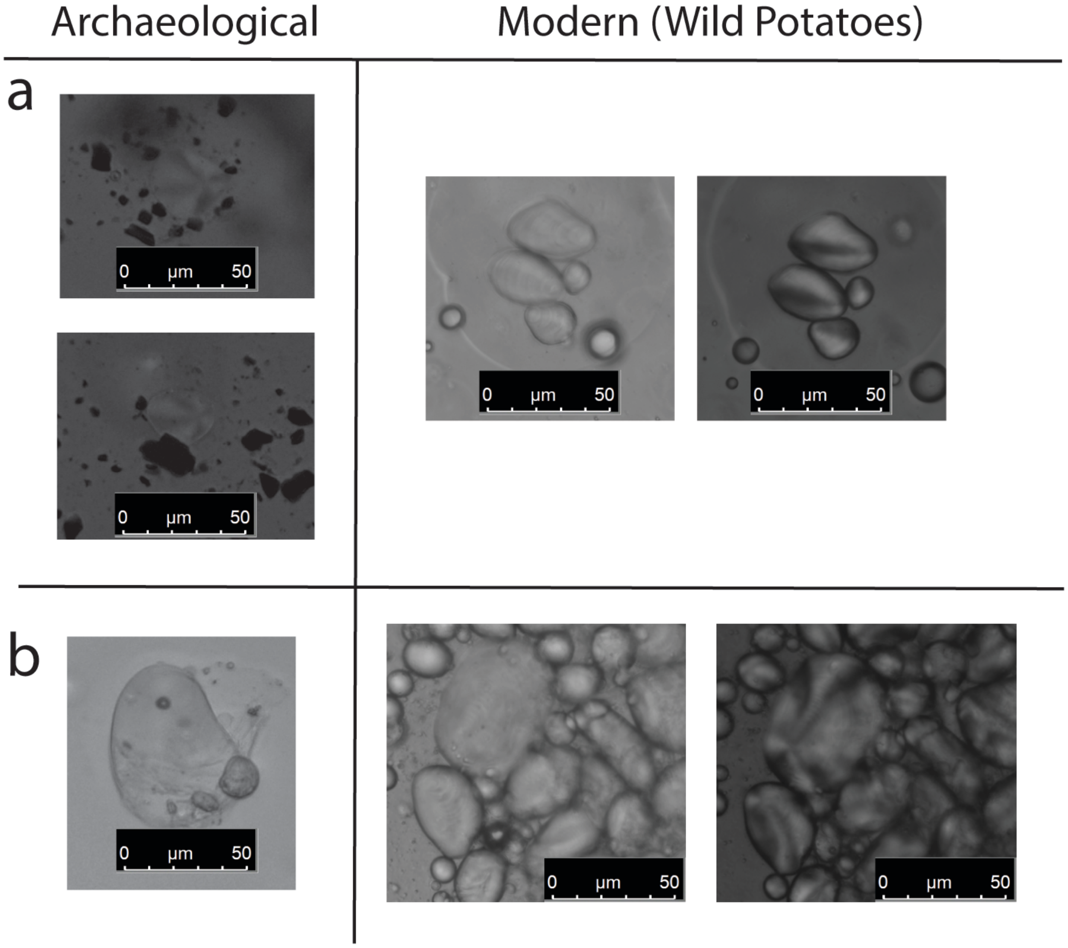


Figure 20. Side-by-side comparisons between archaeological (left) and modern potato starches (right): (b) Record # 389 (top), 391 (bottom), *Solanum bulbocastanum*; (b) Record # 381, *Solanum pinnatisectum.*

More research is needed on using starch granule morphology to speciate Central American potatoes. The interpretive power of the observations of comparative specimens presented in the current study is somewhat limited by the fact that only one potato was sampled from each group. A study with a larger sample size would be able to better assess the impacts of different growing conditions, plants, and tubers on the sizes and shapes of potato starches. Regardless of species, the La Blanca potato assemblage still provides clear evidence of exchange with more upland locations (e.g., near Huehuetenango) where elevations are sufficiently high to grow potatoes. Better understanding of variety in the shapes and sizes of wild potato starches at the species level could later open the doors for species level identification of potato starches in the La Blanca assemblage.

Miscellaneous

The miscellaneous category includes identifications that could not be classified into the previous categories. Some identifications could only be made to the family level, such as palm family (Arecaceae), grass family (Poaceae), and bean family (Fabaceae). In other cases, specimens could possibly be associated with one of two taxa from different plant families (e.g., *Calathea*/Wild yam [*Calathea* sp./*Dioscorea* sp.]). The miscellaneous category also includes small seeds that could possibly represent incidental inclusions dispersed by wind instead of by people (e.g., sedge [*Cyperus* sp.], Mexican copperleaf [*Acalypha mexicana*]). Additionally, counts of unidentified and unidentifiable specimens are placed in this category.

Native grasses and shrubs with counts reported in the miscellaneous category provide valuable insight into environmental conditions. However, it should be noted that the degree to which this list comprehensively reflects local ecology is biased by certain factors such as whether seeds of a specific plant are typically carbonized by humans or swept into fires by wind. Wetland habitats are indicated by carbonized seeds of certain grass-like plants and shrubs, including sedge, beak-sedge (*Rhynchospora* sp.), and jointvetch (*Aescynomene* sp. cf.). Other identified plants, Mexican copperleaf (*Acalypha mexicana*) and paspalum (*Paspalum* sp. cf., tentatively identified), grow primarily in brackish and saltwater environments (Flores-Olvera et al. 2016). Thus, the La Blanca site appears to have been situated in proximity to not only freshwater sources (e.g., rivers and lagunetas), but also brackish and salt water.

There is evidence to suggest that residents used land on or near the La Blanca site for cultivation and agriculture. Horse purslane (*Trianthema portulacastrum*) and Mexican poppy (*Argemone mexicana* cf.) commonly grow in disturbed areas and cultivated fields (Odero et al. 2013). Finding these resources in the La Blanca assemblage suggest that at least some field clearance and planting likely occurred near the site. Deer, one of the main animals to target fields, often consume canegrass (*Eragrostis* sp.; Gabriel 2006:95), tentatively identified in the La Blanca assemblage.

Certain miscellaneous taxa have high potential for food, economic, medicinal, and/or ritual use. For example, woods commonly used by the Yucatec Maya for timber (Kunow 2003; Nishida 1999; Roys 1931) and fuel (Dussol et al. 2021) include *Beilschmledia* sp. and *Piscidia* sp., with the latter taxon considered to be particularly rot resistant (Patterson 1992:45). *Beilschmledia* also produces edible fruits (Blake 1919), while *Piscidia* leaves are not safe for human consumption and have traditionally been used as a fish poison in Jamaica (Patterson 1992:45). Piscidia is most common in dry forests but may also grow in more saturated soils (Pennington and Sarukhan 1968:218). Leafy branches of *Piscidia piscipula*, often referred to as habin by the Yucatec Maya, are often used in agricultural ceremonies where branches are bent to form a canopy over altars (Patterson 1992:44). Medicinal plants identified at La Blanca include bec (*Ehretia tinifolia*), used to treat headaches and ulcers (Kunow 2003; Roys 1931). Purslane (*Portulaca* sp., *P. oleracea*), used to cure convulsions, heart pain, and spitting blood, also produces edible leaves (Kunow 2003; Roys 1931:220).

Piscidia is used as a treatment for cough, fever, asthma, and ringworm (Kunow 2003), and *Pereskia* has known anti-inflammatory properties (Guerra et al. 2018; Kunow 2003).

Modern ecological surveys suggest that La Blanca residents would have brought in one of these miscellaneous taxa, pereskia (*Pereskia* sp.), from elsewhere. The La Blanca macrobotanical assemblage contains one confidently identified and 53 tentatively identified seeds. Only one species, *Pereskia lynchnidiflora*, is native to Guatemala (Véliz 2008) but its range is far from the La Blanca site. It is instead prevalent in the drier departments of El Progreso, Zacapa and Chiquimula to the northeast, closer to the border with Honduras (Véliz 2008:76). The detection of *Pereskia* in the La Blanca assemblage suggests that residents formed social connections with distant regions that allowed them to gain access to unfamiliar medicinal plants. Thus, though the city of La Blanca certainly underwent important internal developments over the course of its social lifespan, it is important to also acknowledge that this center did not exist in a vacuum. Rather, it appears to have been a nexus within a mosaic of complexity (see Rosenswig 2011) whereby residents of more populous and rural settlements frequently participated in social negotiations and exchanges. The following section shifts the focus from the types of plants selected by La Blanca residents to how they used these plants in their daily lives.

Food Processing

Starch and phytolith data produced by the current study demonstrate evidence of edible and inedible plants that do not often preserve in the macrobotanical record due to factors such as decomposition of unburned material or human consumption of edible portions (Dickau et al. 2007; Sandweiss 2007). Morphological changes in starch granules can also be induced by a variety of human activities involved in food preparation, including grinding, boiling, baking, freeze-drying, fermentation, nixtamalization, and more (Henry et al. 2009). Identification of these changes has allowed for the development of specific morphological signatures that can be used to recognize evidence of food-related activities in the archaeological record (e.g., Fullagar et al. 2006; Johnson and Marston 2020; Melton et al. 2020a).

In this section, I discuss the results of starch and phytolith analyses with respect to insights into food preparation at La Blanca. Ground stone equipment, such as the mano and metate combination, have long been a feature of foodways in Pacific Guatemala (Figure 21). Based on the ubiquity of starch granules and phytoliths in La Blanca artifact residues, sampling of artifacts used in processing and/or cooking food has high potential to yield starch granules indicative of the practices used in preparing them for consumption (Table 9). Phytolith analysis focused on identifying domesticates, keeping with the focus of this study, rather than seeking to assess environmental conditions more broadly.

Figure 21. Photograph of Doña Aura Ramírez demonstrating how to use her grandmother's mano and metate. Doña Aura resides in Pueblo Nuevo, Guatemala.

Table 9. Detection of Starches and Phytoliths in Residues from La Blanca Artifacts.

				Phytolith Sediments			Starch Sediments		
Object	Op	Sub	Artifact Description	1	2	3	1	2	3
4	49	2	Mano	N	-	-	N	N	N
6	50	1	Grinding stone	N	-	-	-	-	-
9	50	1	Sherd	N	-	-	N	-	N
10	50	2	Sherd	N	N	-	N	-	N
11	50	2	Metate	N	N	N	N	N	N
12	50	2	Mortar	N	-	-	N	-	-
13	50	1	Sherd	N	N	N	N	N	N
18	51	1	Sherd	-	-	-	-	N	-
19	51	3	Metate	N	-	-	-	-	-
21	53	1	Metate	N	N	N	-	-	-
23	53	4	Grinding stone	N	N	N	N	N	N
25[a]	37	2	Human face vessel	-	N	N	-	-	-
26 (143)[a]	32	3	Jaguar face vessel	-	N	N	-	Y	N
27 (137)[a]	32	4	Jaguar face vessel	-	-	N	-	-	Y
28[a]	32	2	Human face vessel	-	N	N	-	N	N
29 (131)[a]	34	2	Human face vessel	-	N	N	-	N	Y
30	55	4	Metate	-	N	N	-	-	-
34	55	3	Metate	-	-	-	N	-	-
38	55	4	Grinding stone	N	N	-	N	N	-
41	50	3	Sherd	N	N	N	N	N	N
42 (145)	50	3	Rim sherd	N	N	N	N	-	Y
43	50	3	Mortar	N	N	-	N	N	-
44 (139)	50	3	Sherd	N	Y	N	N	Y	N
45	55	3/5	Metate	N	N	N	N	N	N
46	55	3/5	Mano	N	N	N	N	N	N
47	57	1	Plate rim sherd	N	Y	N	Y	Y	N
48	57	1	Flaring rim jar sherd	N	N	N	N	N	N
49	50	3	Stone ball	N	Y	N	N	N	N
50	55	4	Bowl rim/base	N	N	Y	N	N	N
52	50	3	Vessel base	N	-	N	N	N	N
56	50	3	Stone ball	N	N	Y	N	-	N
57	57	1	Vessel base	N	N	N	N	Y	N
58	55	2	Vessel rim/side	N	Y	N	N	N	Y
59	56	3	Mano	N	N	-	N	N	N
61	57	5	Mano	Y	N	Y	Y	N	Y
62	57	5	Grinding stone	Y	N	N	N	N	N
63	57	5	Vessel rim/side	N	N	N	N	Y	N

64	57	5	Rim sherd	N	N	N	N	Y	Y
66	57	3	Vessel rim/side	N	N	N	Y	N	N
69	57	3	Figurine mouth	N	N	-	N	Y	-
70	57	3	Rim sherd	N	Y	Y	N	-	N
71	57	5	Vessel rim/side	N	N	N	N	Y	Y
73	57	3	Figurine mouth	N	N	N	N	Y	Y
75	64	1	Grater bowl	N	Y	Y	N	Y	N
76	64	1	Vessel base	N	N	N	Y	N	-
77	64	3	Vessel rim/side	N	N	N	N	N	N
78	64	3	Vessel base	N	N	N	Y	N	Y
79	64	3	Vessel base	N	N	N	-	N	Y
80	64	1	Complete vessel	-	-	-	N	Y	N
82	64	1	Grinding stone	-	-	-	Y	N	Y
84	65	2	Grinding stone	N	N	N	N	Y	N
85	64	1	Grinding stone	N	N	N	Y	Y	Y
86	64	1	Grinding stone	N	N	N	N	Y	Y
87	65	5	Vessel rim/side	N	N	N	N	Y	Y
88	66	1	Vessel base	N	N	N	N	N	N
89	66	1	Grater bowl	N	N	N	N	Y	Y
90	66	1	Recycled tool fragment	-	-	-	N	N	N
93[a]	65	5	Bark beater	-	-	-	-	N	N
95	66	1	Stone ball	N	N	N	N	N	Y
97	66	1	Stone ball	N	Y	-	N	N	N
99	66	1	Figurine mouth	-	-	-	N	N	Y
100	66	4	Miniature vessel	-	-	-	N	N	Y
106	66	3	Metate	N	N	Y	N	Y	Y
107	66	3	Metate	N	N	N	N	Y	N
108	66	3	Stone ball	N	N	Y	N	Y	N
110	66	5	Metate	N	N	Y	N	N	N
111	67	3	Vessel rim/side	Y	N	N	N	Y	N
112	66	3	Metate	N	N	N	Y	-	N
113	66	3	Miniature mano	-	-	-	Y	N	Y
114	37	8	Mortar	Y	N	N	N	N	N
115	41	8	Vessel rim/side	N	N	N	N	N	N
116[a]	32	9	Stone ball	-	N	N	-	Y	N

[a] Washed before sampling

Note: Y = analyzed samples with findings; N = analyzed samples without findings. Dashed line indicates sample not analyzed for this study.

Phytolith Results

Analysis of phytoliths focused on the identification of specific morphotypes and taxa: wavy top rondels from maize cobs, scalloped spheres from squash rind (*Cucurbita* sp.), and seed phytoliths from *lerén* (*Calathea allouia*). Over the course of analysis, a few non-domesticate phytoliths were identified and counted (see Table 7). It is important to note that the presented results do not reflect a systematic count using the standard 200 phytoliths per slide approach (Piperno 2006; Zurro 2018). Small numbers of cross bodies and rondels were encountered, but they are classified as general grass family (Poaceae) because the small assemblage size makes a maize identification via discriminant function analysis of cross bodies (Pearsall 2015; Piperno 1984, 1988) potentially problematic. No evidence of burning or cultural damage could be found on any encountered phytoliths.

Most of the assemblage (Figure 22; Appendix G) consists of taxa that could be found in background vegetation, including palms (Arecaceae) and grasses (Poaceae). A member of the sedge family (Cyperaceae cf.), a grass-like taxa typically found in wetlands, was tentatively identified. A possible secretory cell of manioc (*Manihot esculenta* cf.) represents the only identified domesticate. Given that phytoliths are often in inedible plant portions, the fact that artifact residues from La Blanca produced more starches than phytoliths should not be surprising. Future studies sampling phytoliths in soils may offer a productive avenue for improving our understanding of background vegetation and paleoenvironment at the La Blanca site. For now, results of the phytolith study only tentatively echo macrobotanical and starch findings indicating a wetland environment and the presence of root crops.

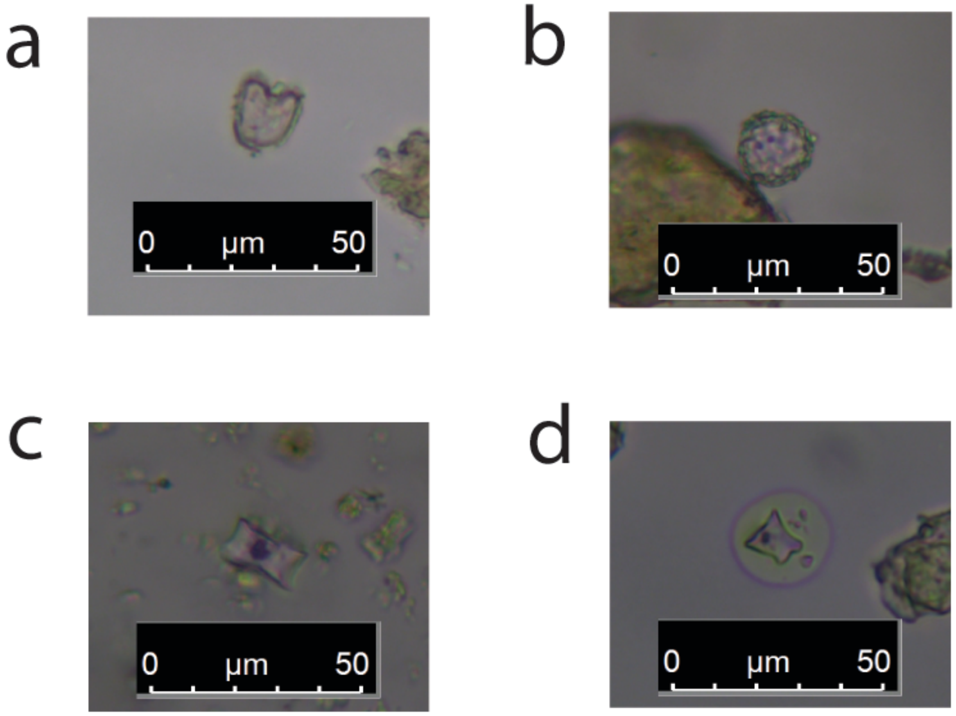


Figure 22. Phytoliths identified in La Blanca artifact residues: (a) Manioc secretory cell cf. (Record #427); (b) Palm family (Record # 404); (c-d) Grass family (rondel) (Record # 425, 411).

Starch Results

Starch granules offer the most promising source of information regarding food processing activities at La Blanca. Food preparation and preservation activities can result in diagnostic alterations to starch granules that are indicative of the source(s) of damage (Henry et al. 2009; Johnson and Marston 2020; Li et al. 2020; Thoms et al. 2015). Goals for starch analysis of La Blanca residues were two-fold: (1) identify the types of plants processed; and (2) ascertain how residents processed these plants.

The study revealed a much greater variety of starch taxa than expected (see Table 6) based on previous microbotanical research on La Blanca artifact residues. Pearsall and colleagues (2016) identified maize starches (n = 58) on every artifact type (e.g., mano, metate, pottery, figurine) sampled from the La Blanca assemblage; fifty-eight of chili pepper (*Capsicum* sp.) was also identified, but in much smaller numbers, with two granules identified and four tentatively identified. One granule consistent with *Manihot* sp. (the genus that includes manioc) was also identified. Unfortunately, the field team washed all artifacts sampled by Pearsall and colleagues (2016) along with other artifacts in shared basins prior to sampling. The current study in contrast has the benefit of building on this foundation by sampling mostly unwashed artifacts that were largely collected from new areas of the site excavated in the last few years. My personal supervision of artifact removal, handling, and sample collection helped to mitigate the risks of contamination.

The current study revealed starches of maize, root crops, and wild tubers with evidence of damage (Table 10; see Appendix F). Just over 23% of starches have evidence of damage. Grinding is the number one source of damage, followed by thermal damage from boiling or baking. Thermally damaged starches did not have adequate preservation of morphology to allow for discrimination of boiling versus baking damage.

Table 10. Damage Sources for Starch Granules Identified on La Blanca Artifacts.

Damage Source	Count	Percent of Starches	Contexts	Taxa Represented
Grinding	19	6.76%	Vessel base (#57); Mano (#61); Figurine mouth (#69, 73); Rim sherd (#70); Grater bowl (#75); Complete vessel (#80); Grinding stone (#82, 85, 86); Metate (#106); Jaguar face vessel (#143); Sherd (#145)	Maize; Maize cf.; Yam; Wild yam; Wild potato; *Calathea* cf.; *Calathea*/Wild yam; Unidentified; Unidentifiable
Possible grinding	8	2.85%	Vessel base (#57); Mano (#61); Grinding stone (#85); Jaguar face vessel (#143); Plate rim sherd (#47);	Arrowroot cf.; Unidentified; Unidentifiable
Physical (other)	4	1.42%	Rim sherd (#64); Metate (#107); Human face vessel (#131)	Unidentified; Unidentifiable

Thermal (boiling/baking)	15	5.34%	Mano (#61); Vessel rim/side (#63, 71, 87, 111); Grater bowl (#75); Grinding stone (#85, 86); Figurine mouth (#99); Miniature vessel (#100); Sherd (#139); Stone ball (#116)	Arrowroot; Wild yam; Wild *Calathea* cf.; *Calathea*/Wild yam; Root crop; Wild potato; Wild potato cf.; Unidentified; Unidentifiable
Possible thermal	4	1.42%	Vessel base (#78); Grinding stone (#85, 86); Metate (#106)	Wild potato; Wild potato cf.; Manioc cf.; Unidentifiable
Grinding and thermal	3	1.07%	Metate (#107); Vessel rim/side (#111); Grater bowl (#89)	Arrowroot; Root crop; Unidentified
Possible grinding and thermal	1	0.36%	Sherd (#139)	Arrowroot
Unknown	11	3.91%	Vessel rim/side (#58, 71); Figurine mouth (#69); Grinding stone (#82, 85, 86); Plate rim sherd (#47); Jaguar face vessel (#143); Stone ball (#116)	Arrowroot; Arrowroot cf.; Manioc; Manioc cf.; Sweet potato cf.; Unidentified
Total	65	23.13%	-	-

Note: Physical (other) damage includes flattening and minor cuts along the margin that could not be easily attributed to grinding.

Damage analysis of La Blanca starches produces findings that allow for more precise identification of the roles of different artifacts in food preparation or service. For example, grater bowls that began to be produced in the Río Naranjo area during the Conchas phase have long been thought to have been used for some type of maize or spice preparation but identified starches (Figure 23) are from tubers (arrowroot, *Calathea*/Wild yam, and *Calathea* cf.). Moreover, some of these starches have evidence of thermal damage, in addition to or aside from grinding damage.

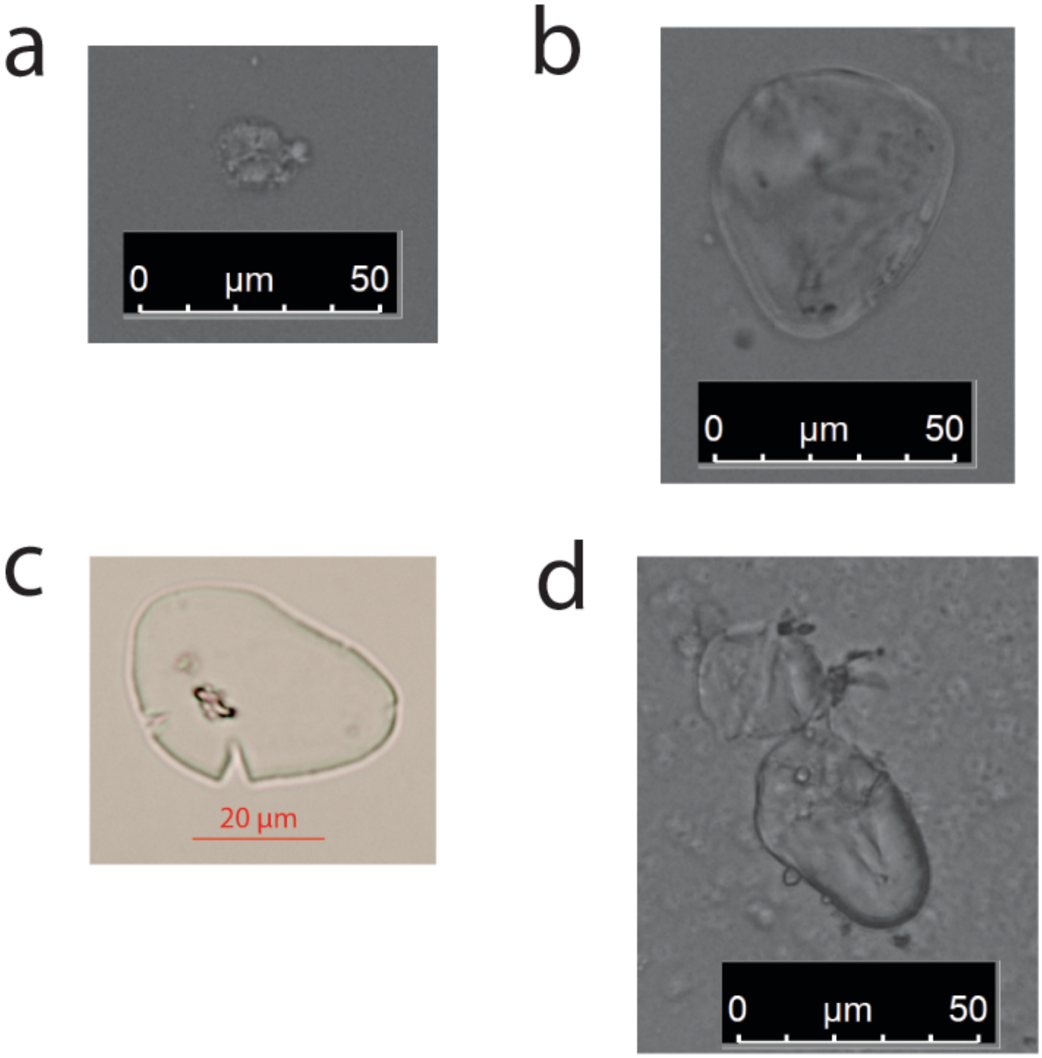


Figure 23. Damaged starches recovered from La Blanca artifact residues: (a) Maize, grinding damage (Record # 298); (b) *Calathea*/Wild yam, thermal damage (Record # 303); (c) Arrowroot, grinding and thermal damage (Record # 105); (d) Wild potato, thermal damage (Record # 334).

Tubers prepared using grater bowls and many other artifacts, including manos, metates, and stone balls were boiled or baked before being ground. Thus, it appears that, in addition to producing flour, La Blanca inhabitants boiled/baked and then ground their root crops into pastes before adding them to meals. There is no evidence of thermal damage on maize starches, meaning that this is a food preparation technique exclusive to tubers. These boiled/baked and ground tubers also appear on ceramic cooking wares, indicating that the paste produced from boiling/baking and grinding was then re-added to meals cooked in ceramic pots. Residents even added thermally altered (but not ground) wild potato starches to a miniature vessel that, without starch analysis, might be typically considered more of a decorative than utilitarian object. La Blanca thus offers a case study for the beginnings of a chaîne opératoire (Sellet 1993) of tuber production among the Middle Preclassic Maya of the Pacific coast. My starch granule analysis not only reveals how people processed food, but also relationships between food and non-culinary artifacts such as figurines.

Feeding Figurines

Figurines played a key role in social relations at the La Blanca site. While it is tempting to focus on evidence for social stratification (e.g., jade bead distributions, differences in house quality), the use histories of figurines provide evidence of interconnectedness between households (see Chapter 2). Handheld ceramic figurines of humans and animals explode in popularity on the Pacific Coast during the Middle Preclassic period (Guernsey 2020). These figurines are ubiquitous in households at La Blanca. Guernsey's (2012, 2020) research explores the use histories of Middle Preclassic figurines and other forms of sculpture on the Pacific coast. Her investigations into spatial patterning of figurines at La Blanca have revealed that body parts are broken off and exchanged between households as a means of expressing social connections and articulating personhood (Guernsey and Love 2019). Figurines are thus emblematic of the social bonds forged between humans at La Blanca, yet they also hold potential for exploring interactions between human, figurines, and ancestors.

Open-mouthed figurines, a subset of the La Blanca assemblage, depict human faces with prominently gaping mouths (Guernsey 2020:70). The functions of these open mouths are poorly understood. One possible explanation is that the mouths could serve as spaces for interacting with ancestors depicted in the figurines. Ancestor veneration is a central component of Mayan religious practice even as far back as the Preclassic period (Guernsey 2010). Feeding of these open-mouthed figurines would offer a plausible means of enlivening these ancestors and bringing them into everyday practice. However, to support an argument that La Blanca residents fed their open-mouthed figurines, it is necessary to explore whether food remains show up in these spaces and, if so, what types of food remains are present.

Microbotanical sampling methods were used to carefully collect residues only from the mouths of open-mouthed figurines at the La Blanca site (see Chapter 4). Three of the six sampled figurines yielded starch granules (Figure 24). Recorded starches include maize, root crops (arrowroot, yam, *Calathea* cf.), wild yam, and unidentified/unidentifiable starches (Table 11). These starches are unlikely to represent contamination due to the rigorous sampling procedures which focused only on artifacts collected from the field that day/week. Moreover, these starches only derived from residues close to the artifact surface, Sediments 2 and 3 (wet brushed and sonicated, respectfully). In all cases, Sediment 1 represented a dry brushing of the entire figurine head to control for potential contamination, and no granules were found in these samples.

Figure 24. La Blanca figurines with identifiable starches from collected mouth samples: (a) Object 69, Op 53 Sub 3 Level 9 Element B; (b) Object 73, Op 57 Sub 3 Rasgo 269; (c) Object 99, Op 66 Sub 1 Level 11.

Table 11. Starch Granules Found in the Mouths of Figurines Excavated from La Blanca.

Artifact	Figurine mouth	Figurine mouth	Figurine mouth
Object	69	73	99
Op/Sub	Op 57 Sub 3	Op 57 Sub 3	Op 66 Sub 1
Context	Nivel 9B	Rasgo 269	Nivel 11
Taxa identified			
Field cultigens			
Maize	-	1[a]	-
Maize cf.	-	1[a]	-

Root crops			
Arrowroot	3	-	-
Calathea cf.	-	1[a]	-
Yam	-	1[a]	-
Wild tubers			
Wild yam	1	-	-
Miscellaneous			
Unidentified	1	-	-
Unidentifiable	1[a]	-	1[b]

[a] Grinding damage

[b] Thermal damage

Many of the starches collected from the mouths of sampled figurines have signs of cultural alteration. All starches from Object 73 (maize, *Calathea* cf., yam) and one unidentifiable starch from Object 69 demonstrate evidence of grinding (see Table 11). Signs of thermal damage, perhaps from boiling or baking, are evident on the unidentifiable starch from Object 99 (see Table 11). The morphological changes (e.g., fractures radiating from the hilum) seen on maize and potential maize granules from the figurine mouths match those of maize starches recovered from a grinding stone (Object 82) and metate (Object 106). The yam granule found in a figurine mouth (Object 73) has a similar morphological signature to a yam granule from a rim sherd (Object 70) with evidence of severe grinding damage. Thermal damage is also present on granules from food processing and cooking equipment sampled in this study, such as grater bowls and ceramic vessels (see Food Processing section above).

Starch findings from the open-mouthed figurines suggest that they were intentionally fed processed plant foods used for subsistence at the La Blanca site. Foods for figurines included maize (a field cultigen), root crops, and a wild tuber (*Dioscorea*). These foods appear to have been prepared for figurines in much the same way that they were prepared for human consumption. Most of the foods used to feed figurines were ground, some beyond recognition. One granule from a figurine suffered thermal damage to such an extent that it could not be identified taxonomically. These damage patterns match examples, even representing the same taxa, seen on food processing equipment. These lines of evidence suggest that certain open-mouthed figurines were brought to life at La Blanca through the process of feeding them foods also consumed by humans at the site. In this way, open-mouthed figurines (and the ancestors they likely represented) would have not only played roles in forging connections between households, but also between past/present, spiritual/physical, and deceased/animate worlds. Botanical evidence helps to support extant arguments regarding the immense overlap between these worlds, particularly those of the dead and living, in Mayan cosmology and the integration of ancestors into the practices of living people (Gillespie 2002; Guernsey 2012; Guernsey and Love 2019; Love and Rosenswig 2022; McAnany 2013). The present study contributes evidence that this fundamental connection between worlds was expressed as early as the Middle Preclassic period when figurines were fed as living entities at La Blanca. Having detailed the basic botanical findings on a qualitative basis, the next step in unraveling the daily inner workings of La Blanca is to look to statistical analysis to further explore patterning in the plant data.

CHAPTER 6: SPACE AND SUBSISTENCE: DESIGNING URBAN LIVING

Urban living is a collaborative process in which social relationships play out across a built landscape. Household groupings may signify nuanced relations with social, economic, and/or political significance. Hutson (2016) situates neighborhoods as a defining attribute of ancient urban spaces, particularly in the Maya region. Focusing on the Maya Lowlands, he argues that archaeologists may find neighborhoods in even low-density urban centers if appropriate approaches are used to detect them. Similarly, Smith (2010, 2011a) notes that using specialized habitation zones, which he calls neighborhoods and districts, as a key criterion for detecting ancient cities avoids biases introduced by traditional definitions based on expectations for European and Near Eastern cities (see Chase et al. 1990). Thus, the identification of neighborhoods is a valuable tool for defining urban spaces of the Americas but also, and perhaps more importantly, investigating how these spaces were used by inhabitants over the course of a city's life cycle from founding to occupation and, eventually, abandonment.

The investigation of neighborhoods at the La Blanca site offers a valuable window into the relationship between space and meaning in the earliest cities of Mesoamerica. Moreover, the site's long history of around three hundred years of continuous occupation during the Middle Preclassic Conchas phase offers a rare opportunity to investigate how its inhabitants rearticulated that relationship over time. The necessary inclusion of plant remains in their daily practice makes this material type ideal for assessing the significance of neighborhoods generated using other techniques. This chapter begins by presenting statistical approaches to assessing feature function and identifying neighborhoods at the La

Blanca site. Botanical findings are then considered in context with the identified neighborhoods to explore patterning within and across these social nodes of the city.

Feature Types and Their Uses

The botanical sampling strategy at the La Blanca site targeted Conchas phase features identified in residential areas of the site. The most frequently sampled feature types include house floors, large trash pits, smaller trash pits, walls, and artifact concentrations. Large trash pits are remarkably wide, filled with refuse (e.g., ceramics, animal bone, plants), and tend to be located outside of residences. Smaller trash pits include features with a wide range of profiles that have a smaller spatial footprint than trash pits, include less refuse, and might be located inside or outside of residences. It is important to recognize that this distinction is qualitative, based on field observations of feature characteristics, not quantitative (e.g., significance testing of feature volumes for the two groups). Investigating the abundance of processing and consumption debris in different features has the potential to shed light on depositional practices at the site. I use statistical analysis of maize, including edible portions (kernels) and inedible portions (cupules), to evaluate the distribution of processing activity areas at the La Blanca site. Although the site has multiple occupations, all analyzed flotation samples date to the Conchas phase based on the latest results of ceramic analysis by Michael Love (personal communication 2022).

I compare maize abundances in samples based on density, calculated as count divided by soil volume for each sample (Miller 1988:73). Box plots of maize densities for different feature types reveal that artifact concentrations and pits have a higher concentration of maize than floors, and the difference is statistically significant (Figure 25). Interestingly, samples collected near walls have statistically more maize than those collected from large trash pits and floors. However, the sample size for the wall category is small, leading to folding over of both ends of the box and a weaker distribution in terms of interpretive value. Overall, this set of box plots indicates that lower concentrations of maize are generally present in samples from floors, which makes sense as these surfaces would have been regularly swept clean. To get a more precise sense of where certain types of debris were deposited, it is necessary to isolate and separately discuss kernel and cupule distributions.

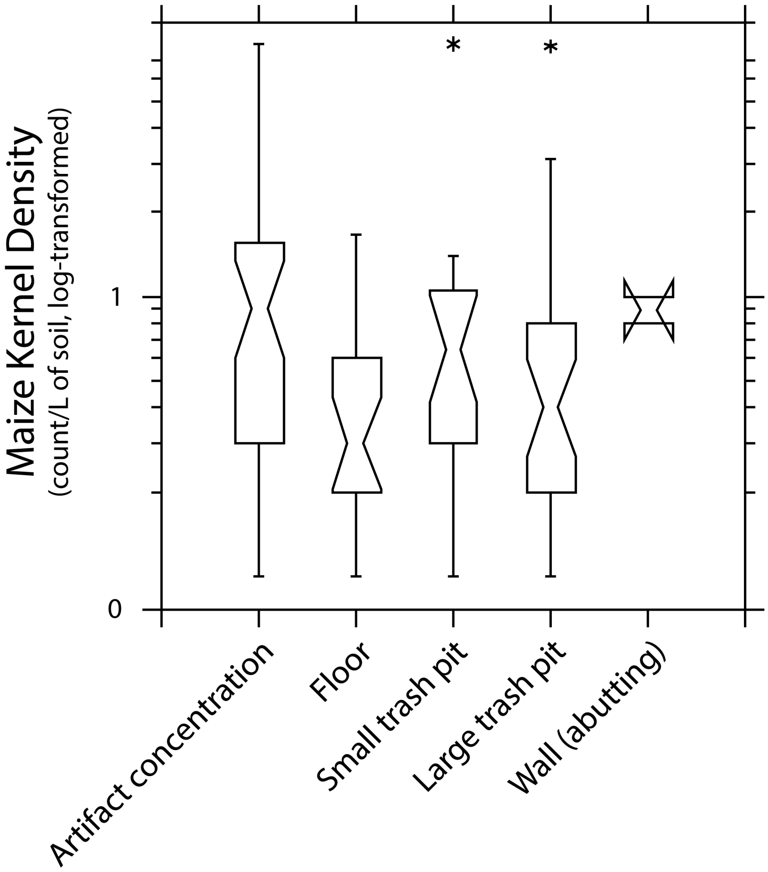


Figure 25. Box plots of maize densities by feature type. Y-axis is log-transformed.

Patterning in the distributions of maize kernels by feature type (Figure 26) strongly resembles the patterns for maize collectively (see Figure 25). Floor samples have statistically lower densities of maize kernels than those from pits or artifact concentrations. Thus, most edible debris is regularly cleaned from floors and deposited in pits (large trash pits and smaller pits), but occasionally gets trapped near walls. Cupule patterns indicate that both floors and large trash pits have significantly lower maize cupule densities than artifact concentrations and other pits (Figure 27). Large trash pits thus typically contain less maize processing debris than smaller pits and artifact concentrations.

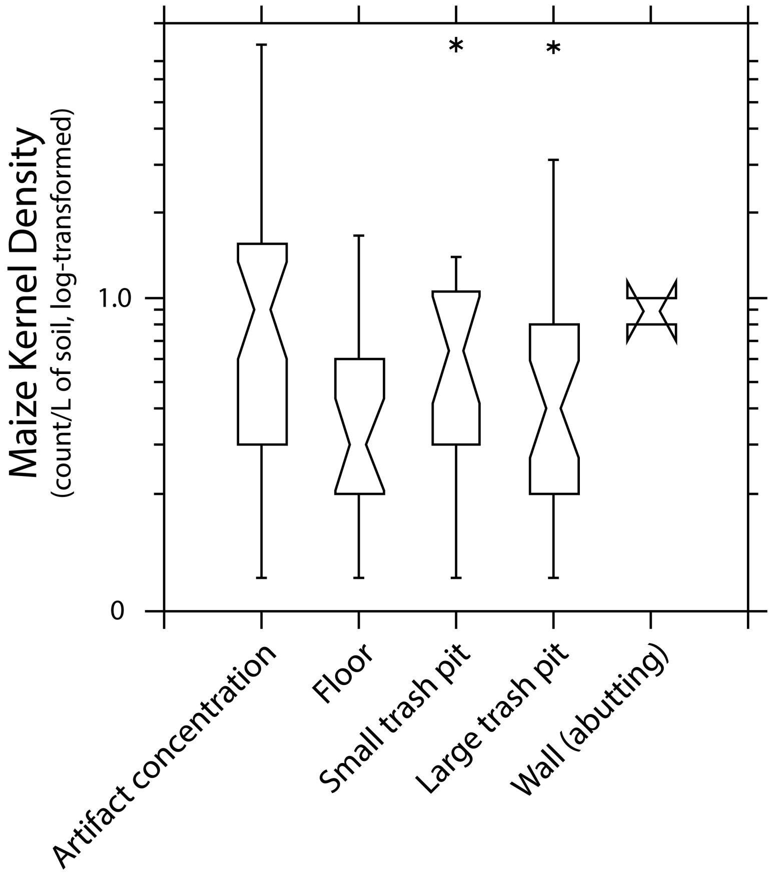


Figure 26. Box plots of maize kernel densities by feature type. Y-axis is log-transformed.

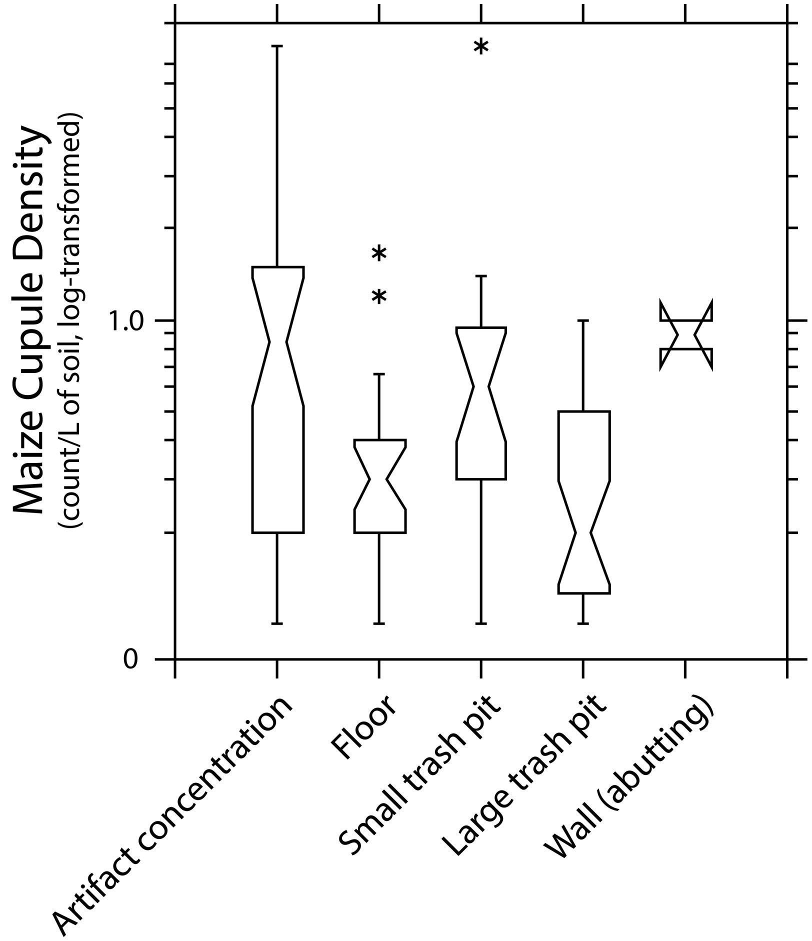


Figure 27. Box plots of maize cupule densities by feature type. Y-axis is log-transformed.

Large trash pits at La Blanca tend to be located adjacent or in proximity to houses (see Love 2002a). They are usually filled with pottery but, in addition to botanical remains, can also contain figurines, lithic blades, jade beads, and animal bones. Other pits can be bell-shaped, conical, straight-walled, or other forms and located either inside or outside of houses. Artifact concentrations can also be located inside or outside of houses. These distinctions between features are important to point out because the statistically lower densities of maize cupules in large trash pits suggests that these otherwise rich deposits are less likely to be used to dispose of processing debris. Instead, maize cupules are more typically incorporated into other types of pits or general dumping sites (artifact concentrations). Processing activities also take place within houses as indicated by the appearance of cupules on floors, but statistically low concentrations indicate that they were regularly cleaned, aside from the cupules that inevitably got caught near walls and in corners.

Functional analysis of sampled botanical features provides uniquely valuable insights into how Middle Preclassic Maya peoples living on the Pacific coast managed their households. Raw counts demonstrate that more maize kernels were clearly present at the site than cupules. Maize cupule densities from the densest deposits (large trash pits) are considerably lower than those for kernels. Several explanations, or a combination of these explanations, are possible: (1) La Blanca inhabitants shelled most of their corn outside of domestic areas or off-site; (2) pre-processed corn was brought into the site from hamlets in the hinterlands. The first explanation seems more likely. Corn at the site was typically ground with a mano and metate or a mortar and pestle, a prerequisite for which is shelled kernels. Shelling activities conducted outside of homes and activity areas would present a low likelihood of entering the disposal contexts sampled in this study. The second explanation makes less sense because of the high transport weight of corn over long distances (particularly if stored in pots). Another reason is that the small hamlets surrounding La Blanca would have each consisted of around one to three households at most, meaning that there would have been few laborers to support the needs of those houses let alone meet the subsistence needs of a growing city. In supporting the first explanation, it is important to recognize that unprocessed corn would have also been brought home by families and stored in netted bags in the rafters to protect against pests (Johannessen

1982:88). These stores would have been useful in supplementing yields or ameliorate short-term food shortages, leading to the noticeable amounts seen in artifact concentrations, pits, against walls, and, less often, on floors. The topic of where processing debris are located at the site will be revisited after first exploring how domestic space is organized at La Blanca.

Spatial Analysis

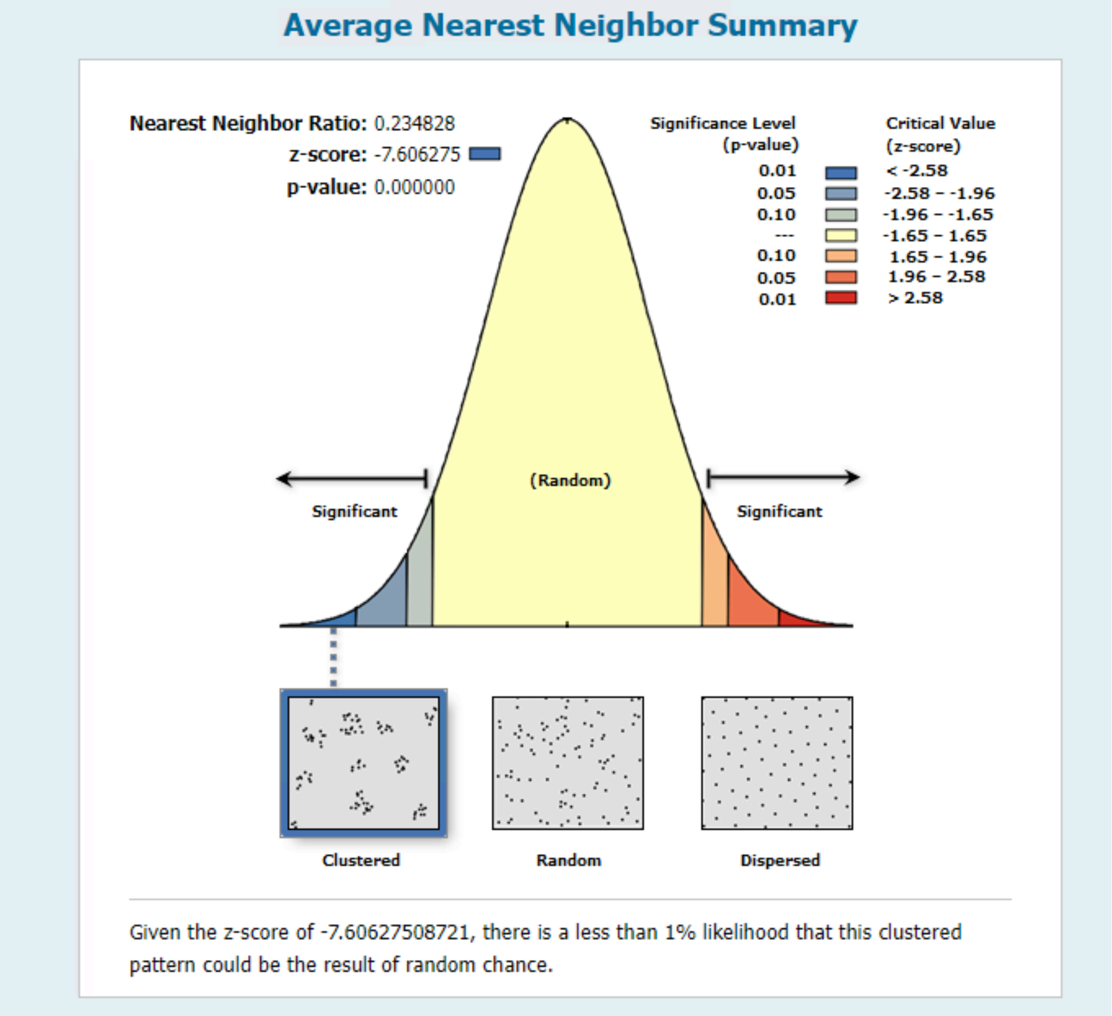
While the household is the smallest social unit (Netting 1989; Wilk and Netting 1984), the neighborhood is the building block of social interactions in a city. Neighborhoods can be occupied by individuals with different craft specialties, ethnic affiliations, social statuses, or other aspects of identity (Arnauld 2012; Hutson and Welch 2021; Smith 2010, 2011a; Smith and Novic 2012). Thus, studying the lived histories of neighborhoods and the relationships between them has great potential to illuminate multiple types of urban social interactions. I posit that evaluating activities at a neighborhood scale productively complements investigations of household status differentiation. Neighborhoods offer the potential for broad reflections on aspects of social differentiation that may be apparent through exploratory analysis of daily residues but cannot be easily characterized along traditional evaluative axes applied to households (e.g., social status, function). The regularity of plant use in daily life presents an ideal opportunity to evaluate the lived histories of neighborhoods over the course of La Blanca's occupation. However, before botanical patterns can be explored, it is essential to explore the potential for neighborhood identification at the La Blanca site.

Spatial analysis of neighborhoods at La Blanca focused on a few key goals. First, to determine if households at La Blanca are clustered significantly. Drawing neighborhoods subjectively allows for the possibility of different results every time. Quantitative measures with significance testing introduce fewer biases and produce replicable results. Second, using statistical analysis to detect neighborhoods and establish if they exist at the site. Third, applying any statistically meaningful neighborhoods to inform spatial comparisons of botanical results. Lastly, I use the results of my neighborhood analysis to broadly inform understandings of low-density urbanism (Fletcher 2011; Morrill 2006; Sharer and Traxler 2006) as applied to the city of La Blanca and the Middle Preclassic Pacific Coast more generally. The existence of and connections between neighborhoods reflect the degree of social integration within urban spaces (Hutson and Welch 2021). Thus, neighborhood analysis can critically comment on the qualities of La Blanca as an urban center. Three types of statistical tests were conducted using ArcMap 10.8.1: average nearest neighbor, multi-distance spatial cluster analysis, and Euclidean distance.

Average Nearest Neighbor

The Average Nearest Neighbor (ANN) spatial statistic generates an index based on averaging the distance from each feature to its nearest neighbor (ESRI 2022a). Five values are generated: Observed Mean Distance, Expected Mean Distance, Nearest Neighbor Index, z-score, and p-value. Z-score and p-value results provide significance values that determine whether to reject the null hypothesis of this statistic, which is that features are randomly distributed (ESRI 2022a). The Nearest Neighbor Index is another measure that helps to inform a determination of random or patterned clustering; if the index is less than 1, the pattern is clustered whereas if it is greater than 1, features tend to be randomly dispersed. Rather than identifying specific clusters, the Average Nearest Neighbor (ANN) statistic provides a general sense of whether a distribution is clustered to a degree that exceeds expectations for a random distribution. As this metric is most useful for analyzing points within a fixed study area, it is ideal for analyzing the distribution of units excavated across the La Blanca site. The statistic was run on a polygon feature class of excavated two by two-meter units produced using total station data collected during fieldwork; default program settings were applied.

ANN results indicate that the distribution is clustered (Figure 28). The p-value is <0.0000001 and the z-score is -7.606275, less than the critical value of -2.58 and thus statistically significant. In fact, the program determined that there is a less than one percent likelihood that the pattern is a result of random chance (see Figure 28). A discerning critic would be quick to point out that a distribution of excavated units does not necessary reflect the distribution of households. However, each of the excavated units except for Operation 25 (which likely represents a public building) is situated atop a house mound identified via pedestrian survey. Therefore, the distribution of units included in the ANN reflects at least a portion of identified households within a given area of the site. These households were selected for maximum site coverage rather than intensive excavation of a given area, meaning that selection bias has a low impact on the distribution of features included in ANN analysis. One can thus conclude that clustered result is not a product of artificial bias, but an indication that sampled households are arranged in a clustered pattern. While the ANN result of significant clustering is intriguing, measuring the size of observed clusters requires the integration of another method, Multi-Distance Spatial Cluster Analysis.



Nearest Neighbor Ratio: 0.234828
z-score: -7.606275 🟦
p-value: 0.000000

Significance Level (p-value)		Critical Value (z-score)
0.01	🟦	< -2.58
0.05	🟦	-2.58 - -1.96
0.10	⬜	-1.96 - -1.65
---	🟨	-1.65 - 1.65
0.10	🟧	1.65 - 1.96
0.05	🟧	1.96 - 2.58
0.01	🟥	> 2.58

Given the z-score of -7.60627508721, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 28. Summary of Average Nearest Neighbor results.

Multi-Distance Spatial Cluster Analysis

Multi-Distance Spatial Cluster Analysis (MDSCA), also called Ripley's K Function, determines whether features are statistically clustered or dispersed over a range of measured distances (ESRI 2022b). This statistic can help to determine the size of clusters across the site. The MDSCA analysis can help to recognize if the ANN analysis detected a clustered distribution, but only one large cluster, versus many smaller clusters. MDSCA can also detect the size of clusters. The spatial statistic was run on the same polygon feature class of excavation unit outlines on which the ANN analysis was performed. MDSCA was run without a specified Weight Field to generate a confidence envelope based on data permutations and to explore the clustering/dispersion of feature locations (ESRI 2022b). This confidence envelope was computed based on 999 permutations of the data (~99.9% confidence level) in which the set of points is randomly distributed 999 times per iteration. For each distance, the Observed K values with the greatest difference above and below the Expected K value set the limits of the confidence envelope (ESRI 2022b).

The MDSCA results indicate that clustering of geographic features (in this case, unit centroids) is most pronounced by around 100 m of distance (Figure 29). When no Weight Field is specified, the distance at which clustering is most pronounced is dictated by the highest value of DiffK (157.732773, 100 m), representing the difference between Expected K and Observed K values (Table 12). Dispersion between unit centroids becomes statistically significant by around 400 m, reaching the lowest DiffK value by ~460 m. These results indicate that at around 100 m distance one is likely to encounter another 4 m^2 domestic area, but by around 400 meters from the first point one is likely to be outside of the initial cluster. In other words, households at La Blanca are clustered at around the 100 m distance, but become statistically dispersed by 400 m.

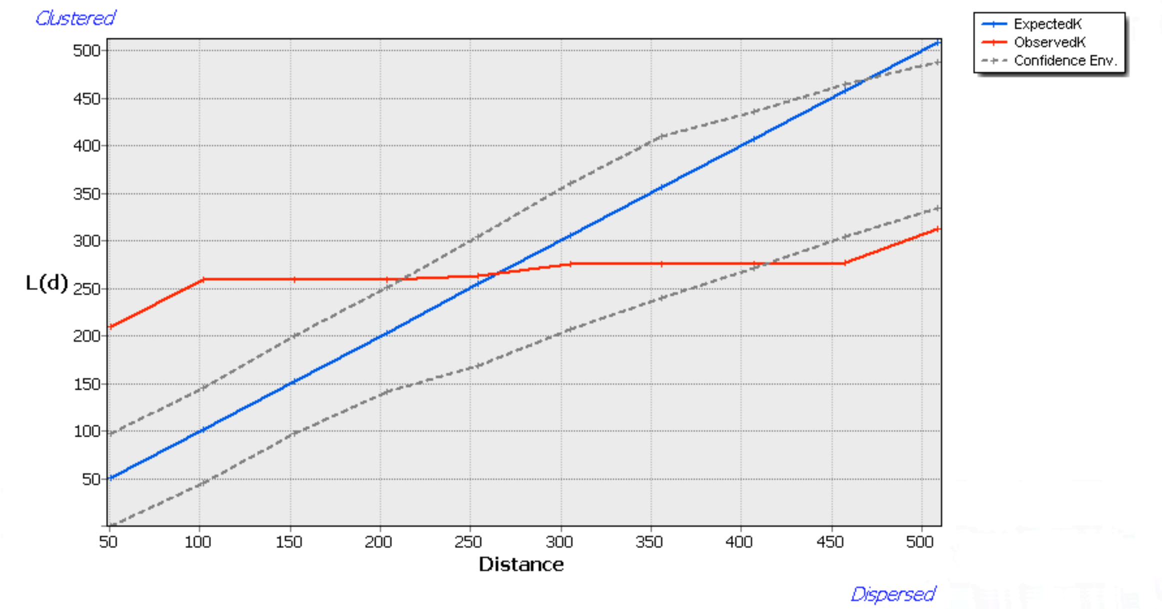


Figure 29. Results of Multi-Dimensional Spatial Cluster Analysis (Ripley's K) on polygons of unit outlines at the La Blanca site. The red line maps the Observed K value (spatial pattern from inputted data), while the blue line charts Expected K (spatial pattern based on random distribution). Dashed gray lines mark the limits of the confidence envelope, outside which statistically significant values fall.

Table 12. Statistical Output of Multi-Dimensional Spatial Cluster Analysis (Ripley's K).

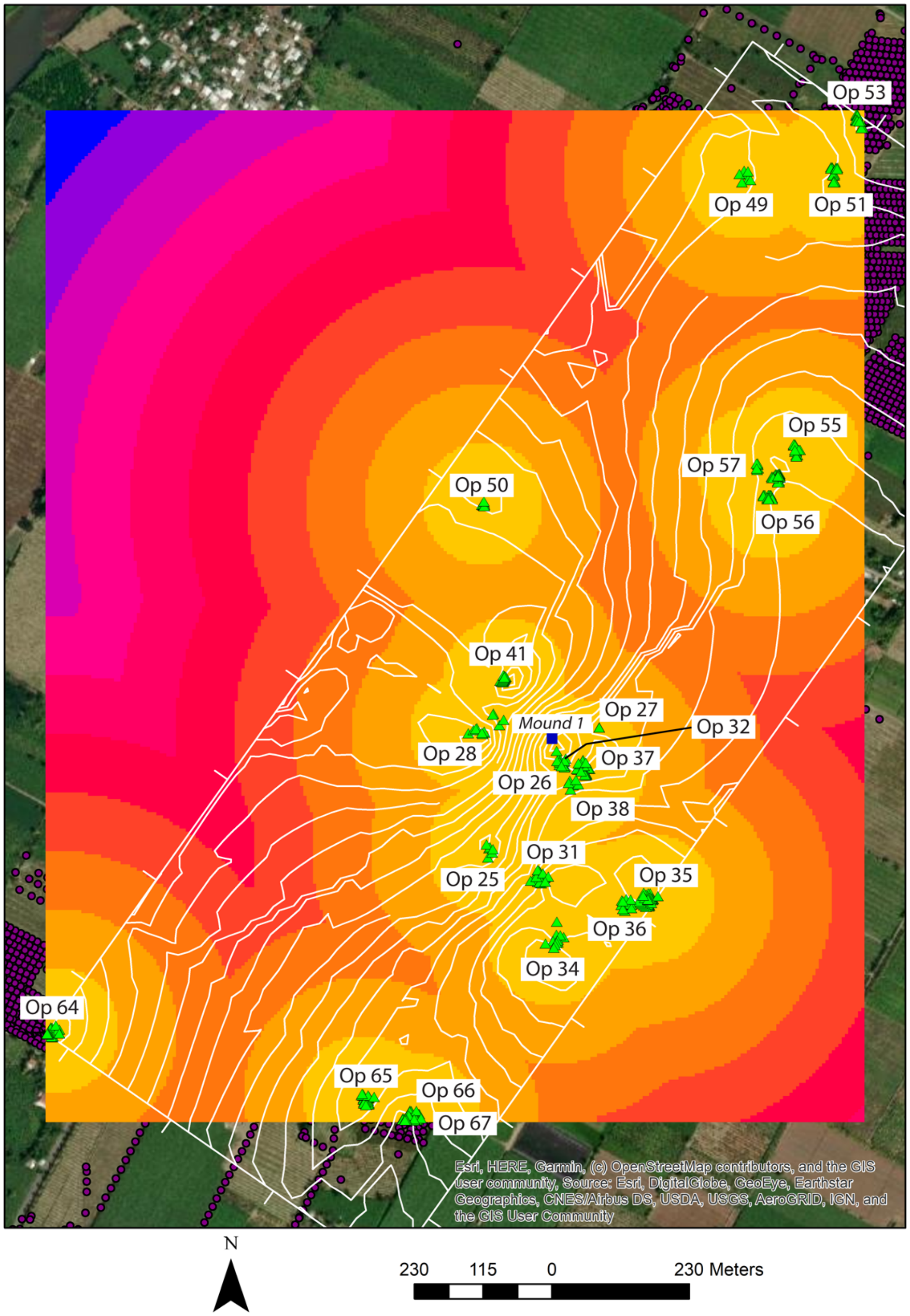
Distance (m)	ExpectedK	ObservedK	DiffK	Low Confidence Envelope	High Confidence Envelope
50	50.855975	210.174248	159.318272	0	97.291772
100	101.711951	259.444724	157.732773	45.863781	158.876798
150	152.567926	259.444724	106.876798	91.727562	207.6571
200	203.423902	259.444724	56.020822	137.591343	242.688317
250	254.279877	263.467363	9.187486	171.606555	293.671487
300	305.135852	275.182686	-29.953167	205.109064	335.464637
350	355.991828	275.182686	-80.809142	242.688317	362.585025
400	406.847803	275.182686	-131.66512	280.857152	399.831173
450	457.703779	277.087087	-180.61669	309.368116	433.89173
500	508.559754	312.749289	-195.81047	327.532909	462.06479

We can conclude two major findings from the MDSCA results. First, the MDSCA supports ANN findings that excavation units at La Blanca, located on house mounds, are clustered in a manner that defies expectations for randomly distributed points. Both the ANN and MDSCA analyses support the hypothesis that domestic space was clustered on the landscape at La Blanca. Second, MDSCA indicates that clusters of residences at La Blanca are between 100-400 m in diameter, with the most clustering at 100 m. It is notable that results of the ANN and MDSCA analyses alone do not prove that neighborhoods, or house groups, existed at La Blanca. More evidence, including archaeological findings, are needed to bolster this hypothesis.

Euclidean Distance

A third and final spatial analysis tool, Euclidean Distance (EuD), can help to define clusters of points on a landscape. EuD converts locations in feature classes to a raster before performing the analysis and then measures the Euclidean distance from each cell to the closest source (ESRI 2022c). A point feature class with total station-mapped unit corners and excavation locations was used to calculate EuD as a higher number of geographic features would ultimately produce a more nuanced raster for analysis. The EuD tool was run with default settings applied.

Results of EuD analysis identified several domestic clusters (Figure 30). Each Operation, or excavation area, is encircled by a buffer zone in yellow. Overlapping buffer zones clearly indicate areas where houses exhibit clustering. Notably, Operations that are close together are located ~100-200 m away from one another, reinforcing the MDSCA results that suggested a cluster size of between 100-400 m. All clusters identified through the EuD analysis fit that general size range. In summary, all spatial tools indicate that habitation areas are clustered at La Blanca. MDSCA identified that clusters tend to range from 100-400 m in diameter, while Euclidean distance drew clusters of this size on the landscape independently of the previous analysis. However, spatially significant clustering does not directly translate to socially significant neighborhoods. Contextualizing these statistical results in relation to previous work at La Blanca is a first step in investigating neighborhoods and their use histories at this site.



Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 30. Euclidean Distance analysis of La Blanca excavation locations. Euclidean distance output overlays contour map of the site produced in SURFER based on total station-mapped elevations. Green triangles represent corners of excavation units mapped using a total station. One excavation area mapped here, Operation 27, could not be incorporated into the analysis as unit corner locations are not mappable. This area was later added to the output map using Adobe Illustrator, but its location fits well with produced clusters. The location of Mound 1 was also added to the map following analysis.

From Clusters to Neighborhoods

Excavations at La Blanca began near the center of the site, in and around Mound 1 (see Chapter 2). Since Michael Love's investigations of this area began in the 1980s, pedestrian survey has covered an expansive area surrounding this central zone in attempt to determine the boundaries of the settlement. In 2014, Love submitted a Senior Grant proposal to the National Science Foundation for funds to excavate three likely habitation areas (detected via systematic pedestrian survey) within the approximate site boundary. In the proposal he referred to these new habitation areas, along with the previously excavated zone as districts (Figure 31). The proposal was funded and excavations of these three additional districts took place from 2016-2017, the botanical data from which are included in the current study.

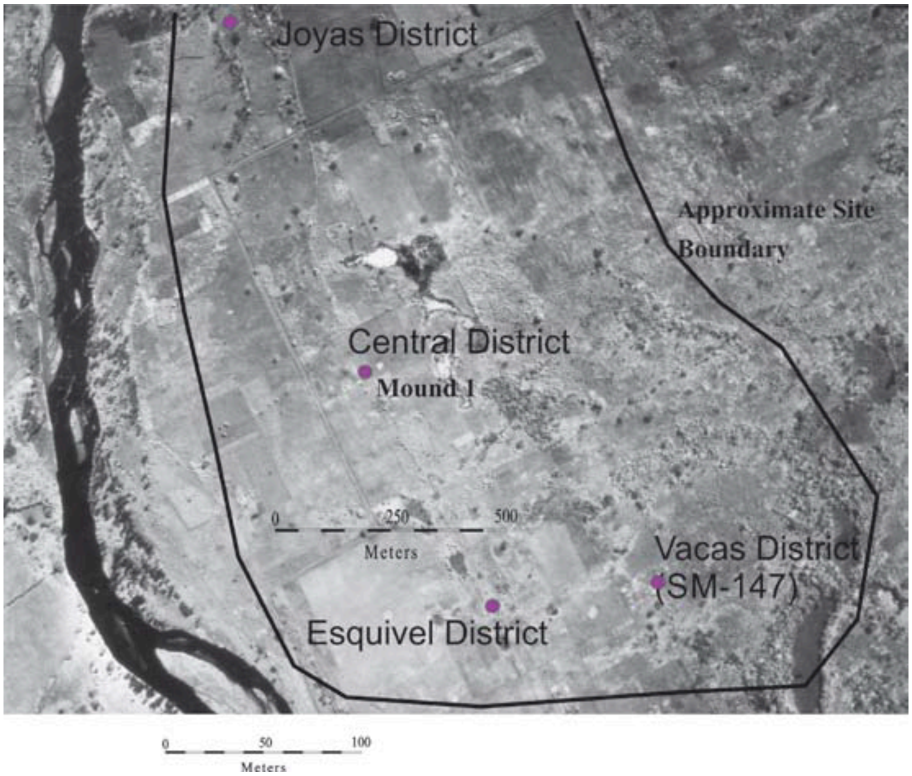


Figure 31. La Blanca districts mapped by Michael Love in a proposal submitted to the National Science Foundation in 2014. Reproduced with permission.

Considering the Euclidean Distance results alongside the districts proposed by Love in 2014, there are apparent similarities. Reorienting Figure 31 approximately 90° clockwise to match the orientation of Figure 30, the large cluster matches the location of Love's Central District. The other domestic areas are approximately situated in the same expected locations presented in the 2014 proposal. However, achieving additional nuance in domestic groupings is now possible in the wake of excavating the Joyas, Vacas, and Esquivel areas.

Using Euclidean distance results as a guide, I propose the division of excavated La Blanca contexts into one area and five neighborhoods that complement Love's initial observations during proposal writing (Tables 13 and 14). Whenever possible, new names explicitly complement those used by Love in 2014. The clusters in the middle and southeastern portions of the site (Figure 32) match the Central District and Vacas District locations defined by Love, thus I refer to these neighborhoods as the Central Neighborhood and Vacas Neighborhood, respectively. I split Love's Joyas District into two neighborhoods: Joyas North Neighborhood and Joyas South Neighborhood. Operation 50 does not cluster with any other operations and is thus referred to as a satellite area, or a cluster with no intersecting buffers in the EuD analysis. I refer to Operation 50 as Satellite Area North and Operation 64, another operation that does not cluster with others, as Satellite Neighborhood South. Operation 50 represents construction fill from the Western Acropolis that, while containing domestic debris, is more representative of a wider range of activities including public ritual deposits (e.g., Rasgo 240). Operation 64 is a domestic context and is thus appropriate to refer to as a neighborhood. As each Operation is expansive (~100 m diameter in area or larger) and includes several units, multiple domestic structures likely exist within the confines of each of these satellite clusters.

Table 13. Proposed Locales at the La Blanca Site.

Proposed Neighborhood	Operations	Abbreviation
Joyas North Neighborhood	49, 51, 53	JNN
Joyas South Neighborhood	55, 56, 57	JSN
Satellite Area North	50	SAN
Central Neighborhood	41, 28, 26, 27, 37, 32, 38, 31, 25, 34, 35, 36	CN
Vacas Neighborhood	65, 66, 67	VN
Satellite Neighborhood South	64	SNS

Table 14. Districts Outlined in Michael Love's 2014 National Science Foundation Proposal.

Districts in Love 2014	Operations
Joyas District	49, 51, 53, 55, 56, 57
Central District	27, 32, 37, 26, 38, 35, 36, 34, 31, 25
Esquivel District	64
Vacas District	65, 66, 67

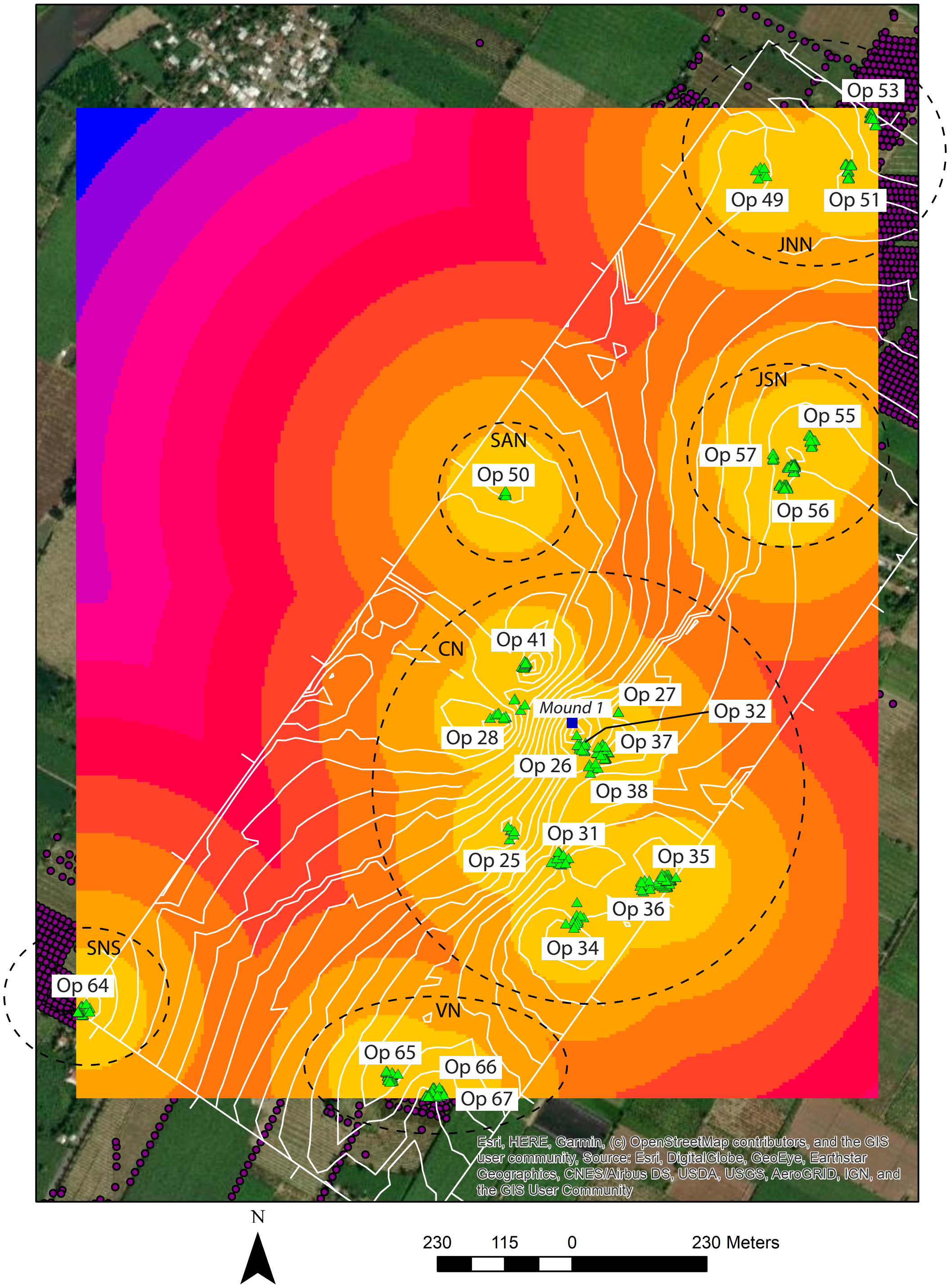
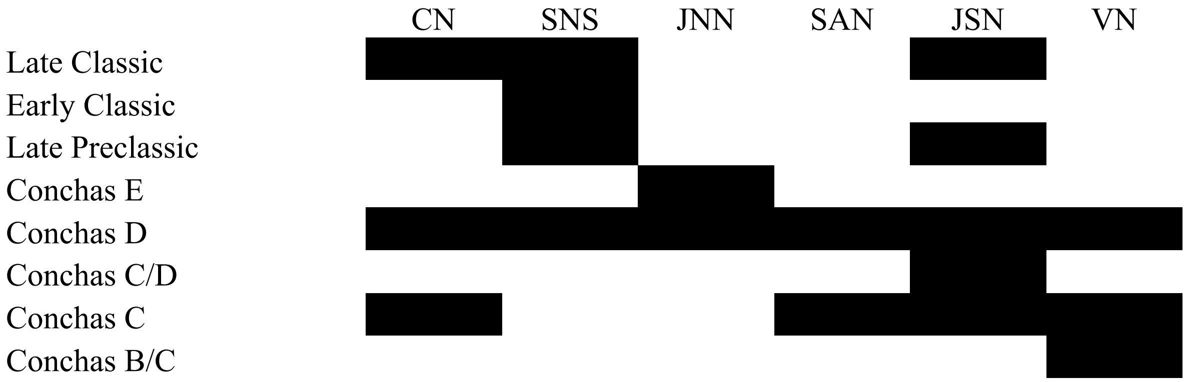


Figure 32. Euclidean distance results overlaid with proposed locales. JNN = Joyas North Neighborhood, JSN = Joyas South Neighborhood, SAN = Satellite Area North, CN = Central Neighborhood, SNS = Satellite Neighborhood South, and VN = Vacas Neighborhood.

Chronological data based on ceramic analysis conducted by Michael Love is available for each of the proposed neighborhoods. Love has analyzed ceramics from multiple Operations (excavation areas) and Sub-Operations (units) in each of the proposed neighborhoods, offering a perspective on their occupational histories (Figure 33). Subphases with slashes in their titles (e.g., Conchas B/C) indicate that ceramics could belong to either phase based on ambiguity in attributes. The Vacas Neighborhood, located in the southern portion of the site, began to be occupied during either the end of the Conchas B subphase or the beginning of the Conchas C subphase. By the Conchas C subphase, the Central Neighborhood, Satellite Area North, and Joyas South Neighborhood are also occupied, indicating expansion to the north. By Conchas D, all neighborhoods at the site are occupied, including new additions Joyas North Neighborhood and Satellite Neighborhood South. There is a large drop in spatial spread of occupation during Conchas E, with the only sherds from this period found in the Joyas North Neighborhood. Satellite Neighborhood South was only established after the primary occupation of the site during the Middle Preclassic period. Sherds dating to the Late Preclassic, or Late Preclassic, periods have been recovered from two neighborhoods in the north and south, Joyas South Neighborhood and Satellite Neighborhood South, respectively. Satellite Neighborhood South also yielded Early Classic sherds. There was then a break in occupation until the Late Classic, with sherds from Satellite Neighborhood South and the Central and Joyas South Neighborhoods matching stylistic expectations for this period.



	CN	SNS	JNN	SAN	JSN	VN
Late Classic	■	■			■	
Early Classic		■				
Late Preclassic		■			■	
Conchas E			■			
Conchas D	■	■	■	■	■	■
Conchas C/D					■	
Conchas C	■			■	■	■
Conchas B/C						■

Figure 33. Occupational histories of proposed locales based on results of ceramic analysis conducted by Michael Love.

In summary, statistical and qualitative evaluations point toward La Blanca having been an urban center composed of several neighborhood clusters containing houses. Occupation of these neighborhoods began in the southern portion of the site, with expansion during the Conchas C subphase and occupation of all locales by the Conchas D subphase. The population appears to have decreased dramatically during the Conchas E subphase with the occupation becoming far less expansive. Perhaps a few households continued to occupy the site during the Late Preclassic with potential continuity at Satellite Neighborhood South into the Early Classic. After another break in occupation, La Blanca appears to have risen in popularity during the Late Classic with three neighborhoods being reoccupied during this time. This basic analysis of spatial and chronological relationships demonstrates that contexts at La Blanca have the temporal specificity necessary to track changes in human behavior during its rise, growth, and decline over the course of the Middle Preclassic period. One of the most consistently deposited categories of material is food remains which, when patterns are compared between locales, have the potential to illuminate characteristics of daily life in different portions of the site during its Conchas-phase occupation.

Botanical Patterns by Locale

Plant Exploitation

Wood is by far the most abundant plant remain at La Blanca in terms of weight (see Chapter 5). Charred wood, commonly derived from cooking fire debris, can serve as an indicator for intensity of cooking activities. In the Americas, wood charcoal can also indicate evidence of nixtamalization using wood ash as an alkali treatment (Katz et al. 1974); lime, lye, and crushed shells represent other commonly used sources of alkali (Johnson and Marston 2020; Katz et al. 1974:772). Results organized by neighborhood have the potential to shed light on which areas of the site La Blanca inhabitants used most intensively for cooking and/or maize nixtamalization. Note that neighborhoods with longer occupations have the potential to have produced more wood over their lifespans, but this influence cannot be easily corrected. Assumptions that longer occupations would produce more wood are complicated by the factor of occupation density as more briefly occupied and populous occupations could potentially produce more wood than longer, less populous ones. Thus, it is important to recognize these potential influences but to also put them aside for now as they can only be properly corrected for if/when reliable population estimates can be generated for the identified neighborhoods.

Wood density, calculated as weight divided by soil volume, was used as a standardizing measure, with either sample or neighborhood as the smallest unit of analysis (Figure 34). There are no statistically significant differences between box plots when sample values are grouped by neighborhood. However, when wood densities are tabulated at the neighborhood level, noticeable differences appear. Satellite Area North has the highest wood density by far, a surprising finding considering its small relative size (but not substantially smaller number of flotation samples) and shorter occupation span than other neighborhoods (see Figure 33). Among the remaining neighborhoods, values for Joyas South and Central Neighborhoods are similar, with the former being only slightly higher than the latter. Neighborhoods with the lowest wood densities are the Vacas Neighborhood and Joyas North Neighborhood, in that order.

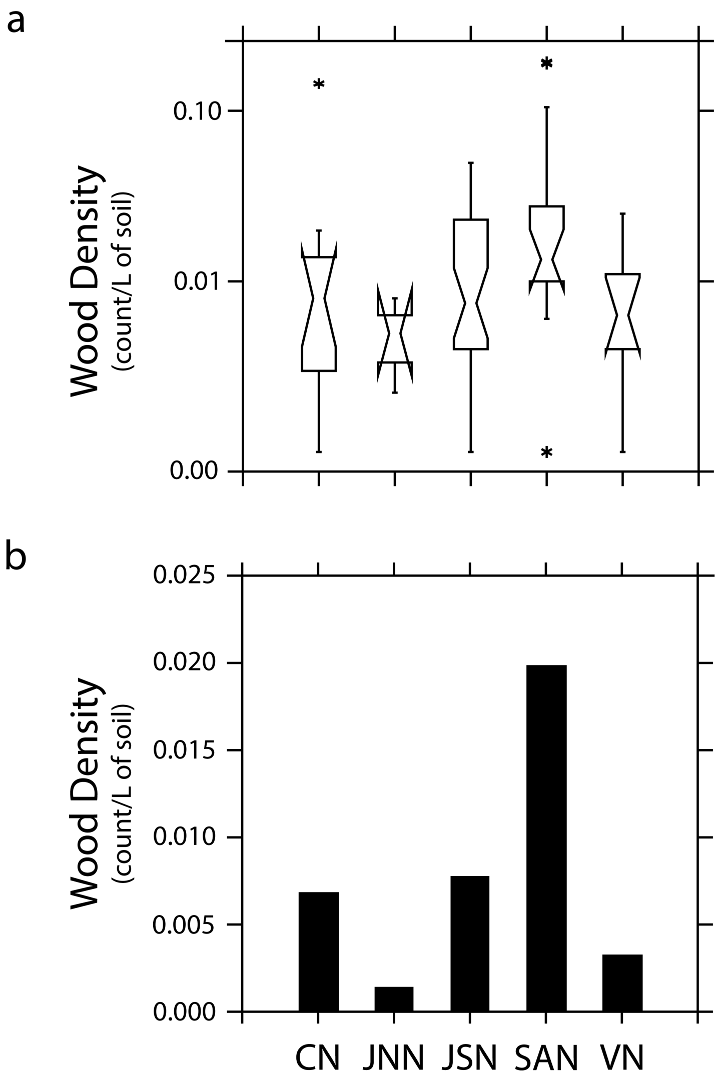


Figure 34. Wood density results by (a) samples (box plots, top) and (b) spatial context (bar graph, bottom). Abbreviations used for neighborhoods are as follows: CN = Central Neighborhood, JNN = Joyas North Neighborhood, JSN = Joyas South Neighborhood, SAN = Satellite Area North, and VN = Vacas Neighborhood.

Wood density analysis indicates that Satellite Area North served as a nexus of cooking and/or nixtamalization activities at La Blanca. It is less likely that this locale was merely a group disposal area of wood charcoal for the entire city as residents would have had to laboriously haul large amounts of charcoal across the site. The nixtamalization hypothesis is intriguing as the nearest limestone mines as of 2005 are in the Guatemala and El Progreso departments, near the center of the country (Ministerio de Energía y Minas 2005). Thus, residents of the Pacific Coast would have had to turn to other sources of alkali to engage in nixtamalization. Further evaluating whether Satellite Area North served as a focal point for deposition of plant remains, not just wood remains, requires neighborhood-based comparisons of seed densities.

Seed density, or count of seeds divided by total soil volume, is a measure of plant density independent of wood weight. I have adopted this measure to contend with a paleoethnobotanical challenge that is commonly faced in tropical regions, including parts of Mesoamerica like the Pacific Coast. Due to taphonomic factors such as a wet-dry climate, warm temperatures, and high humidity, the long-term integrity of even carbonized small seeds is compromised in coastal Mesoamerica and thus wood composes most of the weight in analyzed flotation samples (Pearsall et al. 2016; VanDerwarker 2006; VanDerwarker and Kruger 2012). Separately considering the contribution of wood and seeds in flotation samples thus avoids problems with comparing low plant weights or excluding samples with plant weights that did not register on the scale (<0.01 g).

When examining seed density results, several neighborhoods stand out from the rest (Figure 35). Box plots reveal that Satellite Area North and the Vacas Neighborhood have significantly higher seed densities than the remaining neighborhoods. The difference between these two contexts, however, is not statistically significant. In looking at the bar graph with combined values for each neighborhood (Figure 35b), the Vacas Neighborhood has the highest value and again stands out, with Satellite Area North having a more moderate value. The Joyas South Neighborhood has a greater overall seed density than Satellite Area North, but it is evident from examining the box plots that this higher value is being driven upwards by the outlier and other high values contributing to the long whisker at the top of the plot. The bar graph, in summary, reveals three groups, from highest to lowest seed density: Vacas Neighborhood (Group 1); Joyas South Neighborhood and Satellite Area North (Group 2); and Central Neighborhood and Joyas North Neighborhood (Group 3). It is interesting that the Central Neighborhood has one of the lowest seed densities in both the box plot and the bar graph as it is one of the most densely occupied neighborhoods at the site (see Figure 32). Another interesting finding to be gleaned from the seed density analysis is that Satellite Area North contained comparatively high quantities of identifiable seeds, not just wood. This finding indicates that Satellite Area North, despite its small spatial footprint, served as a key locale for the deposition of both wood and plant remains at La Blanca.

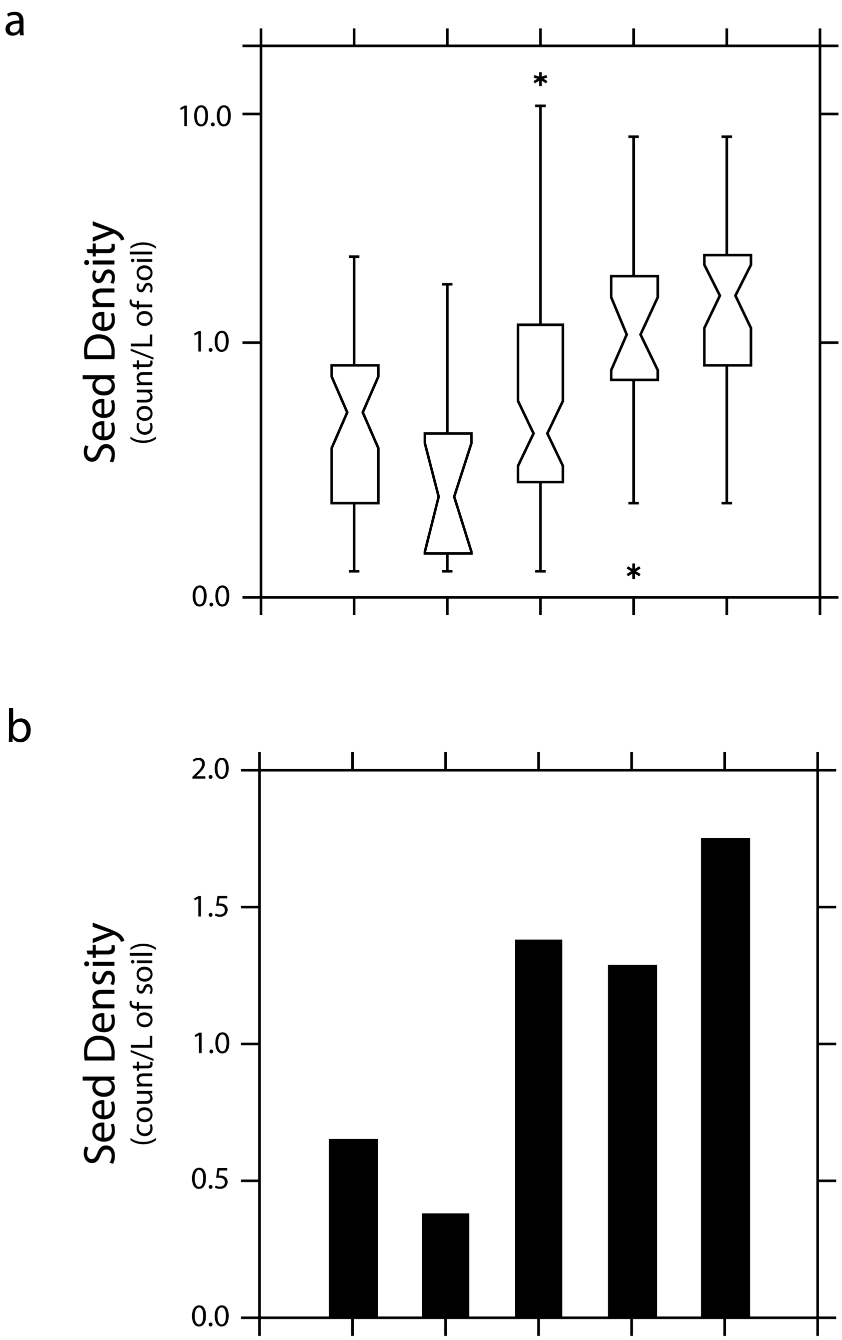


Figure 35. Seed density results by (a) samples (box plots, top) and (b) spatial context (bar graph, bottom).

Exploring patterning in wood and seed density results is only the first step in spatial analysis of botanical remains. Indeed, the analyses presented thus far provide insights into relative densities of plant material but have yet to consider the types of plants present in each neighborhood. The high wood and seed density values for Satellite Area North, for example, can be assessed in more detail through comparing the types and quantities of plants recovered.

Field Crops

I begin with field crops—maize, beans, and squash/gourd—as the distribution of edible and inedible maize parts is key to identifying processing and cooking locales at La Blanca. I use two normalizing metrics to compare the abundance of plants in samples and neighborhoods: density and mean count. Density is a measure of counts divided by soil volume with a long history in paleoethnobotanical analysis (Miller 1988; Marston 2014). Mean count, introduced by VanDerwarker and Kruger (2012), is calculated as counts divided by number of features in the target context (e.g., neighborhood, phase). This measure was introduced to provide an approach to normalizing plant abundance that is not sensitive to plant weight unlike standardized count (calculated as counts divided by plant weight), a traditional measure in paleoethnobotanical analysis (Scarry 1986). In regions where plant weights are generally low, like Neotropical Mesoamerica, mean count offers a standardizing measure that is not susceptible to division by zero in contrast to standardized count. I begin by comparing densities and then transition to mean count results.

Density. Field crop density values are compared in box plots organizing results by neighborhood (Figure 36). Maize is the most abundant field crop at La Blanca in terms of raw counts. It consequently has a strong statistical influence on density values of field crops. The patterns in box plots of maize values are thus identical to those observed for field crops and not displayed. The Vacas Neighborhood has a significantly higher maize density than three other neighborhoods, Central Neighborhood, Joyas North Neighborhood, and Joyas South Neighborhood. Satellite Area North also has a significantly higher distribution than Joyas North Neighborhood and Joyas South Neighborhood, but not the Central Neighborhood. Joyas North Neighborhood has the lowest hinge of all the box plots, but it also has the weakest distribution statistically as indicated by the top hinge being bent back toward the median.

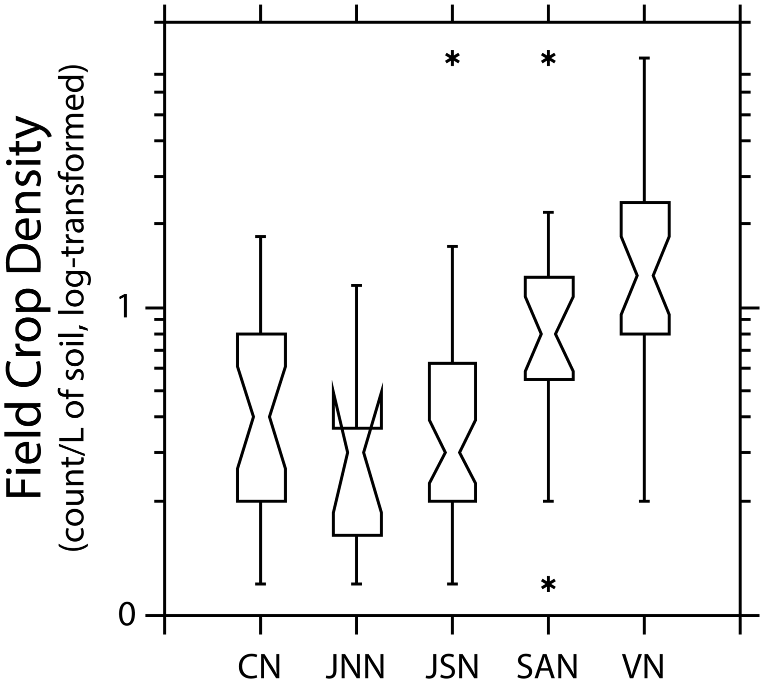


Figure 36. Box plots of field crop densities for flotation samples, grouped by spatial context. Y-axis is log-transformed.

Independently evaluating maize kernel and cupule densities has the potential to provide insights into cooking and processing areas, respectively (VanDerwarker 2005;

VanDerwarker and Detwiler 2002). However, when La Blanca maize kernel densities are considered separately, relationships between box plots are identical to those for field crops (see Figure 36). Values for cupules, or the inedible portions of maize, are too limited for adequate differentiation of contexts via boxplots as many neighborhoods can only be plotted as a line or dot. Overall, these analyses demonstrate that density is a poor metric for examining maize values in the La Blanca assemblage as (1) there is not enough variation in numeric values to differentiate box plots and (2) cupule counts are so low in comparison to soil volumes that many values fall below SYSTAT's minimum storable value of 0.001.

Mean Count. Mean count represents a more suitable approach for analyzing the La Blanca maize assemblage. Developed by VanDerwarker and Kruger (2012), mean count is calculated by dividing the count of identified specimens belonging to the indicated taxon by the number of features belonging to that phase. Count of identified specimens only derives from a single feature associated with the specified phase, making each feature a unique data point in the analysis. Samples from levels are excluded from this analysis, including all samples from Operation 32 (Central Neighborhood). Counts are standardized by the number of features in each neighborhood with identifiable plant remains, which tends to be lower than soil volume as most flotation samples derive from 10 liters of soil. This smaller denominator produces larger numeric values (in comparison to density measures) that can be more easily plotted and compared. Bar graphs are used instead of box plots as most samples would otherwise have a value of one as each sample derives from one feature. Using number of features in the neighborhood as the denominator for a single sample would be flawed as the findings in the sample derive only from that context and not the entire neighborhood.

Bar graphs of mean counts for field crops (Figure 37) more clearly demonstrate differences between neighborhoods than density results. Note that field crop results are again virtually identical to those for maize as high maize counts, in comparison to those of other field taxa, have a strong influence on mean count results. The Vacas Neighborhood has the highest mean count, closely followed by Satellite Area North. The next lowest group of similar values is composed of the Central and Joyas South Neighborhoods. Finally, the Joyas North Neighborhood has the lowest mean count. Mean count results complement density outcomes (see Figure 36) by indicating that Satellite Area North and the Vacas Neighborhood have comparatively high amounts of field crops, whereas the Central Neighborhood and Joyas South Neighborhood have more moderate outcomes and the Joyas North Neighborhood has the lowest value of the group.

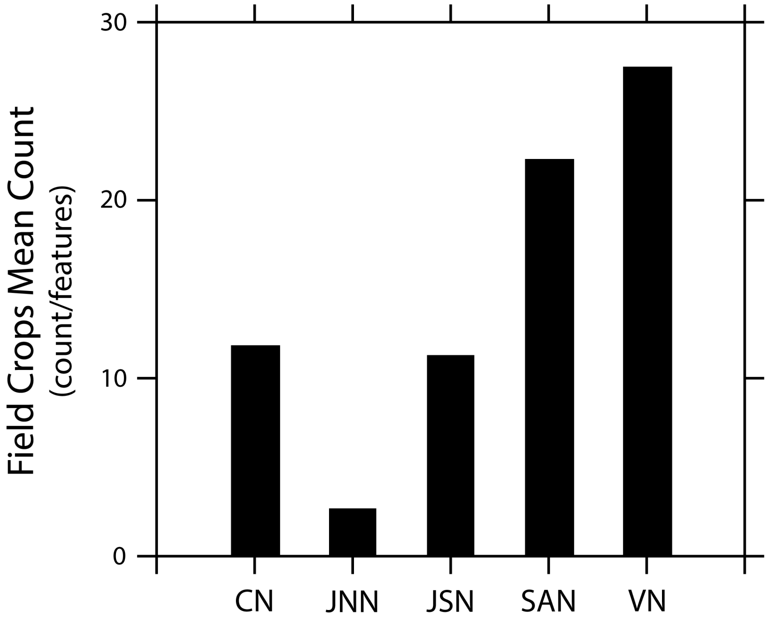


Figure 37. Bar graph of field crop mean counts by spatial context.

Comparisons of maize kernel (Figure 38) and cupule (Figure 39) mean count values reveal that some neighborhoods are relatively consistent in their representation of different maize parts, but other neighborhoods differ markedly. The Central Neighborhood is the most consistent neighborhood with relatively moderate mean counts for both kernels and cupules. In contrast, the Vacas Neighborhood has drastically more kernels than cupules. This neighborhood has the highest mean count of maize kernels, but only the third highest value for cupules. Satellite Area North exhibits the opposite trend, albeit less drastically. This locale has the highest maize cupule mean count, but only the second highest mean count of maize kernels. This relatively high representation of maize cupules would never have been detected if maize parts were not considered separately. Low counts of maize cupules at the site introduce barriers in comparing normalized counts by sample, but this category has more statistical power when raw counts are compiled by neighborhood. Although the maize kernel and cupule mean counts for Joyas North Neighborhood and Joyas South Neighborhood are not comparatively high overall, both neighborhoods do have higher maize cupule values than kernel values. This difference suggests that these areas of the site may have focused more heavily on maize processing, but to a lesser extent than other areas of the site such as Satellite Area North. Although the measures presented thus far have addressed abundance, they do not have the analytical power to comment on the distribution of maize across households within each neighborhood.

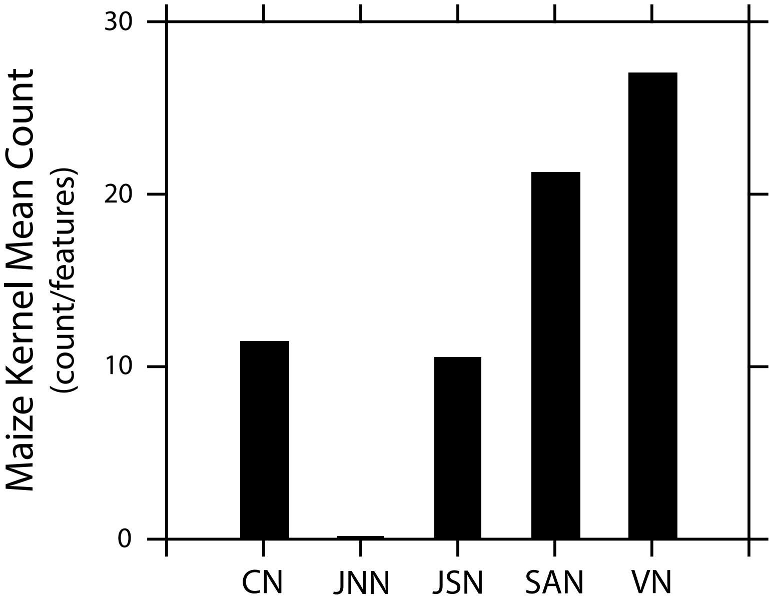


Figure 38. Bar graph of maize kernel mean counts by spatial context.

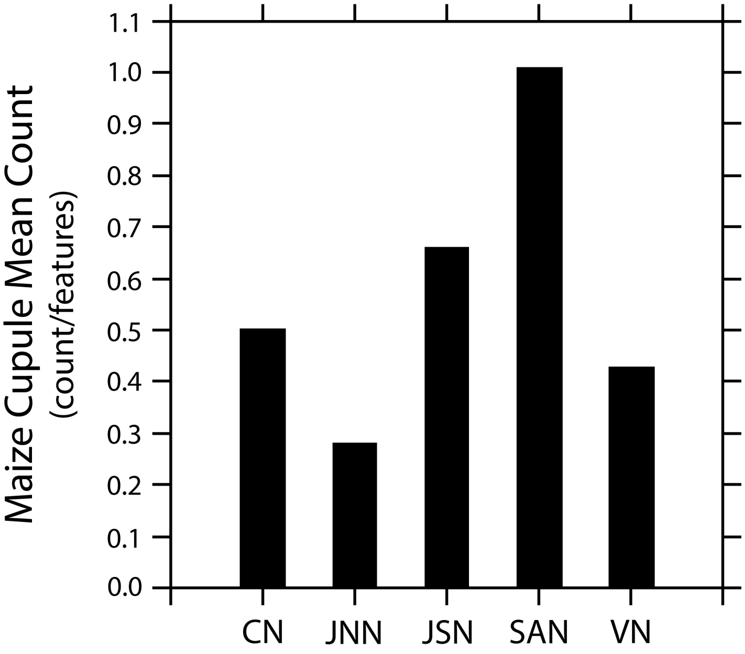


Figure 39. Bar graph of maize cupule mean counts by spatial context.

Maize Ubiquity. Analysis of the distribution of plants at a site reveals the extent to which the use of a specific plant or portion of a plant was widespread or more spatially restricted. One of the most common measures of plant distribution is ubiquity, or presence/absence of maize in samples divided by total number of soil samples (Popper 1988), in this case the total number with identifiable remains. The final value is then multiplied by 100 and reported as a percentage. Both maize portions are present in every neighborhood at the site. Maize ubiquity is highest at Satellite Area North, followed closely by the Vacas Neighborhood (Table 15). Next are two similar values, Joyas South Neighborhood and Central Neighborhood, with the former slightly higher than the latter. Finally, Joyas North Neighborhood has the lowest ubiquity at the site.

Table 15. Ubiquity of Maize and Maize Portions at the La Blanca Site.

Neighborhood	Maize	Maize cupule	Maize kernel
CN	72.97%	18.92%	70.27%
JNN	66.67%	8.33%	66.67%
JSN	79.66%	10.17%	77.97%
SAN	96.15%	15.38%	96.15%
VN	93.55%	12.90%	93.55%
Entire site	81.76%	13.84%	80.50%

When ubiquities of different maize portions are calculated separately, Satellite Area North has the highest ubiquity of maize kernels and the second highest ubiquity of cupules (the Central Neighborhood has the highest). Thus, not only does maize appear most consistently in features at Satellite Area North, but both edible and inedible maize portions appear consistently. These patterns, in conjunction with the abundance results reported above, suggest that Satellite Area North served as the main hub for maize processing, cooking, and possibly nixtamalization at the La Blanca site. However, other neighborhoods also participated in their own unique ways.

The Vacas Neighborhood has a high ubiquity of maize kernels, nearly as high as the Satellite Area North value. This neighborhood also has the highest mean count of maize kernels. These patterns collectively indicate that the Vacas Neighborhood likely served as a hub for maize cooking. Joyas South Neighborhood has a higher kernel ubiquity than cupule ubiquity. Looking at abundance results, it is the fourth highest in terms of maize kernels yet is the third highest in terms of cupules (see Figures 38-39). This apparent disconnect means that most of the households in the Joyas South Neighborhood (77.97%) cooked and likely consumed maize, but certain areas of the neighborhood (mostly Operation 57, see Figure 32 for location) placed more of a focus on processing than cooking.

Maize abundance and ubiquity results emphasize the central role that this crop played in the lives of Middle Preclassic Maya residents. Around 20 years ago, Middle Preclassic maize intensification on the Pacific coast was hotly debated (Blake et al. 1992). But new data from La Blanca presented here demonstrate that nearly all households at the site processed or cooked maize. Kernels are much more ubiquitous than cupules and present in most domestic contexts across the La Blanca site, illustrating that nearly all households participated in the creation of maize dishes in or around their homes with varying intensity. Identifying which households participated in cooking versus processing activities is a more nuanced question. Answering this question requires comparing the abundance of different maize parts between Operations.

Patterning by Operation (Locus). Nearly every Operation excavated at the La Blanca site represents a targeted house mound. The only exceptions are Operation 25, likely a public building, and Operation 41 (a trench dug to investigate the remains of Mound 1) but no flotation samples from the latter context were selected for the current study. I calculated mean counts of maize, maize kernels, and maize cupules by Operation—counts divided by number of features in each operation with identifiable plant remains—to examine patterning at the household level. Operations are coded by neighborhood in all graphs to facilitate comparisons at more narrow and broader spatial scales. Regression analysis was initially considered for comparing mean counts by Operation, but the case size is too small to avoid each case having high influence on the result; thus, scatterplots are used instead.

Comparisons of maize mean counts by Operation demonstrate marked variability both within and across neighborhoods (Figure 40). Operation 67 (Vacas Neighborhood) has the highest mean count by far. The remaining points are dispersed into two groups: values from ~10-25 and values <10. The first group includes Operations 26, 27, 32, and 37 (Central Neighborhood); 50 (Satellite Area North); 57 (Joyas South Neighborhood); and 65 and 66 (Vacas Neighborhood). The group with the lowest values includes Operations 25 (Central Neighborhood); 49, 51, and 53 (Joyas North Neighborhood); and 55 and 56 (Joyas South Neighborhood). Joyas North Neighborhood values are uniformly low, but all other neighborhoods have some level of variability between Operations with no easily discernable patterning in values.

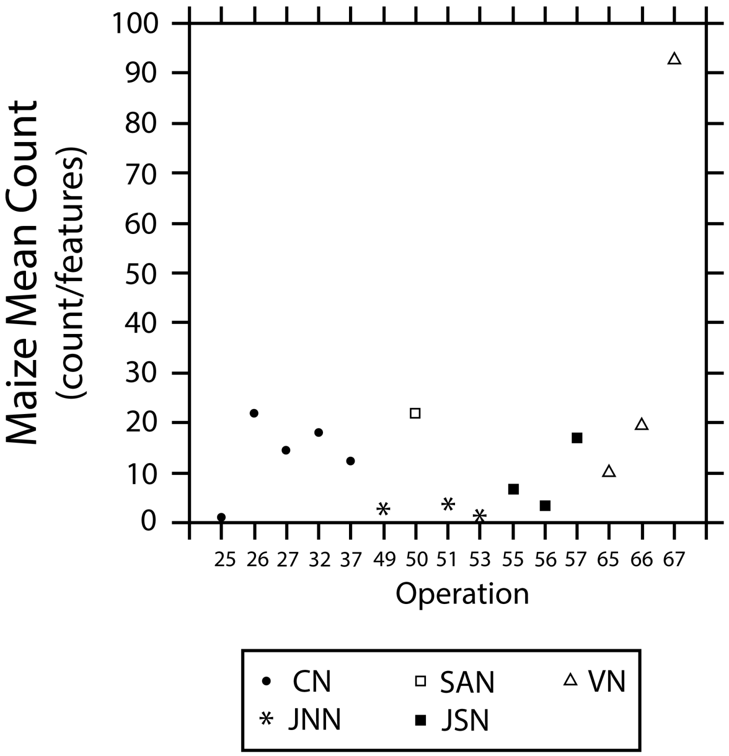


Figure 40. Scatterplot of maize mean counts for Operations, grouped by spatial context.

Separately analyzing mean counts by maize portion (Figures 41 and 42) provides more nuanced insights into the relative degree of cooking and processing debris influencing the maize patterns. The high mean count for Operation 67 (Vacas Neighborhood) is mostly influenced by high counts of maize kernels. This finding is consistent with the developing hypothesis that the Vacas Neighborhood, specifically Operation 67, served as a center for maize cooking and/or nixtamalization at the site. The same two groups of Operations detected for maize mean counts appear again in the maize kernel graph, suggesting the strong statistical influence of maize kernels on maize mean count results due to their high overall counts. In summary, maize kernel comparisons by Operation demonstrate that nearly all neighborhoods, Joyas North Neighborhood being the only exception, have at least one household characterized by moderate abundance of edible maize remains. Thus, maize cooking appears to have been conducted by most households at the site, with some variability in intensity both within and between neighborhoods.

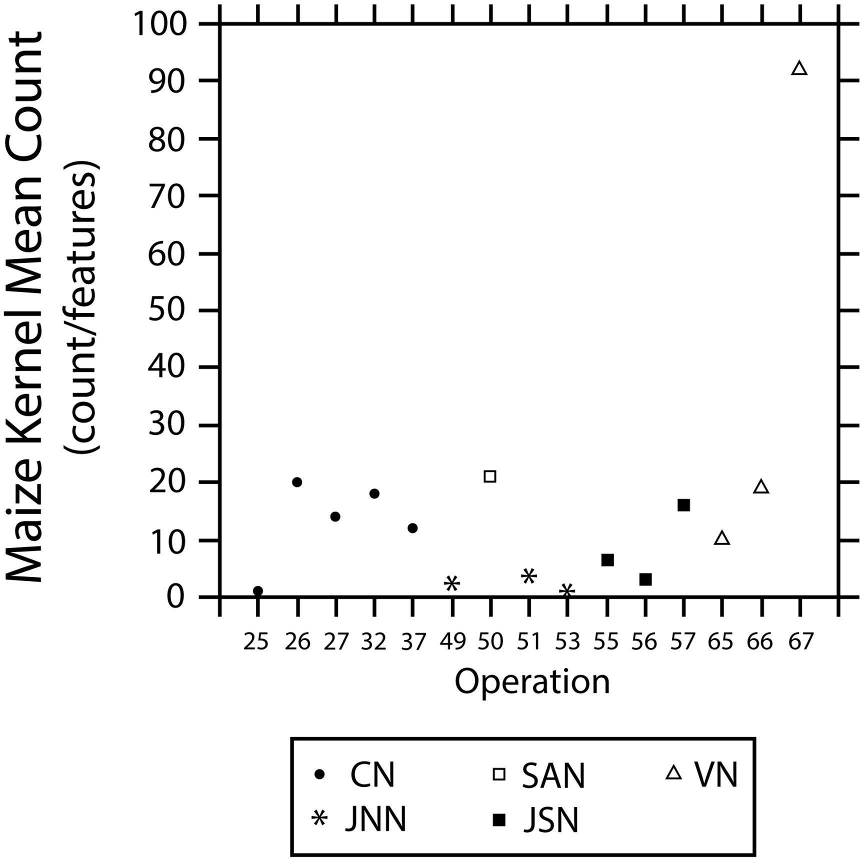


Figure 41. Scatterplot of maize kernel mean counts for Operations, grouped by spatial context.

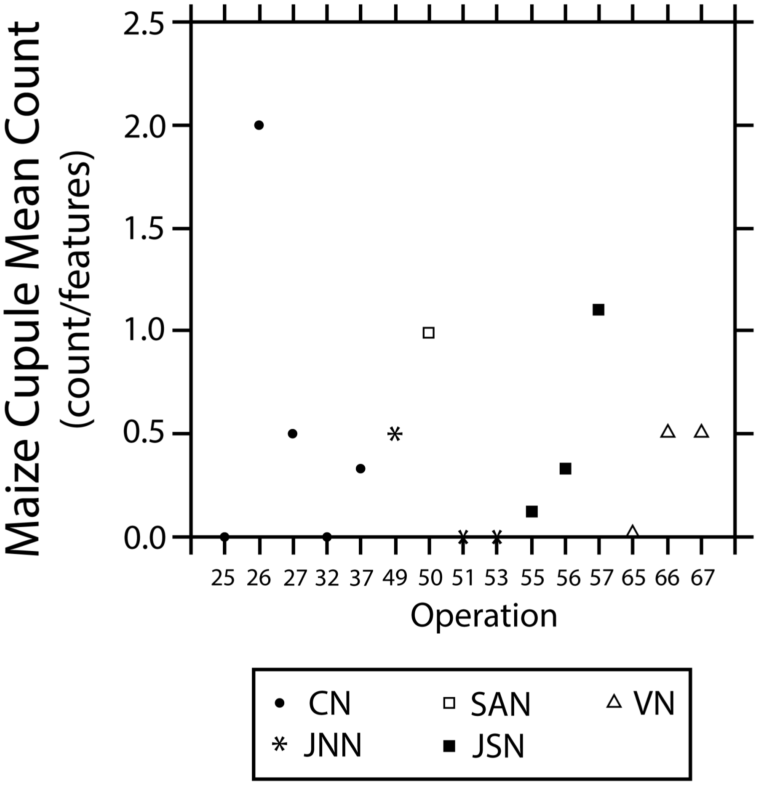


Figure 42. Scatterplot of maize cupule mean counts for Operations, grouped by spatial context.

Inter-neighborhood variability is even more pronounced when comparing maize cupule mean counts (see Figure 42). Although values can be sorted into groups of low, moderate, and high abundance, more Operations and neighborhoods have high outliers. Operation 26 (Central Neighborhood) has the highest value at the site, followed by Operations 57 (Joyas South Neighborhood) and 50 (Satellite Area North) in that order. Notably, each locale has one or more Operations with a value that exceeds those for other Operations in the same locale. For example, the following loci have high values in comparison to others in their neighborhood: Operations 26 (Central Neighborhood), 50 (Satellite Area North), 57 (Joyas South Neighborhood), and 66 and 67 (Vacas

Neighborhood). Thus, each neighborhood appears to have had its own center of maize processing. The idea of when each neighborhood played a role in maize processing will be explored further in Chapter 7, when the temporality of neighborhoods is considered alongside botanical results and radiocarbon data. Yet maize is not the only plant for which processing activities can be detected in the archaeological record. Commonly preserved are fragments of inedible seeds from another category of subsistence plants, tree crops.

Tree Crops

Statistical analysis of tree crop distributions provides a sense of which neighborhoods engaged in arboriculture. I focus on tree crops domesticated and cultivated in Mesoamerica for their edible fruits, excluding nuts. As nuts are not commonly recovered archaeologically from Middle Preclassic contexts in most regions of Mesoamerica (see Chapter 5), excluding them from this analysis allows for better standardization with results from other sites. Nut results, however, are qualitatively integrated into my discussion of evidence for tree crop production in different neighborhoods.

Tree crop abundance is analyzed in terms of mean count rather than density as values of the latter were so small that SYSTAT either did not register them or the miniscule quantitative space between them produced nearly identical box plots lacking any statistically significant differences. Mean count results, when calculated by neighborhood, indicate differences in abundance between neighborhoods (Figure 43). Joyas South Neighborhood has the highest mean count of tree crops by far. Most of the tree crops in this neighborhood consist of sapote (61.28% by count) and coyol (37.02% by count) fragments, a pattern that also applies to the remaining neighborhoods and the entire site assemblage. The fact that coyol made such a strong contribution to the site assemblage of tree crops is potentially suggestive of not only use of the fruits but also extraction of the oil, an edible resource among the Maya (McNeil 2021:138). If this theory is correct, oil extraction would have been mostly concentrated in the Joyas South Neighborhood. In comparison to the Joyas South Neighborhood, Satellite Area North and the Central Neighborhood have moderate values of tree crops, while Vacas Neighborhood and Joyas North Neighborhood values are low.

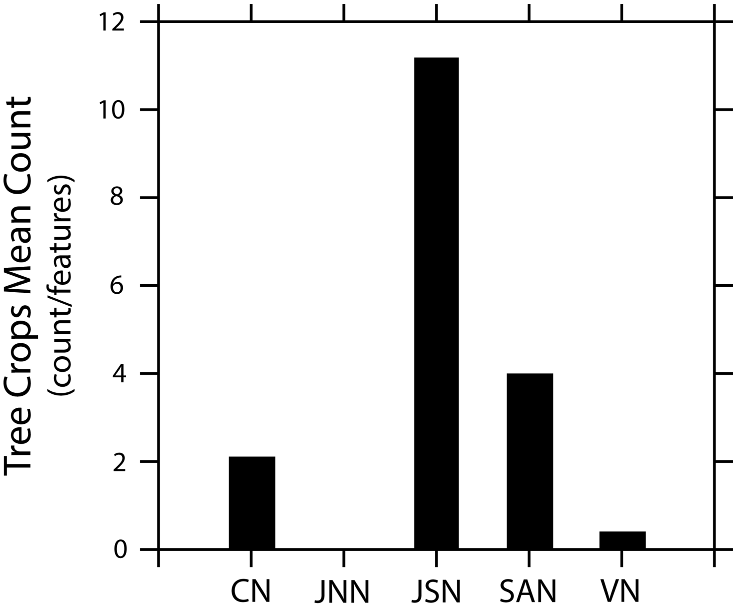


Figure 43. Bar graph of tree crop mean counts by spatial context.

Situating maize results in context with high abundances of seeds from tree crops supports an interpretation that the Joyas South Neighborhood served as a key zone for processing/cooking tree crops and, to a lesser extent, maize. Maize kernels are widespread across households in the Joyas South Neighborhood, but mean counts are more moderate in comparison to other neighborhoods (see Table 15, Figure 38). Cupules are less widespread but comparatively more abundant, particularly in Operation 57. I have already discussed that each neighborhood had a role in maize processing. Thus, the Joyas South Neighborhood should not be envisioned as having necessarily processed maize for the entire site. Although nut counts are too low for statistical analysis, patterning in nut distribution reinforces the interpretation of Joyas South Neighborhood as the main processing area for arboreal resources. Nuts are mostly located in the Joyas South Neighborhood, with lower counts in the Central Neighborhood. In comparison to the Joyas South Neighborhood, Satellite Area North and Central Neighborhood represent more minor production zones for tree crops. In summary, while maize production centers existed in every locale, production and use of tree crops was more spatially restricted. Joyas South Neighborhood had the largest output, Satellite Area North and Central Neighborhood had more moderate outputs, and the final two neighborhoods had negligible (Vacas Neighborhood) to zero outputs (Joyas North Neighborhood). More direct comparisons between tree and field crop counts have the potential to shed light on the relationship between neighborhoods and relative investment in agriculture versus arboriculture.

Ratios of Tree to Field Crop Abundance

A direct method of comparing tree and field crop abundance is calculating a ratio of tree crops to field crops based on raw counts. Initially, I performed correlation (Pearson’s R) analysis on field crops and tree crops to gauge relationships between the two variables, but the correlation was not statistically robust. Tree crops are either present in samples, sometimes in comparatively great quantities in comparison to other taxa, or not present at all. This situation creates a predicament where the inputted variables are more binary instead of continuous, the latter being more ideal for correlation analysis. Although the correlation analysis did not end up being a successful approach, it did recognize the problem of low tree crop ubiquity in the La Blanca assemblage. It is thus important that tree crops serve as the numerator and field crops the denominator in any ratios as division by zero would otherwise be a persistent problem.

Tabulation of tree to field crop ratios by neighborhood (Figure 44) provides a new perspective on the independent outcomes of mean count analysis for field crops, maize, and tree crops. Although the Joyas South Neighborhood undoubtedly has a much higher abundance of tree crops than any other neighborhood at the site, the ratio of tree to field crops is virtually 1:1; note that this ratio is not normalized by volume or number of features, meaning that a high number of counts for one category may derive from more heavily sampled contexts. In characterizing Joyas South Neighborhood as a processing locale it is important to keep in mind that these activities included both tree and field crops; some cooking also took place here as indicated by a moderate mean count of maize kernels (see Figure 38). Satellite Area North and the Central Neighborhood have more moderate tree crop counts with about 0.15-0.2 tree crop fragments for every one field crop fragment. The Vacas and Joyas North Neighborhoods yielded almost exclusively field crops with low to null numerators (tree crops).

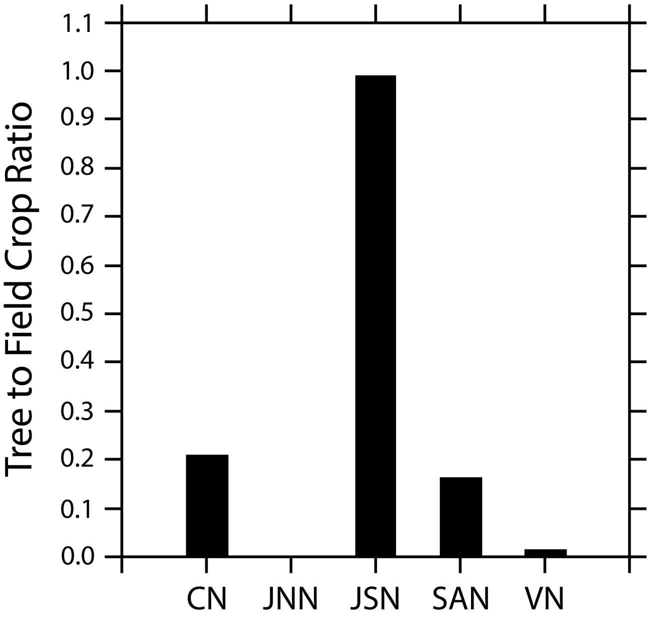


Figure 44. Bar graph of tree to field crop ratios by spatial context.

Tree to field crop ratios provide another means of testing and exploring patterns in the La Blanca botanical dataset. As each layer of analysis has been added, patterns found through one technique have been considered more/less robust or interpreted in a different light as more techniques are tested. Each technique has a unique perspective on the raw data that is restricted by the scope of taxa considered in the analysis. One method of broadening the perspective on a botanical assemblage is considering diversity measures, which provide a holistic view of the taxonomic composition of a botanical assemblage.

Diversity

Measures of diversity are used in botanical analysis assess the richness and equitability of taxa in an assemblage. Richness is a measure based on the number of identified categories, where taxa count is often positively correlated with richness (Odum and Barrett 2005:37-40). Equitability assesses the distribution of specimen counts among those taxonomic categories, with a more even distribution of counts contributing to a higher equitability value (Pielou 1966; Sheldon 1969). Richness and equitability measures situate counts of identified taxa and specimens in relation to overall assemblage size, but different normalizing criteria are applied depending on the method of calculating diversity. I use three methods to calculate diversity: Shannon-Weaver index, DIVERS, and Minimum Richness Value. By using several methods and comparing results, I arrive at a more robust perspective on plant diversity within and across neighborhoods at the La Blanca site.

Shannon-Weaver Index. The Shannon-Weaver index (Shannon and Weaver 1949) is a measure deriving from the ecological literature. In archaeological applications, this index assesses the types and quantities of flora or fauna within a selected area to assess taxonomic diversity (Marston 2014; Peres 2010; VanDerwarker 2010). The value generated by the index can then be objectively compared with results for other areas to assess relative diversity. However, archaeobotanical assemblages do not represent a full and unbiased sample of available food, medicinal, and economic plants present on the landscape. In interpreting Shannon-Weaver index results for La Blanca neighborhoods, for example, it is important to acknowledge that results provide a valuable glimpse into human-plant relationships. Yet it is also imperative to recognize that these results do not directly address ecological diversity or provide a means to reconstruct ancient ecosystems.

Results for each neighborhood at La Blanca are reported in Figure 45 and Table 16. Richness is represented by H’ and does not have a numerical limit, whereas equitability is represented by V’ and can go up to a value of one. Higher values correspond to greater richness or equitability, respectively. Joyas South Neighborhood has the highest richness score and the highest equitability. This finding is not surprising as other metrics described above have contributed to an interpretation of this neighborhood as a locale for the processing of various resources. But the Shannon-Weaver result recognizes the comparative variety of resources in this locale, and that inhabitants did not prioritize processing of one taxon or few taxa over others.

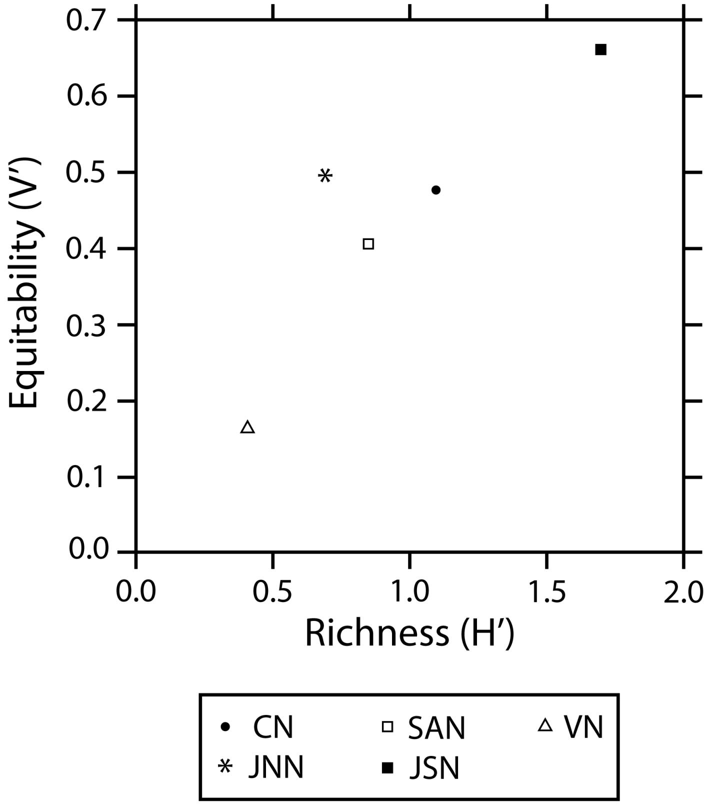


Figure 45. Scatterplot of Shannon-Weaver index values by spatial context.

Table 16. Shannon-Weaver Index Results by Locale.

Locale	CN	JNN	SAN	JSN	VN
H'	1.097	0.687	0.877	1.695	0.408
V'	0.477	0.496	0.399	0.661	0.164

The Central Neighborhood, Joyas North Neighborhood, and Satellite Area North have relatively similar combinations of scores. The Central Neighborhood has slightly higher richness and Joyas North Neighborhood has the lowest richness of the three, but equitability scores are roughly comparable. Thus, it appears that inhabitants of these three neighborhoods exploited a moderate range of taxa at similar amounts, a pattern that matches expectations for mundane activities. Everyday refuse from different domestic spaces might differ in number of taxa represented, but one would expect the average household to invest relatively equally in a moderate range of taxa rather than prioritizing the processing or consumption of one, few, or all available resources.

Finally, the Vacas Neighborhood has the lowest richness and equitability values by far. The pattern for this neighborhood contrasts with the archetype of the average domestic assemblage presented above. The Vacas Neighborhood assemblage consists primarily of maize kernels (see Figure 37), with low H' and V' values reinforcing the interpretation of this neighborhood as a locale primarily used for cooking and/or nixtamalizing maize. Yet the patterns and interpretations generated from the analysis of Shannon-Weaver index values need to be evaluated for robustness using additional measures of diversity.

DIVERS. Tools for Quantitative Archaeology, a statistical software package developed by Keith Kintigh, includes a DIVERS program capable of performing diversity simulations. The program tabulates richness (H) and evenness (H/Hmax) by using Monte-Carlo style simulation to estimate expected diversity across a range of sample sizes (Kintigh 1984, 1989). The benefit of using this simulation is that there is a calculated 95% confidence interval for which any case falling outside of the upper or lower boundaries of that interval is significantly different from the expected value. This statistical boundary offers a more quantitatively meaningful method of comparing values than relative rankings of Shannon-Weaver index values, for example.

All neighborhoods have richness values that fall below the expected values for their respective sample sizes (Figure 46); lower richness values are expected given the poor preservation (and thus low counts) of plants with small or thinly walled seeds. Only the value for Satellite Area North falls below the lower statistical threshold of the confidence interval. The Vacas, Joyas South, and Joyas North Neighborhoods are at the lower limit of the confidence interval. The Central Neighborhood falls within the confidence interval surrounding the expected value and thus has the highest richness of the neighborhoods relative to its size. Overall, the DIVERS richness output indicates that neighborhoods at La Blanca have characteristically lower than expected richness, with the Central Neighborhood having higher richness and Satellite Area North having lower richness than most neighborhoods.

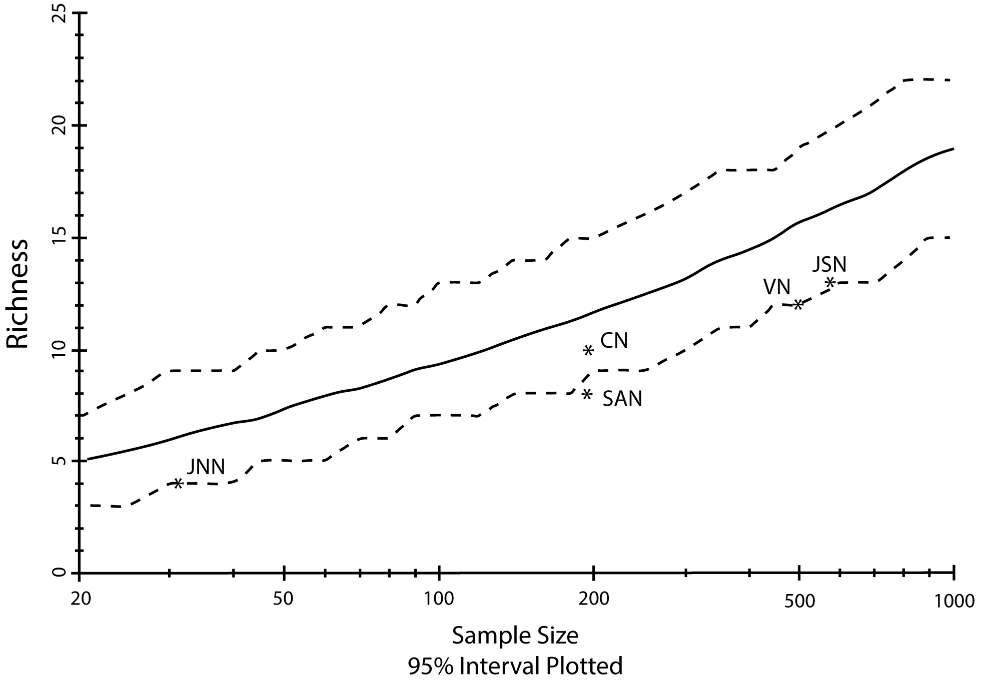


Figure 46. Graph of DIVERS richness values by La Blanca spatial context. Generated using DIVERS and DIVPLT software packages. Dashed lines mark limits of the 95% confidence interval.

Evenness values are more varied than richness values, with neighborhoods plotting below and above the confidence interval (Figure 47). Joyas South Neighborhood is the most even, with the distance above the expected value being statistically significant. Notably, the Joyas South Neighborhood has the highest equitability value on the Shannon-Weaver index (see Table 16). Shannon-Weaver and DIVERS results are also similar for the Vacas Neighborhood. This neighborhood has the lowest equitability value of the group on the Shannon-Weaver index, and its evenness in DIVERS is significantly below the expected value. The Central Neighborhood and Joyas North Neighborhood have more moderate values, while Satellite Area North is significantly lower than the expected value but not to the same extent at the Vacas Neighborhood.

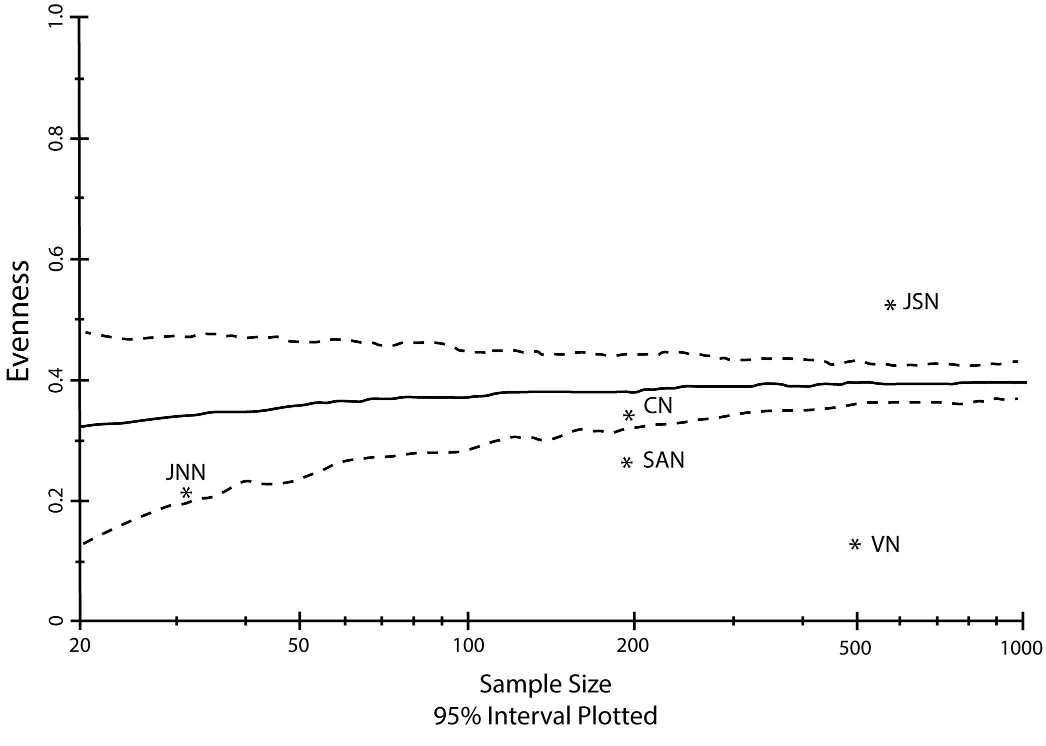


Figure 47. Graph of DIVERS evenness values by La Blanca spatial context. Generated using DIVERS and DIVPLT software packages. Dashed lines mark limits of the 95% confidence interval.

Rankings of the relationships between neighborhoods generated by the Shannon-Weaver index and DIVERS program can be directly compared to assess similarities in outcomes (Table 17). A scale of one to five is used, with one being the highest ranking and five being the lowest. Patterning in richness is less consistent than equitability, indicating that sample size may have a larger impact on the former than the latter. The Shannon-Weaver index controls for sample size but does not generate or simulate expected values for each sample size. Thus, it would be more reasonable to trust the DIVERS rankings as expectations for each analysis are unique to the assemblage. DIVERS richness results indicate that the Central Neighborhood has the highest richness and Satellite Area North has the lowest richness, with the latter being significantly lower in comparison to the expected value. Equitability rankings are more consistent, with Joyas South Neighborhood having the most equitable distribution of counts among taxa, and Vacas Neighborhood the least equitable. Yet these approaches to evaluating diversity do not consider a major focus of the present study, microbotanical results.

Table 17. Ranking of Richness and Equitability Values Generated by DIVERS and the Shannon-Weaver Index.

	Richness		Equitability	
Locale	DIVERS	Shannon-Weaver Index (H')	DIVERS	Shannon-Weaver Index (V')
CN	1*	2	2	3
JNN	3	4	4	2
SAN	5-	3	3	4
JSN	2	1*	1*	1*
VN	4	5-	5-	5-

* Highest ranking

\- Lowest ranking

Minimum Richness Value. Minimum Richness Value (MRV) is a diversity calculation recently developed by Morell-Hart (2019) to include macrobotanical and microbotanical datasets in determinations of diversity. Although microbotanical counts could have easily been incorporated into the previous two analyses, doing so would present problems in combining datasets subject to different taphonomic factors. Moreover, the magnitude of counts is much different for macrobotanical and microbotanical datasets, with the former yielding between one to hundreds of specimens per sample and the latter less than twenty. MRV has the potential to counteract this problem by using number of loci as a normalizing variable.

MRV is calculated by tabulating the number of identified taxa (macrobotanical and microbotanical) and dividing this number by the combined total of macrobotanical and microbotanical loci in the target context. Locus, for the purpose of this analysis, is defined as a stratigraphic level (for samples not collected from features) or feature from which a botanical sample was collected that yielded plant remains (including unidentified and unidentifiable specimens). Loci are not double counted; in other words, a locus with macrobotanical remains and microbotanical remains is only counted once. Each feature is also only counted once even if samples derive from different zones of that feature. Taxa count includes phytolith, starch, and macrobotanical identifications. Tentative identifications (cf.) are only used if the taxon is not securely identified in the assemblage. Unidentified and unidentifiable categories are not counted as taxa. Family level identifications are included, however, which differs from the methodology for calculating the Shannon-Weaver index.

Satellite Area North has the highest MRV value (Table 18). This result is surprising as Satellite Area North ranked in the low to moderate range in both of the previous diversity assays. Which approach best represents human-plant relationships? I argue that in this case the high value for Satellite Area North does not signify culturally meaningful richness, but instead is an artifact of a noteworthy caveat in the statistical utility of MRV. Satellite Area North contains a feature, Rasgo 240, which was heavily sampled in the field. However, this feature was only counted as one locus. Larger sample sizes in paleoethnobotany tend to produce more types and higher quantities of rare taxa (Wright 2005). Therefore, while MRV showed promise in providing an integrative perspective on plant diversity at sites in Honduras analyzed by Morell-Hart (2019), the La Blanca dataset reveals that this index is less successful for assemblages with heavily sampled features and low loci counts. Counting each zone of a feature as a different locus would unfortunately not improve the situation as some features (e.g., floors) had multiple samples taken but only one vertical/horizontal cultural zone identified. MRV results are problematic for neighborhood-level comparisons at La Blanca and will not be used in generating final interpretations. However, problems with these results demonstrate that a statistical method for integrating macrobotanical and microbotanical results in calculations of diversity may not be a one-size-fits-all solution. Fortunately, other techniques are available for comparing macrobotanical and microbotanical results by context.

Table 18. Minimum Richness Value (MRV) by Spatial Context at La Blanca.

Neighborhood	Taxa Count	Macrobotanical Loci	Microbotanical Loci	MRV
CN	14	24	5	0.483
JNN	5	10	0	0.500
SAN	13	7	2	1.444
JSN	29	21	6	1.074
VN	20	17	12	0.690
SNS	5	0	2	2.500

Qualitative Comparisons

Statistical approaches, while providing broad impressions of assemblage composition that are normalized by sample size, exclude observations that can only be made qualitatively. These types of observations include general impressions of assemblage composition and food processing activities, based on complete taxa lists and the results of starch granule/phytolith analysis (see Chapter 5). Table 19 presents a complete list of identified taxa, organized by neighborhood. The Joyas South Neighborhood has the highest number of identified taxa. Yet the most compelling part of this table is not necessarily the number of taxa by neighborhood[7], but the types of plants recovered from each neighborhood. Root crops and tree crops, for example, are found in every neighborhood except for the Joyas North Neighborhood, while maize was recovered from all neighborhoods. This pattern indicates that inhabitants of nearly every neighborhood used a similar range of resources, including agricultural, arboreal, tuberous, and foraged plants. Wild potatoes are present in the Joyas South and Vacas Neighborhoods as well as Satellite Neighborhood South. These potatoes would have had to been acquired through exchanges with higher elevation areas of present-day Mexico or Guatemala (see Chapters 3, 5). Neighborhoods with wild tubers, including potatoes, are in the northern and southern portions of the site, flanking the Central Neighborhood. Thus, use of these small, easily portable, but often underrated wild tubers was not an isolated phenomenon. Instead, subsistence on imported tubers, wild tubers, and other wild resources represents a choice

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[7] Number of taxa identified is a noteworthy limitation for Satellite Neighborhood South as no macrobotanical samples from this neighborhood were analyzed. Most macrobotanical samples from this context date to the Late Classic period occupation.

made freely by La Blanca residents and not one made under duress due to problems in attaining adequate subsistence from other sources.

Table 19. Macrobotanical and Microbotanical Taxa Organized by Spatial Context.

CN	JNN	SAN	JSN	VN	SNS
Coyol	Mexican poppy cf.	Coyol	Avocado	Coyol	Bean family
Avocado	Horse purslane	Squash rind cf.	Bean	Squash/gourd	*Calathea*/Wild yam
Maize	Maize	Maize	Maize	Maize	Maize
Sapote	Bean family	Sapote	Coyol	Sapote	Manioc
Oreomunnea sp.	Palm family cf.	*Cyperus* sp.	Green sapote	Beak-sedge	Wild potato
Walnut		Arrowroot	Sapote	Horse purslane	
Bec		Horse purslane	Walnut	Mexican copperleaf	
Cyperus sp.		Jointvetch cf.	Arrowroot	Arrowroot	
Arrowroot		Scleria	*Calathea* cf.	*Calathea*	
Yam		Manioc cf.	Yam	Manioc cf.	
Horse purslane		Grass family	Sweet potato cf.	*Paspalum* sp. cf.	
Nutshell/palm		Mallow family cf.	Malanga	*Piscidia* sp.	
Palm family		Palm family	Root crop	Purslane	
Grass family			Wild *Calathea* cf.	Tick Clover	
			Wild yam	Wild yam	
			Wild potato	Wild potato	
			Beilschmledia sp.	Root crop	
			Cyperus sp.	Walnut family	
			Eragrostis sp. cf.	Palm family	
			Horse purslane	Grass family	
			Pereskia sp.		
			Root crop		
			Nutshell/palm		
			Walnut family		
			Palm family		
			Grass family		
			Sedge family cf.		

	Bean family cf. Mallow family cf.

Conclusions

In this chapter, I have presented evidence that residences at La Blanca were organized into discrete, meaningful neighborhoods. Residential groups at La Blanca better fit the model of having been created and maintained through bottom-up interactions between inhabitants rather than top-down directives, as would be the case with districts (see Smith 2010; Smith and Novic 2012). Each neighborhood had its own distinct role to play in supplying food to the city.

While the Central Neighborhood has the highest ranked households according to jade density, it defies expectations for hypotheses that wealthy inhabitants would have either benefitted off resources provided by others or organized production at the city center to take on managerial roles. This neighborhood neither appears to have supplied most of the city's food nor solely received food processed elsewhere. It has the highest ubiquity of maize cupules, which suggests processing, but it also had moderate quantities of most other resources and a rich array of taxa overall. It may have been one of the least specialized neighborhoods at La Blanca in terms of foodways. This finding problematizes the connection between economic status and food-related activities. By examining these parts of daily life as separate (but co-existing) social fields, it is possible to shed light on multiple axes of social diversity in ancient cities.

The Joyas South Neighborhood and Satellite Area North both played leading roles in food production, but in different ways. The Joyas South Neighborhood has the longest list of identified plant taxa of any neighborhood at the site, and a significantly even distribution of counts among macrobotanical taxa. Inhabitants of this neighborhood focused heavily on tree crop processing, some of it perhaps focused on extracting oil from the copious amount of coyol seeds recovered. The Joyas South Neighborhood also has the widest variety of root crop taxa of any neighborhood. Starch granules on cooking pots and manos from here demonstrate signs of grinding and thermal damage, which occurred alongside figurines having been fed meals made from ground maize, yam, and *Calathea* cf. (see Chapter 5). Collectively, this evidence suggests that the Joyas South Neighborhood served as a nexus for processing and a site of household rituals involving the feeding of figurines; evidence of these rituals also comes from the Vacas Neighborhood with one figurine mouth from this neighborhood yielding starch altered by baking or boiling.

Satellite Area North, in contrast to the Joyas South Neighborhood, does not exhibit particularly high richness. This locale ranked the lowest in the DIVERS richness assay. Taxa are also unevenly distributed, with maize cupules and kernels contributing most heavily to the overall count. Satellite Area North, therefore, appears to have served as a hub for maize processing and cooking. The Vacas Neighborhood may have served a similar role—processing and cooking maize—but its inhabitants appear to have focused more strongly on maize cooking than maize processing based on higher numbers of kernels in comparison to cupules; this neighborhood has the highest mean count of maize kernels.

Spatial analysis of subsistence activities at La Blanca has revealed that different areas of the site had unique but related functions with respect to food. The distribution of similar types of contributions across neighborhoods would have bolstered the food security of the city. Plant remains from La Blanca illustrate that Middle Preclassic inhabitants of the Pacific Coast engaged in both farming and foraging, with remarkable exploitation of arboreal resources including nuts, fruits, and palms. The degree to which this mixed subsistence strategy played out over time will be explored in the next chapter where temporal data will be coupled with spatial comparisons between neighborhoods.

CHAPTER 7: NAVIGATING CHANGE

The creation of an urban landscape is a generative, but not a formulaic process. Urban spaces typically have protracted histories with episodes of emergence, growth, and decline (Joyce 2009; Love 2011b; Smith 2011a). The La Blanca site is a good example of this concept. Here, occupation of each neighborhood extended across one or more subphases, with some areas being revisited after long periods of abandonment (see Figure 33). The study of ancient urban centers also provides insights into the creative strategies that humans use to maintain densely occupied spaces, a challenge that persists into the present day. Researching early cities has great potential to reveal successful tactics for enhancing urban sustainability. Indeed, the urban occupation of La Blanca lasted around 400 years (Love and Rosenswig 2022), much longer than those of many modern nation-states.

Time adds another analytical layer to the discussion of botanical variation presented in the previous chapter. Subsistence strategies are, at their core, choices. These choices are subject to change over time based on social, environmental, or other considerations. The regularity of preparing, cooking, and disposing of meals offers a detailed record of how La Blanca residents organized labor at the household and neighborhood scales. In this chapter, I consider how time affected subsistence strategies in the entire city, and how relationships between neighborhoods changed with the passage of time. I begin by discussing subphase boundaries for the Conchas phase, and then consider how plants contributed to and reveal the lived histories of each of these subphases at the La Blanca site. Returning to the neighborhoods presented in Chapter 6, I assess subsistence relations between these spatial entities over time. Finally, I reflect on the broader implications of this research through comparing plant and animal data from La Blanca.

Refining Conchas Subphases at La Blanca

The Middle Preclassic, or Preclassic, period on the Pacific Coast includes three ceramic phases (see Figure 5; Love 2007): Jocotal (1100-975 cal. BCE), Conchas (975-600 cal. BCE), and Caramelo (600-400 cal. BCE). Most ceramics recovered from La Blanca date to the Conchas phase, suggesting a primarily Conchas-phase occupation. This occupation extended into the Caramelo phase and the beginning of the Late Preclassic period, with fewer ceramics dating to these temporal contexts (Michael Love, personal communication 2022). Activity at La Blanca appears to have scaled down at around the same time as the founding of El Ujuxte (500 BCE-100 CE), a nearby state center (Love 2016a, 2018).

Fewer than ten excavated settlements on the Pacific Coast date to the Conchas phase, and households have been excavated from even less. Coe (1961:31-34) first identified two Conchas subphases, Conchas 1 (Middle Preclassic) and 2 (now considered early part of Late Preclassic), at the site of La Victoria on the Pacific coast of Guatemala. An estimated seven to 10 households (at least) date to the Conchas phase occupation of this site, in stark contrast to La Blanca where at least 100 households have been identified (Michael Love, personal communication 2022). Izapa, to the north in Chiapas, has a Conchas phase occupation but it is minor in scale in comparison to its urban manifestation during the Late Preclassic period (Love and Rosenswig 2022:153). No Conchas subphases have been delineated here as is also the case with the nearby village of Cuauhtémoc (Rosenswig et al. 2015).

During the Conchas phase, La Blanca is by far the most densely populated and expansive settlement known at present on the Pacific Coast. The high number of residences and trash-laden pits at the site have contributed to the recovery of an enormous amount of pottery. This large ceramic assemblage allows for more minor changes to be detectable during the Conchas phase that facilitate the identification of subphases. Four subphases were initially identified by Love (2002a): Conchas A, B, C, D. An additional subphase, Conchas E, has been recently added to the chronology (Michael Love, personal communication 2021). However, these subphases should be seen as being specific to La Blanca and not the Pacific Coast. Other Conchas-phase sites do not currently offer a sufficiently large ceramic dataset and/or stratigraphically controlled excavations to assess the regional applicability of subphases identified at La Blanca. Thus, ceramic data from La Blanca provide a more precise sense of chronological control during the Conchas phase than is available anywhere else in the region.

New Radiocarbon Dates

Direct dating of annual plants results in high-precision probability distributions that complement the outcomes of ceramic analysis. Eighteen maize kernels from the study assemblage were submitted to the University of California, Irvine for radiocarbon dating (Table 20). Out of these eighteen samples, sixteen yielded reasonable results (Table 21). The two outliers are UCIAMS #255123 and #255129. These dates have laboratory-produced BP values that are far more recent than expected, placing their uncalibrated ^{14}C ages at ~1195 CE and ~1825 CE, respectively. Even when calibrated, these samples date to the Postclassic period or later. Interestingly, pottery from these late periods in the regional chronology has not been recovered from any intact contexts at La Blanca. These dates do not appear to be of analytical significance for studying any occupation of the site, especially the Middle Preclassic period. Thus, they are excluded from any further analysis.

Table 20. Carbonized Maize Kernels from La Blanca Submitted for Radiocarbon Dating.

UCIAMS #	Flotation Catalog No.	Op	Sub	Nivel/Rasgo	Depth (m)
255118	26.5.0.32.1	26	5	R32	-
255119	32.4.19.0.1	32	4	N19	1.8-1.9
255120	32.6.16.0.1	32	6	N16	1.5-1.6
255121	32.6.17.0.1	32	6	N17	1.6-1.7
255122	32.8.0.59.1.1	32	8	R59	-
255123	49.1.10.218.3	49	1	R218 (above floor)	-
255124	55.2.0.245.1	55	2	R245A	0.8-0.9
255125	56.2.0.261.1	56	2	R261	1.0-1.1
255126	57.1.0.266.2	57	1	R266A	1.4-1.5
255127	57.3.0.269.3	57	3	R269B	1.0-1.1
255128	65.5.0.305.2	65	5	R305	1.64-1.7
255129	66.2.0.302.1	66	2	R302	0.8-0.9
255130	66.3.0.322.1	66	3	R322	1.25-1.27
255131	66.4.0.321.1	66	4	R321	1.40-1.47
255132	66.5.0.314.4	66	7	R314D	1.1-1.2
255133	67.1.0.327.3	67	1	R327B	1.1-1.2
255134	67.3.0.325.1	67	3	R325	0.69-0.80
255135	67.3.0.325.4	67	3	R325C	1.0-1.1

Table 21. Radiocarbon Results for Carbonized Maize Kernels from La Blanca.

UCIAMS #	Neighborhood	Ceramic Subphase	δ^{13}C (‰)	±	^{14}C age (BP)	±	2-σ Calibrated ^{14}C age Range (BCE)
255118	CN	No Data	-9.8	1.2	2760	15	970-834
255119	CN	Conchas C	-9.2	1.2	2745	15	922-832
255120	CN	Conchas C	-8.9	1.2	2750	15	925-833
255121	CN	Conchas C	-9.3	1.3	2725	15	907-822
255122	CN	Late Classic/ Conchas D	-9.6	1.2	2770	15	982-837
255123[a]	JNN	Mixed Historic/ Conchas E	-9.2	1.2	755	15	1230-1284 CE

255124	JSN	Conchas D	-9.2	1.2	2755	15	963-832
255125	JSN	Conchas C/D/E	-8.5	1.3	2855	15	1109-932
255126	JSN	Conchas D	-8.6	1.1	2715	15	902-817
255127	JSN	Conchas D	-9.1	1.3	2760	15	970-834
255128	VN	Conchas C	-8.6	1.2	2750	15	925-833
255129[a]	VN	Conchas C	-26.4	1.7	125	15	1686-1928 CE
255130	VN	Conchas	-9.4	1.1	2730	15	910-825
255131	VN	Conchas	-9.3	1.3	2820	15	1015-916
255132	VN	Conchas	-8.7	1.2	2680	15	897-803
255133	VN	Conchas	-10.1	1.1	2780	15	997-847
255134	VN	Conchas D	-9.5	1.1	2605	15	806-779
255135	VN	Conchas D	-9.5	1.3	2590	15	802-776

Note: Calibrations performed using IntCal20 (Reimer et al. 2020) and OxCal 4.4.

[a] Samples excluded from further analysis.

New radiocarbon dates produced by this study are calibrated and displayed in Figure 48. Dates are organized by the ceramic provenience. Organizing results in this way provides insights into possible subphase identifications for contexts with ambiguity or several possible subphases. For example, UCIAMS #255122 has a median that resembles those from Conchas D and thus at least portions of Rasgo 59 date to that subphase. UCIAMS #255125 dates far earlier than its possible Conchas C/D/E identification suggests. Despite its early date, much of its distribution intersects with the Conchas phase. The identification of Conchas phase pottery attributes supports an interpretation of Rasgo 261 as early Conchas rather than late Jocotal phase. Radiocarbon data also shed light on potential proveniences of contexts for which ceramics could only be identified as Conchas (subphase unspecified) or have yet to be analyzed. UCIAMS #255130 (Rasgo 322) appears to be a good match for Conchas C, whereas UCIAMS #255118 (Rasgo 32) closely resemble Conchas D dates. Conchas C dates all have similar distributions, whereas Conchas D has two dates that are more recent than the rest (#255134 and 255135).

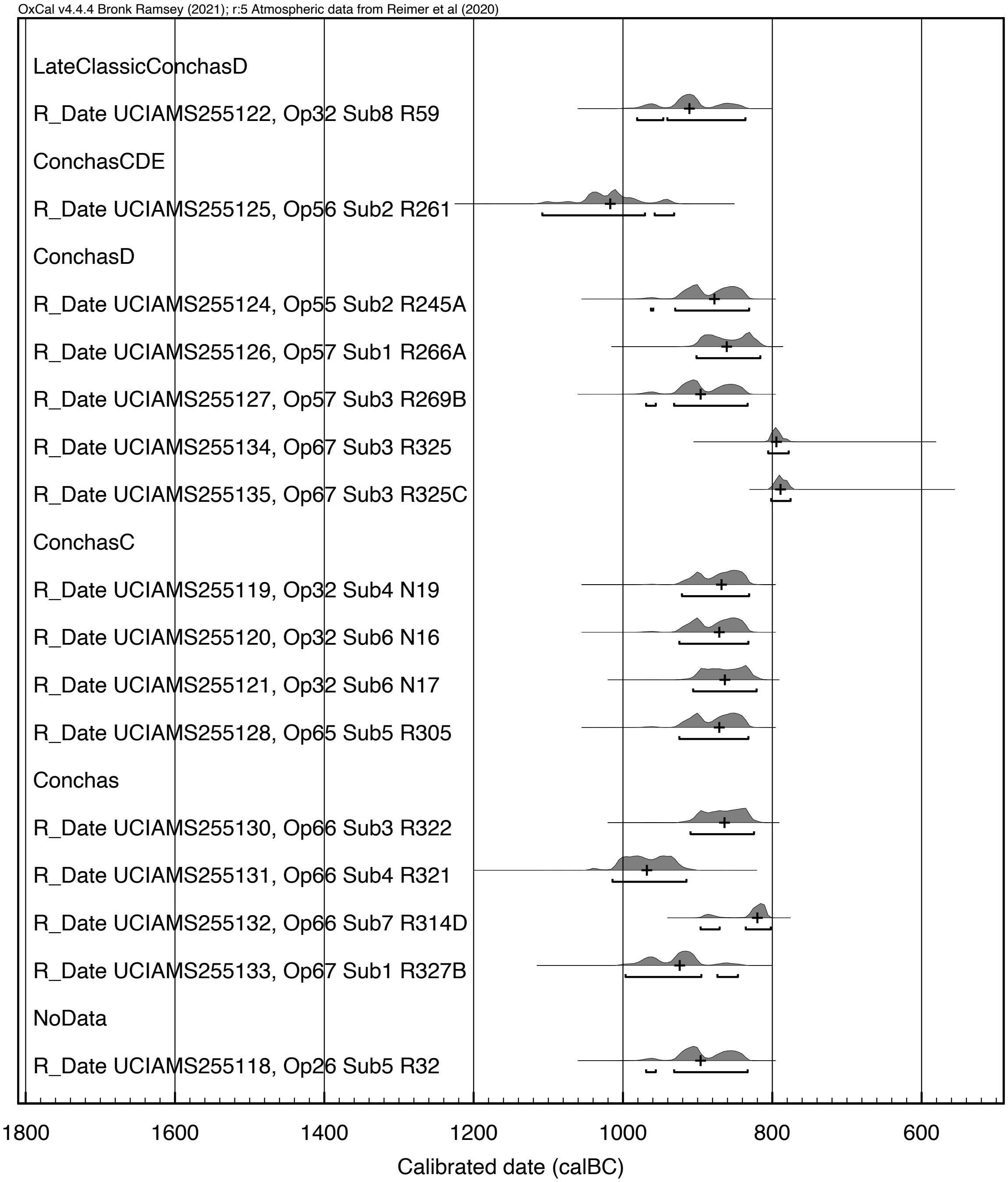


Figure 48. Multiple plot of calibrated radiocarbon dates produced by this study. Dates are organized by ceramic phase. Medians are marked with plus signs.

Although radiocarbon dating provides insights into temporal context, it is important to remember that ^{14}C results should not be seen as preferential to ceramic placements.

Radiocarbon results instead provide an additional perspective on temporal associations that, in the case of this new dataset, appear to date certain contexts more precisely. Observations based on comparing calibrated date distributions in the multiple plot are intriguing but an important caveat is that only one specimen is dated per context, providing no other data with which to compare results.

Merging New and Old Datasets

Before analyzing phase-based associations between botanical remains, it is essential to situate the new radiocarbon dates generated by this study within the broader scope of extant dates from the La Blanca site. All prior dates were run on carbonized wood, with various facilities conducting the analysis (Table 22). Wood fragments were hand-collected with vertical and horizontal coordinates recorded. Yet one of the benefits of choosing annual plants over wood is that the former typically yields more precise probability ranges with less potential for inbuilt age. Inbuilt age is introduced when dating flora and fauna that grow in concentric rings (Bronk Ramsey 2009; Dee and Bronk Ramsey 2014). These materials, namely wood and marine shell, can become highly fragmented by taphonomic processes. Archaeologists then date a portion of that material without knowing whether it comes from a more interior or exterior region. This ambiguity introduces potential error in generating dates as portions created earlier may differ in date from more recent additions. Older radiometric dates, like those generated for Operations 25 and 27 (see Table 22), are also subject to wider probability distributions than Accelerated Mass Spectrometry (AMS) dates due to methodological advancements with the development of AMS (Törnqvist et al. 2015; see also Wilson et al. 2018).

Table 22. Comprehensive List of Radiocarbon Dates for the La Blanca Site.

Laboratory #	Context	Material	Locale	Ceramic Phase	^{14}C age (BP)	Unmodelled: Calibrated (BCE)	Modelled: COM Applied (BCE)
B-24053[b]	Op25 Sub7 R34	Wood	CN	No Data	2875 ± 90	1368-830	1365-822
B-24052/ ETH2598	Op25 Sub7 R9	Wood	CN	No Data	2885 ± 95	1376-833	1373-827
UCIAMS255118	Op26 Sub5 R32	Maize kernel	CN	No Data	2760 ± 15	970-834	969-823
B-23470[b]	Op27 Sub 1 R41	Wood	CN	No Data	2749 ± 150	1382-521	1376-517
B-23471[b]	Op27 Sub2 R26	Wood	CN	No Data	2580 ± 130	1004-398	1000-391
B-24054/ETH3600[a]	Op27 Sub2 R39	Wood	CN	No Data	3135 ± 100	1621-1121	1617-1114
AA-96148	Op28 N30	Wood	CN	Conchas B	2739 ± 38	981-809	977-802
UCIAMS255119	Op32 Sub4 N19	Maize kernel	CN	Conchas C	2745 ± 15	922-832	922-832
UCIAMS255120	Op32 Sub6 N16	Maize kernel	CN	Conchas C	2750 ± 15	925-833	926-832
UCIAMS255121	Op32 Sub6 N17	Maize kernel	CN	Conchas C	2725 ± 15	907-822	907-822
UCIAMS255122	Op32 Sub8 R59	Maize kernel	CN	Late Classic/ Conchas D	2770 ± 15	982-837	982-837
AA-75406	Op34 R83	Wood	CN	Conchas D	2688 ± 36	907-799	908-787
AA-75407	Op34 R92	Wood	CN	Conchas B/C	2704 ± 35	915-804	917-792
AA-75404	Op36 R127A	Wood	CN	Conchas C	2678 ± 39	907-793	906-781
AA-75405	Op36 R125A	Wood	CN	Conchas C	2688 ± 36	907-799	908-787
AA-75409	Op37 R142	Wood	CN	Conchas C	2703 ± 36	917-803	918-792
AA-75408	Op37 R166	Wood	CN	Conchas B	2760 ± 35	997-825	992-815
UCIAMS255123[a]	Op 49 Sub1 R218 (above floor)	Maize kernel	JNN	Mixed Historic/Conchas E	755 ± 15	1686-1928 CE	-
UCIAMS182750	Op50 Sub1 R226	Wood	SAN	Conchas C	2740 ± 15	916-830	916-819
UCIAMS182747	Op50 Sub1 R226	Wood	SAN	Conchas C	2760 ± 15	970-834	969-823
UCIAMS182751	Op50 Sub1 R226	Wood	SAN	Conchas C	2760 ± 15	970-834	970-823
UCIAMS182748	Op50 Sub1 R226	Wood	SAN	Conchas C	2790 ± 15	1004-900	1004-885
UCIAMS182752	Op50 Sub1 R240E	Wood	SAN	Conchas C	2645 ± 15	821-793	821-776
UCIAMS182753	Op50 Sub1 R240J	Wood	SAN	Conchas C	2710 ± 15	900-814	899-806
UCIAMS182749	Op50 Sub1 R266	Wood	SAN	Conchas D	2755 ± 15	963-832	963-820
UCIAMS182755	Op50 Sub3 R240I	Wood	SAN	Conchas C	2760 ± 15	970-834	970-823
UCIAMS182754	Op50 Sub3 R240M	Wood	SAN	Conchas C	2775 ± 15	986-839	981-836

Laboratory #	Context	Material	Locale	Ceramic Phase	^{14}C age (BP)	Unmodelled: Calibrated (BCE)	Modelled: COM Applied (BCE)
UCIAMS182756	Op51 Sub1 N12A	Wood	JNN	Conchas E	2535 ± 15	789-568	787-556
UCIAMS182757	Op51 Sub1 N13	Wood	JNN	Conchas E	2545 ± 15	794-574	791-566
UCIAMS182762	Op57 Sub1 R264	Wood	JSN	Conchas D	2480 ± 15	761-540	757-532
UCIAMS255124	Op55 Sub2 R245A	Maize kernel	JSN	Conchas D	2755 ± 15	963-832	964-832
UCIAMS182758	Op55 Sub4 R255J	Wood	JSN	Conchas D	2540 ± 15	791-569	790-561
UCIAMS182759	Op55 Sub4 R255K	Wood	JSN	Conchas D	2545 ± 15	794-574	791-566
UCIAMS182760	Op55 Sub4 R255L	Wood	JSN	Conchas D	3105 ± 15	1426-1302	1425-1291
UCIAMS182761	Op55 Sub4 R258	Wood	JSN	Conchas C	2670 ± 15	894-801	891-781
UCIAMS255125	Op56 Sub2 R261	Maize kernel	JSN	Conchas C/D/E	2855 ± 15	1109-932	1109-932
UCIAMS182764[a]	Op57 Sub1 N5B	Wood	JSN	Conchas D	215 ± 15	1647-1800 CE	1648-1956 CE
UCIAMS182763	Op57 Sub1 R266	Wood	JSN	Conchas D	2690 ± 15	899-806	896-792
UCIAMS255126	Op57 Sub1 R266A	Maize kernel	JSN	Conchas D	2715 ± 15	902-817	-
UCIAMS182765	Op57 Sub1 R266C	Wood	JSN	Conchas D	2645 ± 20	830-790	829-769
UCIAMS255127	Op57 Sub3 R269B	Maize kernel	JSN	Conchas D	2760 ± 15	970-834	-
UCIAMS255128	Op65 Sub5 R305	Maize kernel	VN	Conchas C	2750 ± 15	925-833	-
UCIAMS255129[a]	Op66 Sub2 R302	Maize kernel	VN	Conchas C	125 ± 15	1686-1928 CE	-
UCIAMS255130	Op66 Sub3 R322	Maize kernel	VN	Conchas	2730 ± 15	910-825	-
UCIAMS255131	Op66 Sub4 R321	Maize kernel	VN	Conchas	2820 ± 15	1015-916	-
UCIAMS255132	Op66 Sub7 R314D	Maize kernel	VN	Conchas	2680 ± 15	897-803	-
UCIAMS255133	Op67 Sub1 R327B	Maize kernel	VN	Conchas	2780 ± 15	997-847	-
UCIAMS255134	Op67 Sub3 R325	Maize kernel	VN	Conchas D	2605 ± 15	806-779	-
UCIAMS255135	Op67 Sub3 R325C	Maize kernel	VN	Conchas D	2590 ± 15	802-776	-
AA-96147	Op40 R204	Wood	Op 40	No Data	2749 ± 38	987-813	987-806
UCIAMS242223	Op41	Wood	Mound 1	No Data	2725 ± 15	907-822	906-812
UCIAMS242229	Op41	Wood	Mound 1	No Data	2730 ± 15	910-825	907-816
UCIAMS242226	Op41	Wood	Mound 1	No Data	2740 ± 15	916-830	916-819
UCIAMS242235	Op41	Wood	Mound 1	No Data	2745 ± 20	928-827	926-813
UCIAMS242231	Op41	Wood	Mound 1	No Data	2745 ± 20	928-827	926-813
UCIAMS242236	Op41	Wood	Mound 1	No Data	2760 ± 20	978-831	975-821
UCIAMS242230	Op41	Wood	Mound 1	No Data	2765 ± 15	976-835	974-826
UCIAMS242222	Op41	Wood	Mound 1	No Data	2770 ± 15	982-837	976-832
UCIAMS242225	Op41	Wood	Mound 1	No Data	2785 ± 15	1005-856	1001-849

Laboratory #	Context	Material	Locale	Ceramic Phase	^{14}C age (BP)	Unmodelled: Calibrated (BCE)	Modelled: COM Applied (BCE)
UCIAMS242232	Op41	Wood	Mound 1	No Data	2795 ± 20	1011-860	1009-857
UCIAMS242227	Op41	Wood	Mound 1	No Data	2810 ± 15	1009-913	1007-904
UCIAMS242224	Op41	Wood	Mound 1	No Data	2815 ± 15	1011-916	1010-904
UCIAMS242237	Op41	Wood	Mound 1	No Data	2820 ± 20	1043-911	1041-901
UCIAMS242228	Op41	Wood	Mound 1	No Data	2790 ± 15	1004-900	1004-885
UCIAMS242233	Op41	Wood	Mound 1	No Data	2905 ± 15	1192-1015	1192-1007
UCIAMS242234	Op41	Wood	Mound 1	No Data	4780 ± 20	3634-3527	3633-3520

Note: Calibrations performed using IntCal20 (Reimer et al. 2020) and OxCal 4.4. COM = Charcoal Outlier Model (Dee and Bronk Ramsey 2014). R = Rasgo (feature). N = Nivel (level).

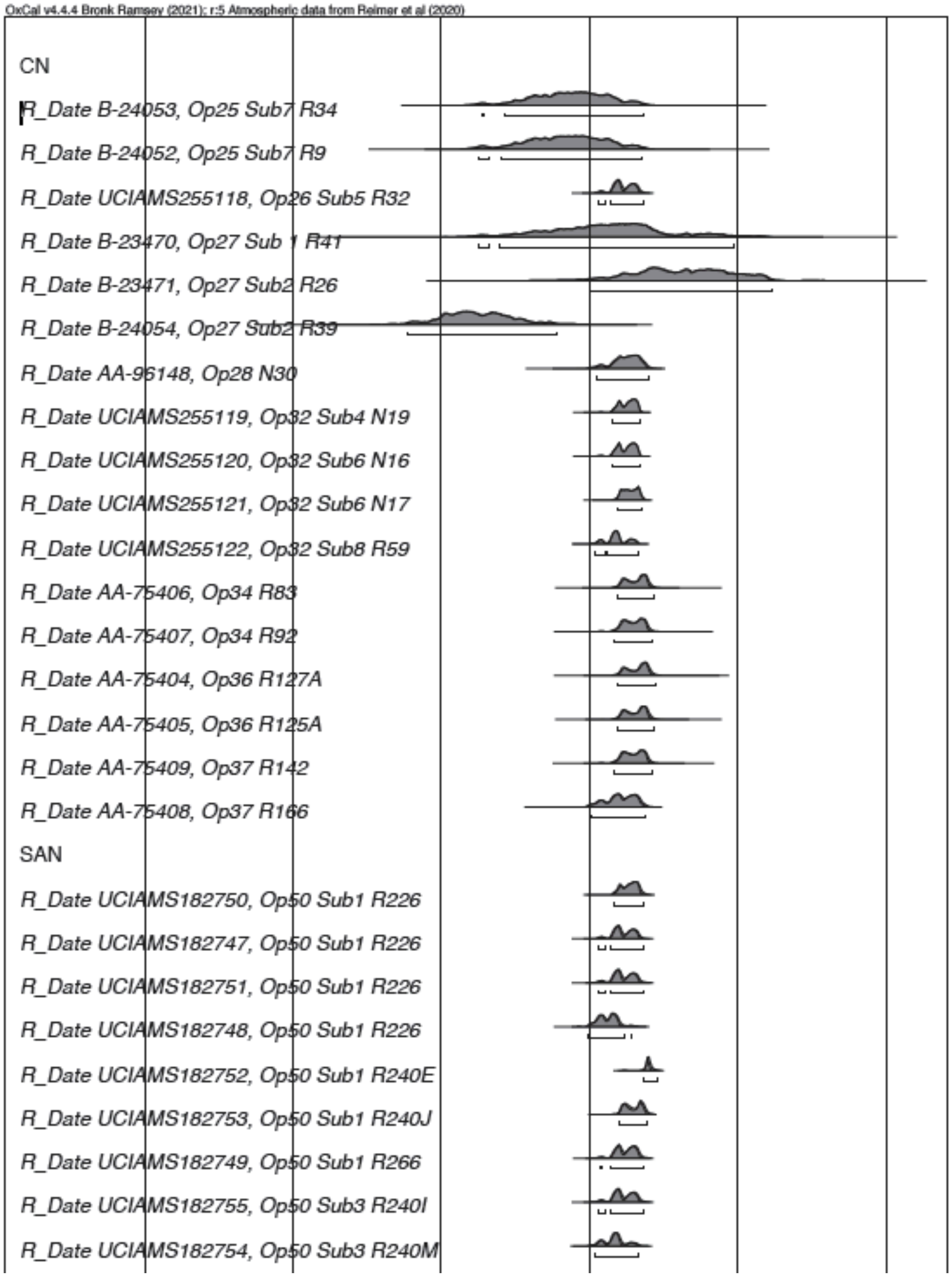
[a] Problematic date.

[b] Radiometric date.

Despite complications with using extant radiocarbon data for La Blanca, such as in-built age for wood and wider error ranges for radiometric dates, it is possible to introduce correction factors that help to adjust for inconsistencies in method and material type. One such correction factor is the Charcoal Outlier Model, developed by Dee and Bronk Ramsey (2014). This method uses an exponential function to correct for common problems encountered in dating wood such as inbuilt age and broader probability distributions than other materials (e.g., annuals). This method also helps to correct for broad probability distributions associated with radiometric dates. The Charcoal Outlier Model is applied to specific dates, meaning that dates altered using this model can be plotted alongside other dates without those dates being affected by the model's parameters. I consistently apply the Charcoal Outlier Model to all wood dates from La Blanca (see Table 22) as a means of better integrating them alongside newer dates on annuals. In looking at the entire radiocarbon assemblage from La Blanca, it is possible to make inferences regarding the pace of neighborhood construction and the duration of ceramic subphases.

Neighborhood Occupation Histories. Organizing radiocarbon dates by neighborhoods has great potential to provide insights into the timing of their construction and abandonment. A multiple plot of most radiocarbon dates from the La Blanca site is displayed in Figure 49. Omitted dates include the two problematic new dates previously described, UCIAMS #255123 and UCIAMS #255129, and one previously generated date, UCIAMS #182764. After calibrating and applying Charcoal Outlier Model correction, UCIAMS #182764 had a distribution of 1648-1956 CE, far more recent than the main occupation of the La Blanca site. Thus, this date was cut from the multiple plot. Unfortunately, no radiocarbon dates have been run on materials from Satellite

Neighborhood South so this area is excluded from the analysis. Table 23 reports the numerical spreads of the occupations for each neighborhood based on the date ranges plotted in Figure 49.



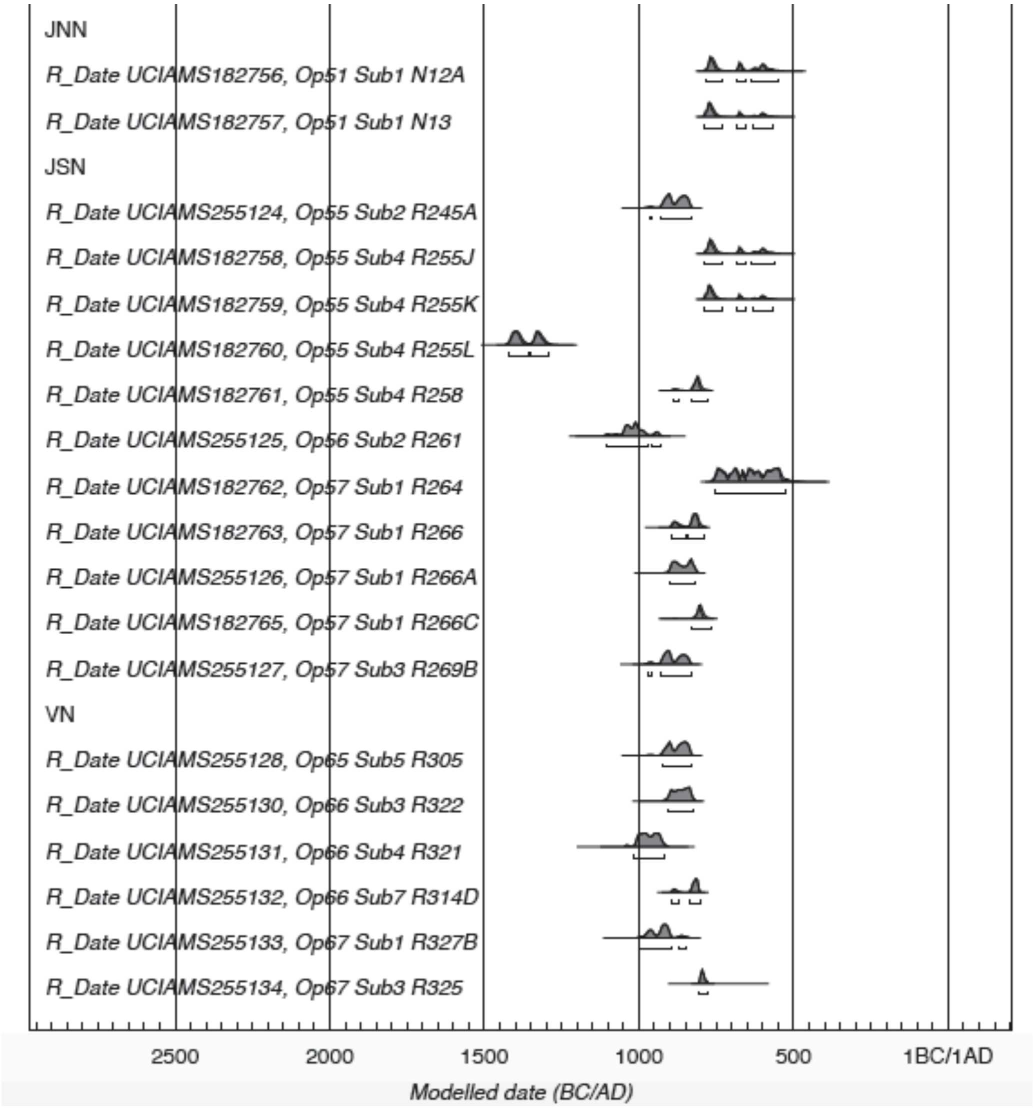


Figure 49. Multiple plot of radiocarbon dates from La Blanca organized by spatial context. Omissions noted in text.

Table 23. Occupations of La Blanca Locales Based on Calibrated Radiocarbon Dates with Charcoal Outlier Model Applied.

Locale	Occupation Interval (BCE)	Notes
JNN	792-551	-
CN	994-779	Excludes Beta dates; with Beta dates: 1375-517 BCE
SAN	1004-771	-
VN	1015-776	-

JSN	1108-529	Excludes UCIAMS 182760; with this date: 1424-529 BCE

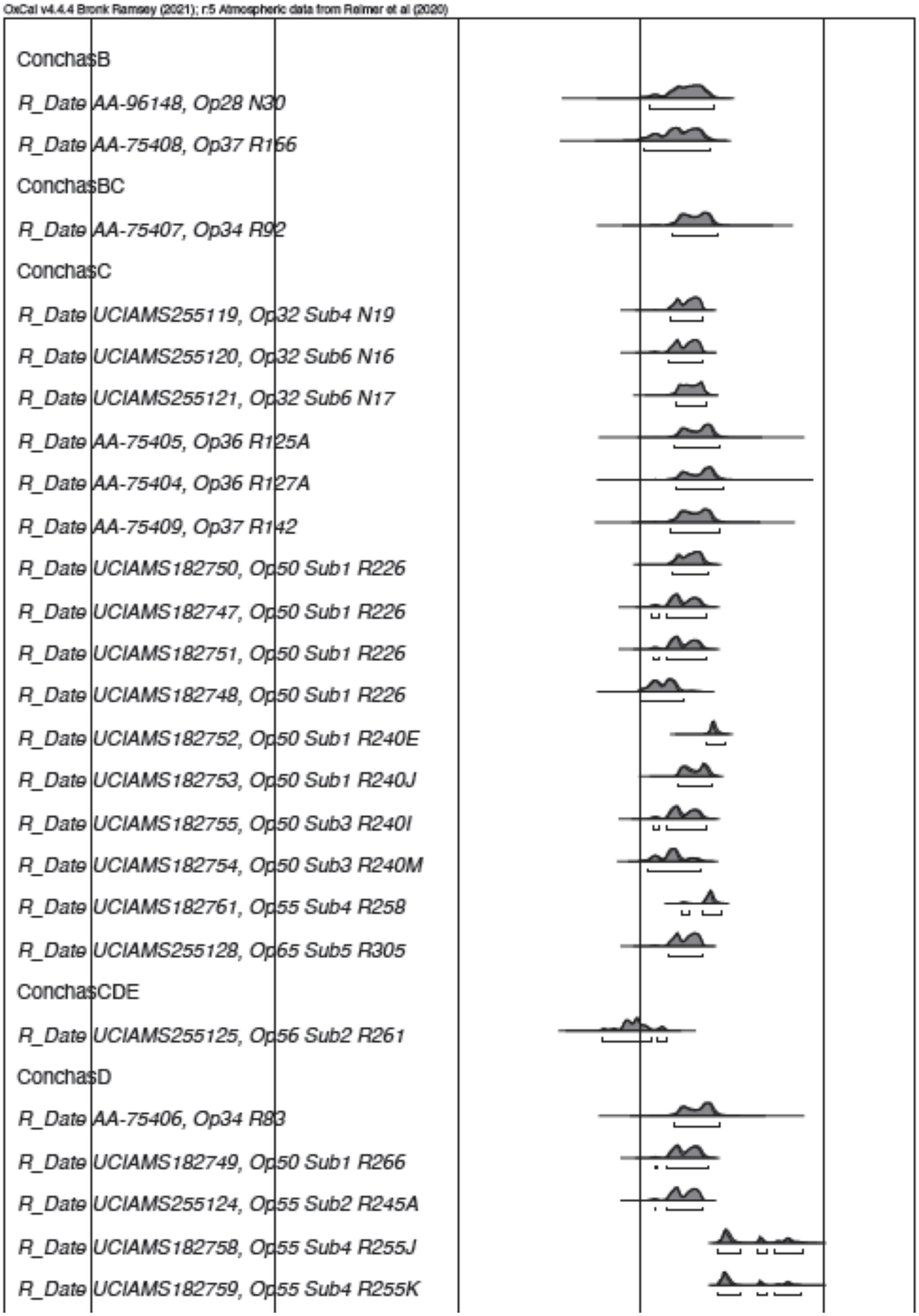
Patterns emerge when interpreting visual and numerical data together. The earliest occupation appears to have been in the Joyas South Neighborhood, with a founding that predates the occupation of any other neighborhood even when excluding UCIAMS #182760; this date is pre-Conchas and much earlier than any other Joyas South Neighborhood dates. Interestingly, the Joyas South Neighborhood occupation is also the most long-lived at the site, extending until 529 BCE.

Founding dates for the next three locales are staggered at roughly 10-year intervals. It is initially tempting to think of these three contexts as sequential occupations, but they are in fact abandoned at around the same time (CN = 779 BCE, VN = 776 BCE, SAN = 771 BCE). The first location to be occupied is the Vacas Neighborhood (1015 BCE), followed by Satellite Area North (1004 BCE), and finally the Central Neighborhood (994 BCE). The assessment of the occupation of the Central Neighborhood presented in Table 23 excludes dates generated by Beta Analytic in the 1980s and 90s. These dates have wide probability distributions, even after applying the Charcoal Outlier Model (see Figure 49). No dates from the Central Neighborhood besides those in the Beta group postdate 779 BCE. Thus, excluding these dates from calculation of the Central Neighborhood occupation span seems reasonable, at least until more precise AMS dates suggest otherwise.

The Joyas North Neighborhood is the last to be founded (792 BCE). Note that the Joyas North Neighborhood is near the Joyas South Neighborhood. The Joyas North Neighborhood occupation begins ~300 years after the start of the Joyas South Neighborhood occupation and ends ~20 years before the latter is abandoned. The Joyas North

Neighborhood is perhaps best interpreted as an addition to the Joyas South Neighborhood area. Later, operations wind down at Joyas North Neighborhood, perhaps due to a lower population in this part of the site near the end of the site's occupation, or a lack of necessity for the functions that this neighborhood may have served. Meanwhile, occupation at Joyas South Neighborhood continues, with the abandonment of this neighborhood marking the end of La Blanca's time as an urban center.

Ceramic Subphases. Organizing the same set of dates in accordance with ceramic subphase distinctions informs our understanding of the timing of these La Blanca subphases (Figure 50). These subphase distinctions are determined based on the results of ceramic analysis for each dated context (Michael Love, personal communication 2021). A few contexts had ceramic assemblages with aspects of two or more subphases/phases represented. These are identified as Conchas BC, Conchas CDE, Conchas LPC (Late Preclassic), and LateClassicConchasD in the multiple plot. Other contexts could only be classified as "Conchas" or did not have any ceramic data to include (NoData).


OxCal v4.4.4 Bronk Ramsey (2021); r:5 Atmospheric data from Reimer et al (2020)
ConchasB
R_Date AA-96148, Op28 N30
R_Date AA-75408, Op37 R166
ConchasBC
R_Date AA-75407, Op34 R92
ConchasC
R_Date UCIAMS255119, Op32 Sub4 N19
R_Date UCIAMS255120, Op32 Sub6 N16
R_Date UCIAMS255121, Op32 Sub6 N17
R_Date AA-75405, Op36 R125A
R_Date AA-75404, Op36 R127A
R_Date AA-75409, Op37 R142
R_Date UCIAMS182750, Op50 Sub1 R226
R_Date UCIAMS182747, Op50 Sub1 R226
R_Date UCIAMS182751, Op50 Sub1 R226
R_Date UCIAMS182748, Op50 Sub1 R226
R_Date UCIAMS182752, Op50 Sub1 R240E
R_Date UCIAMS182753, Op50 Sub1 R240J
R_Date UCIAMS182755, Op50 Sub3 R240I
R_Date UCIAMS182754, Op50 Sub3 R240M
R_Date UCIAMS182761, Op55 Sub4 R258
R_Date UCIAMS255128, Op65 Sub5 R305
ConchasCDE
R_Date UCIAMS255125, Op56 Sub2 R261
ConchasD
R_Date AA-75406, Op34 R83
R_Date UCIAMS182749, Op50 Sub1 R266
R_Date UCIAMS255124, Op55 Sub2 R245A
R_Date UCIAMS182758, Op55 Sub4 R255J
R_Date UCIAMS182759, Op55 Sub4 R255K

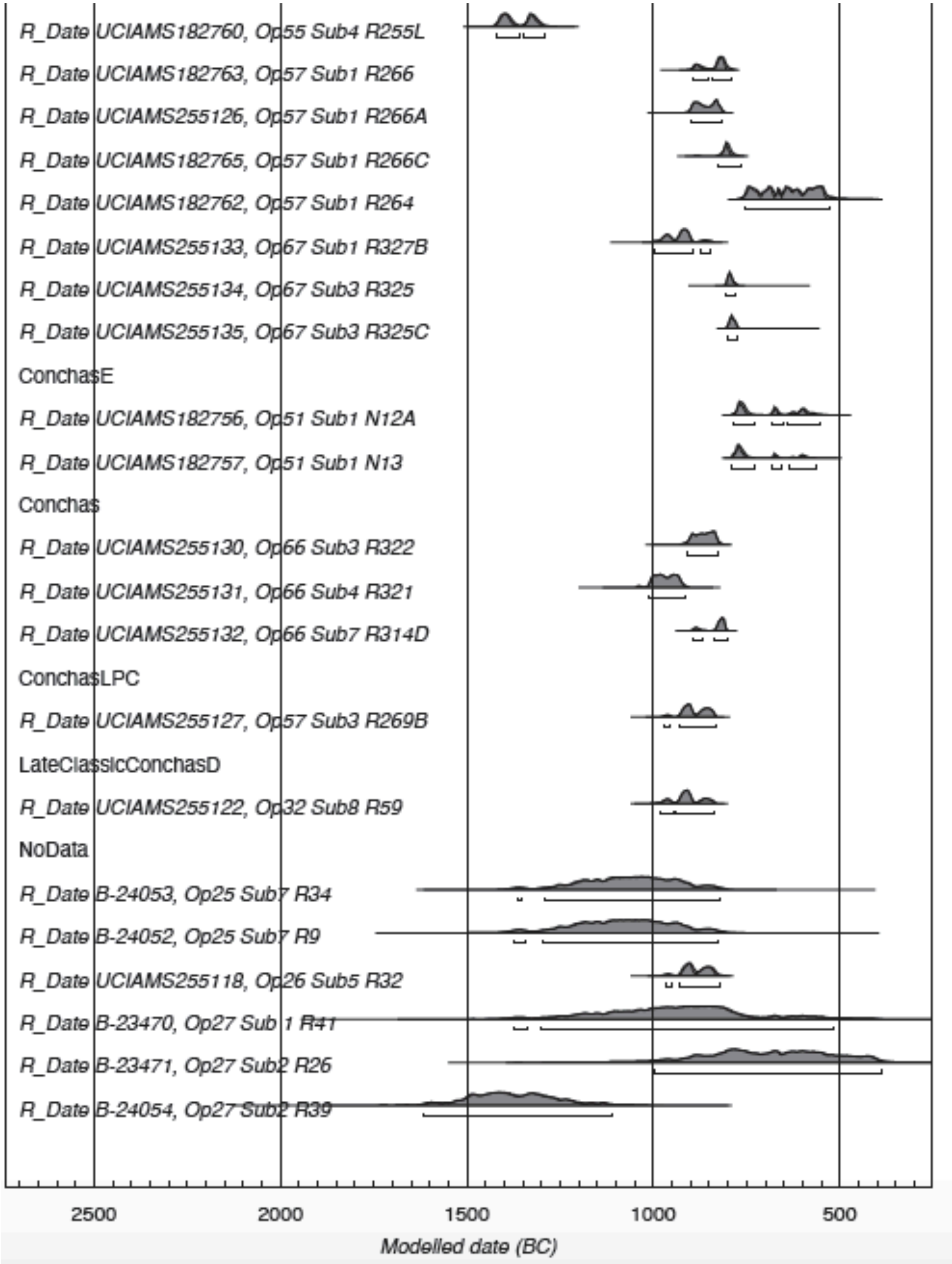


Figure 50. Multiple plot of radiocarbon dates from La Blanca organized by ceramic phase/subphase.

Conchas C and D have the most dates, with 16 and 13, respectively. Conchas B and E have two dates each. Materials dated from the Conchas LPC and LateClassicConchas D categories align well with several of the Conchas D date distributions (see Figure 50). However, it is important to note that the date generated is only for the submitted specimen and not the entire context, which may have lenses of material from different periods. It is evident from examining the subphase spans (Table 24) that there are problems establishing sensible start dates for Conchas C and D. The start dates for Conchas C (1004 BCE) and D (997 BCE) predate the beginning of Conchas B (994 BCE); refinement of these start dates is pursued below using Bayesian analysis. The end dates, however, are more inPreclassic. Although Conchas E is the most recent subphase, it is not the only pottery type being produced ca. 700 BCE. Instead, it appears that Conchas C and—for a longer period—Conchas D pottery continued to be used and produced during the Conchas E subphase. Interestingly, recovery of Conchas B pottery indicates that occupation of the Central Neighborhood, not the Joyas South Neighborhood (see Table 23), likely occurred first. Occupation of the Central Neighborhood, Satellite Area North, Joyas South Neighborhood, and Vacas Neighborhood then occurred during the Conchas C and D subphases. Conchas C and D clearly represent the greatest periods of activity and the peak of La Blanca's life as an urban center, a point that has been previously made by Love (2002a). Subphase results also reinforce the budding argument that La Blanca residents founded the Joyas North Neighborhood last. Inhabitants made this addition toward the end of the city's life, when the long-term residential areas of the site (CN, SAN, JSN, VN) had all been abandoned.

Table 24. Spans of Conchas Subphases at La Blanca Based on Calibrated Radiocarbon Dates with Charcoal Outlier Model Applied.

Conchas Subphase	Span (BCE)	Neighborhood(s)	Notes
E	791-552	JNN	-
D	997-529	CN; SAN; JSN; VN	Excludes UCIAMS 182760; with this date: 1424-529 BCE
C	1004-771	CN; SAN; JSN; VN	-
B	994-801	CN	-

Determining the histories of neighborhoods founded during the Conchas C and D subphases is ultimately complicated by difficulties in determining their start dates. Are Conchas C and D pottery types just two contemporary styles produced at the city's height? As new contexts are associated with these phases, teasing out their timing may help in assessing temporal trends in botanical data. Even if occupation of the same neighborhoods occurred during both subphases, botanical remains from contexts dating to Conchas C or D can uniquely help to tease out temporal changes in daily life over the course of the city's growth. Thus, it is valuable to determine the relationship between these two subphases. One useful tool for teasing out temporal relationships between phases is Bayesian analysis of radiocarbon dates.

Bayesian Analysis

Bayesian analysis is a collective term referring to statistical approaches that integrate prior knowledge into the calculation of probabilities (Berger 2000). This principle of integrating priors to generate posterior calculations is known as Bayes' theorem (Efron 2013). Bayesian analysis has varied applications within the natural and social sciences (Kaplan 2014; O'Hagan and West 2010), but it is particularly useful in reshaping the ranges of radiocarbon dates on archaeological materials (e.g., Arroyo et al. 2020; Culleton et al.

2012; Inomata et al. 2020; Kennett et al. 2011; Melton et al. 2020b). Each radiocarbon date is a probability distribution that is adjusted to better represent the age of the dated material when calibrated using atmospheric or oceanic data. However, calibration does not account for relationships between dates. A key focus of archaeological fieldwork is identifying stratigraphic and horizontal relationships between contexts, yet this information cannot be integrated into determining absolute chronologies by using calibration alone. Bayesian analysis fills this gap for archaeologists, allowing prior information (e.g., field observations, ceramic chronologies) to be integrated when determining probability distributions for radiocarbon dates.

One application of Bayesian analysis is the integration of radiocarbon and ceramic information in dating occupational duration (e.g., Arroyo et al. 2020; Lulewicz 2019; Wilson et al. 2018). The La Blanca site has five Conchas phase occupations (Conchas A through E) discernable in the ceramic record. Only two occupations, Conchas C and D, are suitable for this type of analysis as a minimum of three radiocarbon dates are required per occupation with more dates producing more robust relationships. La Blanca Conchas C and D are evaluated using OxCal v.4.4, a program specifically designed for Bayesian analysis of radiocarbon data.

Before describing the results, it is important to first discuss my use of the term phase. In OxCal, a phase is a group of unordered events which can be compared relatively with other groups (e.g., phases) using various constraints. I use ceramic subphases to inform my creation of OxCal phases, with each OxCal phase containing dates from contexts linked to one subphase through ceramic analysis.

Three models of OxCal phase relationships were tested: contiguous, sequential, and overlapping. The contiguous model assumes that phases occur in the order determined in the archaeological record (Bronk Ramsey 2022). In this case, the Conchas C OxCal phase would be assumed to date prior to the Conchas D OxCal phase. The sequential model assumes that phases come one after another but, in contrast to the contiguous model, these phases are not assumed to abut. The overlapping model supposes that phases can be in any order and may have a gap between them. In each model, the Charcoal Outlier Model was applied to wood dates to correct for the problems encountered when working with these dates (see discussion above). OxCal code for all models is provided in Appendix H.

Agreement (A) determines how well the entered dates fit the assigned constraints; an acceptable value is anything above 60. Every model generated (contiguous, sequential, overlapping) had three dates with poor agreement values. These dates, UCIAMS 182752, UCIAMS 182761, UCIAMS 255133, had A values of 0.9, 13, and 17.5 in the contiguous model, for example, and were cut from each model before calculating the results presented below.

Results of the Bayesian analysis are summarized in Table 25. Prior to looking at the results, the contiguous model is the most sensible choice. There is no evidence of a stylistic jump in ceramic attributes or a break in occupation between the Conchas C and D subphases. In fact, the La Blanca site appears to have been continuously occupied during the Conchas phase, even if each neighborhood was not occupied for the whole phase (see Chapter 6). The contiguous model estimates short durations (see Table 25) for both Conchas C (0-41 years, median = 11) and D (88-216 years, median = 144). The short duration for the Conchas C phase is echoed in the sequential (9 years) and overlapping models (28 years).

This continuity is likely due to the similarities in probability distributions for Conchas C dates, which are apparent in every multiple plot (Figure 51). The Conchas D has a longer duration, though there is a noticeable discrepancy in the durations provided by the three models. Contiguous and sequential models have Conchas D durations that are about ~16 years apart, but the median duration for the overlapping model is ~170 years longer.

Table 25. Bayesian Analysis Results for Conchas C and D Comparison.

	Conchas C		Conchas D		
Model	Boundaries (median, BCE)	Duration (median, years)	Boundaries (median, BCE)	Duration (median, years)	Notes
Contiguous	861-848	11	848-715	144	-
Sequential	863-852	9	846-719	128	Interval between phases = 11 years (median)
Overlapping	870-840	28	975-677	321	-

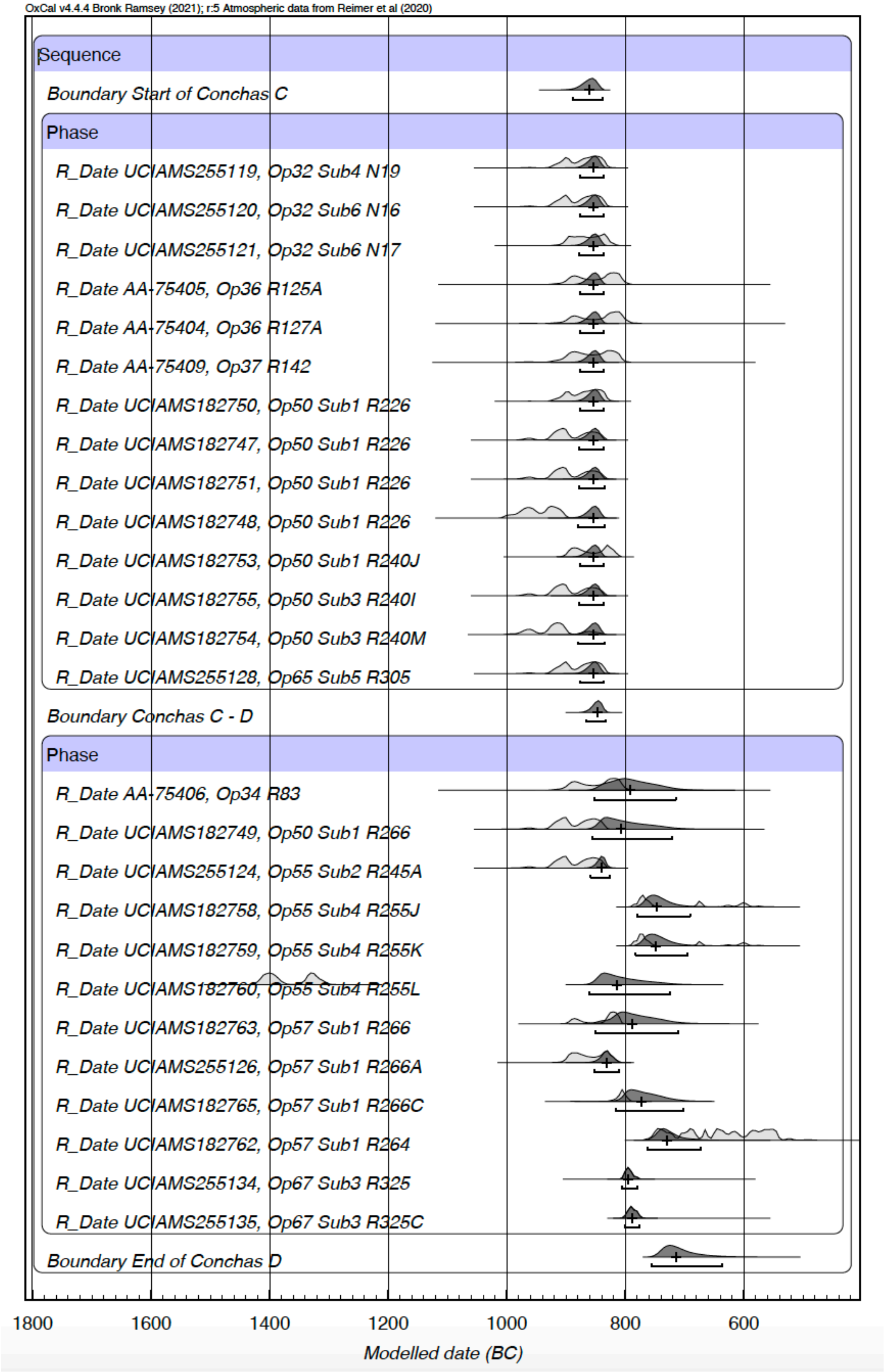


Figure 51. Multiple plot of contiguous model results.

In summary, the contiguous and sequential model provided similar results in terms of both boundaries and durations. This observation is notable because, even when the phases are given the opportunity to be non-contiguous, medians are still within a few years of one another and the interval between phases is brief (see Table 25). These similarities support the initial hypothesis that the relationship between Conchas C and D subphases is likely contiguous. The overlapping model is a poor fit for the dataset, producing results that vary markedly from the other two, more realistic, models. However, note that the Conchas C subphase is still brief in the overlapping model, attesting to the similarities between the probability distributions of Conchas C dates.

Results of Bayesian analysis suggest that continuity in material culture at La Blanca sometimes took the form of short bursts (Conchas C) or lengthier, but still archaeologically brief, strides of a century or more (Conchas D). However, generated models would of course be improved by the inclusion of the other three subphases in the La Blanca chronology as soon as more dates from those subphases are obtained. For now, this small window of modeled time demonstrates that life at La Blanca changed in irregular intervals over the course of its ~500-year history. But did climatic conditions change in context with alterations to material culture? Based on lack of discernable spatial or temporal patterning in carbon isotope ($\delta^{13}C$) values of maize kernels analyzed for radiocarbon dates[8], there is no

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[8] $\delta^{13}C$ values did not yield detectable patterning by ceramic subphase, calibrated radiocarbon age, or neighborhood. Hierarchical cluster analysis also failed to produce cluster matches that reflect ceramic associations or neighborhoods. Similarly, a two-sample t test of carbon isotope values grouped by Conchas C and D ceramics did not result in a statistically significant difference between the two groups.

evidence of shared water stress among maize crops during either the Conchas C or Conchas D subphases.

Botanical Patterning by Phase

Cities, like their inhabitants, have social lives. Although the life of a city is much longer than that of a person, cities are alike in that they have periods of emergence (birth), expansion of social connections (adolescence to mid-life), and abandonment (death). Cities often change over the course of their life histories depending on choices made by their inhabitants; population density and internal economic dynamics are two examples of areas subject to change. Once again turning to exploratory analysis of botanical remains, I situate the city as a living social entity that is capable of both change and continuity as inhabitants design their subsistence strategies. I also interrogate the concept of functional neighborhoods within cities, considering if the neighborhoods of La Blanca served certain functional purposes to support the political economy of the city and if those purposes changed over time.

Field Crops

Changes in field crop dependence can be associated with the adoption of risk-reduction strategies. For example, high investment in delayed return crops (e.g., maize) indicates that inhabitants plan to remain in the same location for months to tend the fields and wait for harvest (Bowles 2011:4761). Immediate returns, in contrast, include tree crops that can be found on foraging missions and consumed the same day (Winterhalder et al. 2015). Examining investment in resources with delayed and immediate returns can thus illuminate whether inhabitants of La Blanca planned to remain in the area long-term or invested in quick returns as the need for evacuation became imminent (e.g., warfare, drought, poor soil fertility). The following analyses will test the relative investment of La Blanca residents in resources with delayed and immediate returns to reflect on whether they experienced catastrophic circumstances leading up to the city's decline; hypotheses of catastrophic decline or "collapse" have been proposed and evaluated for numerous Maya cities and states (e.g., McAnany and Gallareta Negrón 2010; Neff et al. 2006; Santley et al. 1986; Zaro and Houk 2012).

Maize makes an overwhelming statistical contribution to field crop patterning in the La Blanca assemblage; counts of maize far exceed those of any other field crop (see Chapter 5). I focus exclusively on maize patterning in this section to evaluate investment in delayed return resources specifically. While examining neighborhood patterning in botanical remains, density calculations produced low numerical values spaced so closely together that they became hard to differentiate during statistical analysis (see Chapter 6). Mean count is thus used as the normalizing metric used in all analyses to follow.

Maize Mean Counts. Maize kernel mean counts can be compared by subphase using boxplots (Figure 52). Throughout the botanical analysis presented in this chapter, Conchas C/D represents a collective category combining samples associated with Conchas C, D, and indeterminate C or D contexts (located only in the Joyas South Neighborhood). Conchas B/C is plotted in Figure 5 as a line instead of a box because too few features with maize kernels derive from this context to draw a box. There is a statistically significant drop between C and D. Also of interest is a non-statistically significant increase between Conchas C/D and E (Figure 52b). Why would the abundance of consumable maize parts rise during a period in which the population was dwindling? Further evaluation of maize kernel patterning and integration of cupule data help to shed light on this question. The number of samples with maize cupules is too low per subphase to graph using box plots but patterning in processing debris can be examined via other types of analyses.

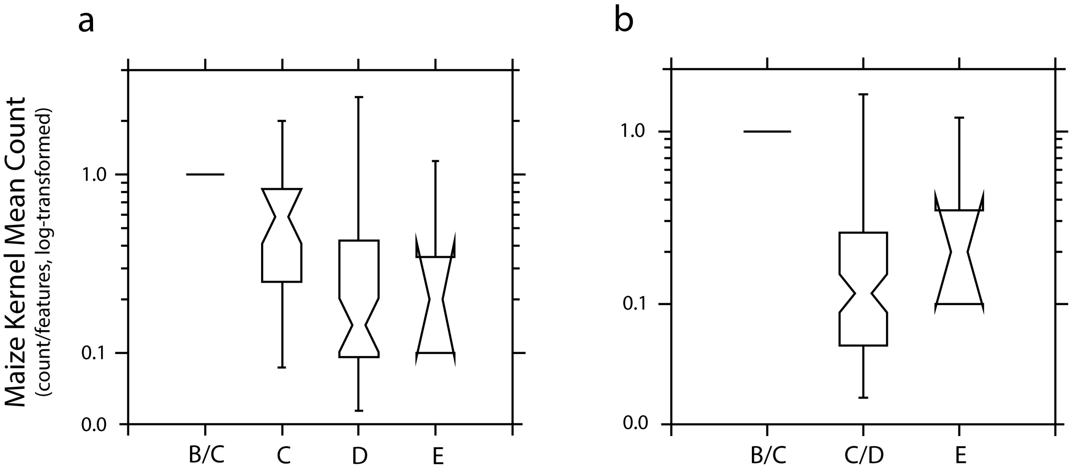

Figure 52. Box plots of maize kernel mean counts by Conchas subphase: (a) all subphases separated; (b) Conchas C and D combined. Y-axes log transformed.

Bar graphs offer a useful alternative for comparing mean counts of maize kernels and cupules (Figure 53). In this analysis, mean counts are calculated by phase with total count of identified specimens belonging to the indicated taxon divided by count of features belonging to the specified phase. There is a marked increase in maize kernels and cupules between the Conchas B/C and C subphases, identifying an increase in consumption and local processing of maize coinciding with the city's boom in population (see Chapter 2). Conchas C and D kernel values are roughly comparable, with Conchas C having a slightly higher value. There is a noticeable uptick in maize cupule abundance by the Conchas D subphase (Figure 53b). This pattern differs from the box plot findings because several features with large amounts of maize kernels (represented by the top tail of the distribution) are not placed in the box as there are not many of these features; there are enough to not be outliers, but not enough to sway the positioning of the box.

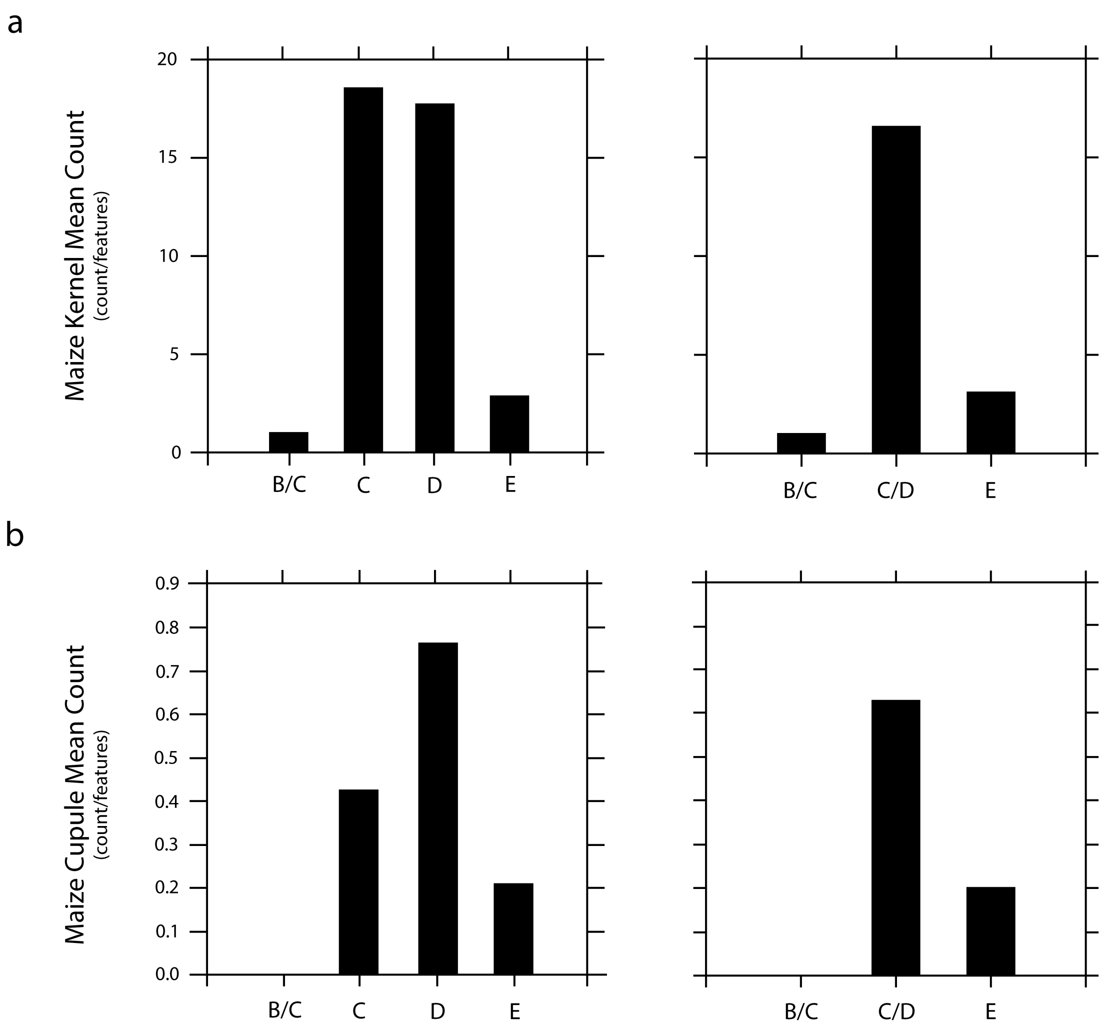

Figure 53. Bar graphs of (a) maize kernel and (b) maize cupule mean counts by Conchas subphase.

The increase in cupules by Conchas D (see Figure 53b) is groundbreaking. Urbanism in Mesoamerica can coincide with the extraction of resources from the hinterlands to meet the subsistence demands of the growing population (Sanders and Webster 1988:540). However, at La Blanca it appears that inhabitants met their subsistence needs during their most populous phase by growing maize locally and not solely depending on hinterland settlements for their subsistence. The abundance of maize produced at La Blanca could have also been co-opted by elites to subsidize followers at smaller hinterland settlements as Love (2002a:195) has previously suggested.

By Conchas E, maize kernel and cupule mean counts decrease in the bar graphs. Conchas E has low maize kernel counts (≤10 per feature) and only five features, contributing to exaggerated mean counts at the feature level. Thus, a bar graph of mean counts calculated by phase (see Figure 53) appears to be a more accurate representation of phase-based relationships than a box plot of mean counts by feature (see Figure 52). The decrease in maize kernels during the Conchas E subphase can be attributed to several possibilities that are not mutually exclusive. Less maize may have been cooked in the settlement as the population decreased and became more spatially restricted. Another possibility is that the frequency of large eating events such as feasts may have declined as the number of inhabitants decreased. The use of maize across space at the site can be better assessed by examining the spread of edible and inedible maize products in different neighborhoods at the site through time.

Maize Ubiquity. Ubiquity, or presence/absence, of plant material by household is often difficult to evaluate for Middle Preclassic sites on the Pacific Coast as many residences have only been identified via surface collections (see Love 2002a). La Blanca offers a rare exception to this trend, with over 100 households identified. The current study only sampled residential contexts, making it possible to pursue an in-depth analysis of maize ubiquity by neighborhood and subphase.

Maize cupule, kernel, and overall maize ubiquities are listed in Table 26. The first striking observation is that the lowest ubiquity value of overall maize is only 50% (SAN, Conchas D). Even at the earliest part of the sequence, Conchas B/C, the Vacas Neighborhood neighborhood has 93.55% maize ubiquity. Once thought of as at least a possibility, maize intensification by the Middle Preclassic on the Pacific Coast is now strongly supported by the results of the current study. These results support previous work by Rosenswig and colleagues (2015) providing archaeobotanical evidence supporting maize intensification at the site of Cuauhtémoc. However, my results also go beyond conclusions possible at Cuauhtémoc by providing valuable data on intra-site comparisons of residential neighborhoods.

Table 26. Maize Ubiquities at La Blanca by Neighborhood and Phase.

Neighborhood	Phase	Maize cupule	Maize kernel	Maize
JNN	Conchas E	8.33%	66.67%	66.67%
SAN	Conchas D	0.00%	50.00%	50.00%
SAN	Conchas C	16.67%	100.00%	100.00%
SAN	Conchas C/D	15.38%	96.15%	96.15%
CN	Conchas D	7.14%	64.29%	64.29%
CN	Conchas C	13.04%	52.17%	82.61%
CN	Conchas C/D	10.81%	56.76%	75.68%
JSN	Conchas D	15.63%	87.50%	90.63%
JSN	Conchas C	0.00%	66.67%	66.67%
JSN	Conchas C/D[a]	11.11%	75.93%	77.78%
VN	Conchas D	11.11%	100.00%	100.00%
VN	Conchas C	0.00%	100.00%	100.00%
VN	Conchas C/D	11.63%	95.35%	95.35%
VN	Conchas B/C	12.90%	93.55%	93.55%

[a] Includes samples that could date to either C or D and cannot be securely associated with a single subphase.

The distribution of processing and consumption debris changes over the course of the city's history. By the Conchas C subphase, maize becomes ubiquitous in the Vacas Neighborhood and Satellite Area North. However, the Vacas and Joyas South

Neighborhoods did not produce any maize cupules during this period. By Conchas D, the centers of processing changed, with Satellite Area North ceasing to produce maize cupules and the Vacas Neighborhood, a region previously unused for processing, began to process maize. In contrast to processing debris, consumption debris is uniformly present to some degree across all neighborhoods and subphases of the site's history.

Over half of households in each neighborhood discarded consumable maize remains during every phase of the site's history. This pattern indicates a decentralized strategy with each household or neighborhood preparing their own meals at least some of the time. Most households and all neighborhoods cooked maize, quashing any possibility that managerial elites organized the cooking of maize in one neighborhood of the city and its distribution to all surrounding neighborhoods. One would expect far lower ubiquities if households did not engage in cooking their own maize.

Processing appears to have been more complexly organized than consumption. Given the deleterious impacts of regional taphonomic issues on botanical preservation, it is difficult to estimate whether maize abundances indicate that La Blanca residents produced all the maize used to feed the city's population. However, ubiquities can provide insights into how residents organized their maize processing over time. During Conchas C, maize processing took place in the central portion of the settlement (Satellite Area North and Central Neighborhood). The Central Neighborhood continued as a processing node during Conchas D, with the addition of a more northern neighborhood (Joyas South Neighborhood). Satellite Area North was no longer used for maize processing and, instead, a neighborhood to the south, Vacas Neighborhood, was added during Conchas D.

The sequence of maize processing at La Blanca clearly illustrates that this task radiated outwards from the center of the settlement over time. Even though inhabitants founded other neighborhoods toward the periphery of the site, not all options were selected for maize processing. In the case of Satellite Area North, its role as a maize processing node ended during Conchas D as the Vacas Neighborhood took over this role. This choice likely reflects a move to process maize in a larger neighborhood as the site's population had increased. Alternatively, the move could reflect relocation due to overcropping of fields near Satellite Area North and a need to access more fertile soils. In sum, all analyses point to La Blanca as having been a supplier of maize for itself and perhaps neighboring hinterlands rather than having been a city that purely received imported maize tribute. Maize, however, is only one crop within a broader subsistence base that included many foraged and cultivated resources, such as tree crops.

Tree Crops

Comparisons of tree crop mean counts by subphase produce differences over time (Figure 54). Conchas C/D is the temporal context with the highest abundance of tree crops by far. Recall that this category includes contexts in the Joyas South Neighborhood that have pottery with Conchas C and D subphase attributes and are thus not included in the separate Conchas C and D categories presented in Figure 54a.

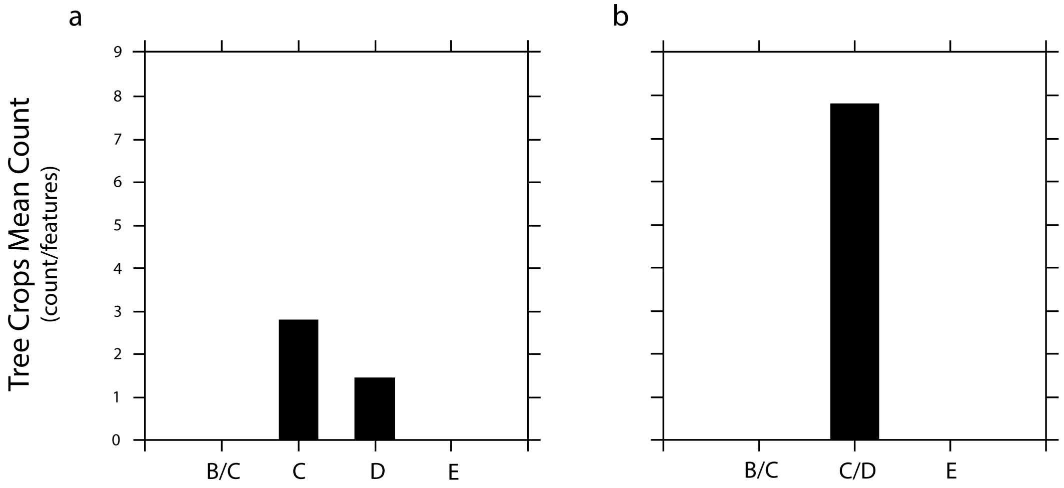

Figure 54. Bar graphs of tree crop mean counts by Conchas subphase: (a) all subphases separated; (b) Conchas C and D combined.

Tree crop use rises and falls in an expected bell curve, with the settlement's founding and decline having lower mean counts. However, it explodes in the Joyas South Neighborhood during the Conchas C and D subphases. Nuts are not included in Figure 54, but they appear during both the Conchas C and D subphases, with the Joyas South Neighborhood being a key production zone. There are several possible explanations for the increase in arboreal resource use. By Conchas C and especially D, residents would have explored the landscape and become more familiar with the fruits and nuts available to them. Maize cupules also increase in ubiquity in the Joyas South Neighborhood during the Conchas C and D subphases, with the Conchas D ubiquity being the highest of the sequence in any neighborhood (see Table 26). Thus, the explosion in tree crop and nut production in the Joyas South Neighborhood appears to indicate resource diversification in the context of maize intensification. Over time, La Blanca residents expanded their territory to the north and south, pursuing opportunities to exploit new habitats and fertile soils.

Diversity

Beyond maize and tree crops, La Blanca residents exploited several nuts and a wide variety of other seed-producing plants (see Chapter 5). Counts of these resources are too small to compare their mean counts via box plots or bar graphs. However, diversity analysis allows for broad assessment of assemblage composition that incorporates resources with small counts. I apply the same three approaches used to assess plant diversity by neighborhood (see Chapter 6) to compare diversity by phase.

Shannon-Weaver Index. Richness (H') and Equitability (V') values for each subphase are graphed in a scatterplot (Figure 55) and presented numerically in Table 27. Results are best described in sequence to provide a full picture of decision making over time. Conchas B/C has the second lowest richness and the highest equitability in the whole assemblage. Thus, at the city's emergence, its inhabitants exploited a small number of plant taxa relatively evenly.

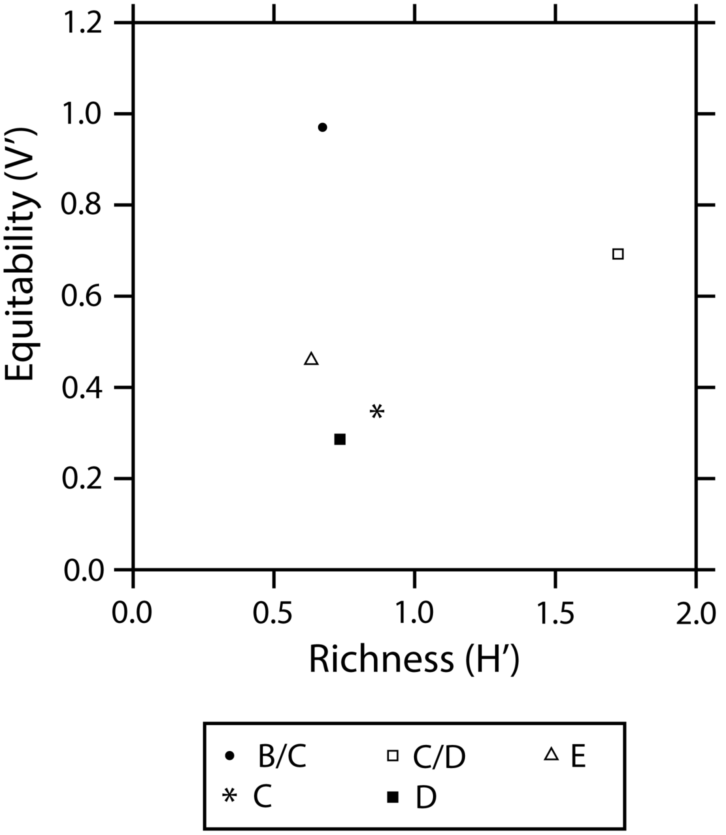

Figure 55. Scatterplot of Shannon-Weaver Index values by Conchas subphase.

Table 27. Shannon-Weaver Index Results by Conchas Subphase.

Subphase	Conchas B/C	Conchas C/D	Conchas C	Conchas D	Conchas E
H'	0.673	1.724	0.867	0.735	0.632
V'	0.971	0.694	0.349	0.287	0.456

By Conchas C, richness increases to its second highest value in the sequence, while equitability decreases. As residents got to know the landscape, they logically incorporated more plants into their regime and favored certain high yield plants (e.g., maize) to support the increased population. The combined Conchas C/D category represents an even higher richness, the highest value in the group, due to the emergence of Joyas South Neighborhood as a major center of plant processing. Equitability is also high during these two subphases as production in the Joyas South Neighborhood focused on a broad spectrum of plants rather than one or two specific taxa. Conchas D represents a decrease in richness and has a lower equitability than any of the preceding periods. This pattern is primarily due to an increased focus on maize to support a much more populous city. However, the focus on maize should not be overemphasized. Indeterminate Conchas C/D subphase contexts from the Joyas South Neighborhood could certainly date to the beginning of Conchas D. Plus, the greatest diversity of tubers at the site is present during the Conchas D phase; however, most tubers are visible only in the microbotanical data which are not incorporated into the Shannon-Weaver analysis. Thus, La Blanca residents used techniques of both intensification and diversification to curb any potential food shortages during the most populous period in the city's history.

Conchas E is only represented by the Joyas North Neighborhood. This small assemblage has a lower richness but a higher equitability value than Conchas D. As the population dwindled, the focus on maize and tree crops became less intense; residue samples dating to this period did not yield any microbotanical remains. Shannon-Weaver Index results support the interpretation of the downscaling of environmental exploration and addition of new taxa to the subsistence repertoire. In fact, the only new addition is a tentatively identified Mexican poppy seed (see Chapter 6), which could simply be an incidental inclusion.

DIVERS. Although patterns presented in the Shannon-Weaver Index analysis align well with population data, it is necessary to include other means of calculating diversity to test the robustness of the Shannon-Weaver patterns. DIVERS, a method introduced in Chapter 6, produces a Monte-Carlo simulation that evaluates assemblages against expected richness and equitability (referred to in this program as evenness) for each sample size. All assemblages except the combined Conchas C/D category fall below the expected richness (Figure 56). Conchas E falls outside of the lower boundary of the confidence interval, indicating significantly low richness. The separate Conchas C and D assemblages are in comparable positions despite differences in sample size. Thus, it appears that the indeterminate Conchas C or D samples from the Joyas South Neighborhood have a strong influence on the combined C/D category that exceeds expectations for richness. The decrease in richness by Conchas E is expected given the smaller population and decline of the city by this subphase.

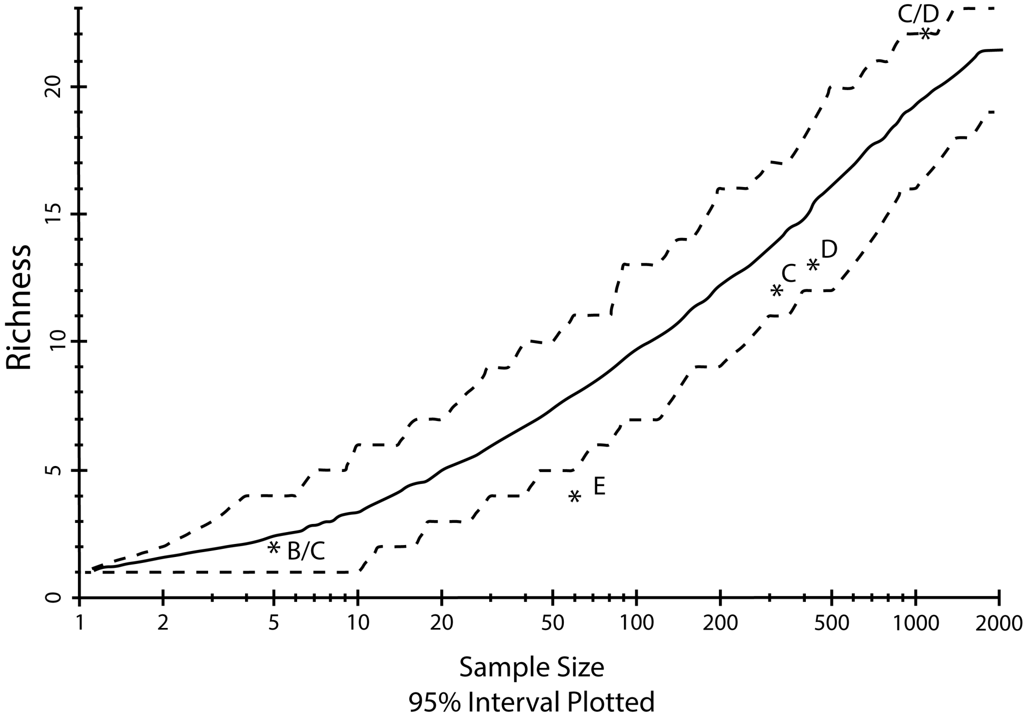

Figure 56. Plot of DIVERS richness values by phase. Produced using DIVERS and DIVPLT software. Dashed lines mark limits of the 95% confidence interval.

The DIVERS plot of evenness values (Figure 57) resulted in more differences. Conchas C/D is above the confidence interval and thus significantly more even than the expected value. Conchas B/C is at the expected evenness, while Conchas C, D, and E are all significantly below their expected values. The combined category of Conchas C/D far exceeds the expected evenness for its larger sample size. Again, the stark difference between C, D, and C/D can be attributed to the high quantities of nuts, fruits, and other resources identified in samples from the Joyas South Neighborhood which may date to either the C or D subphases.

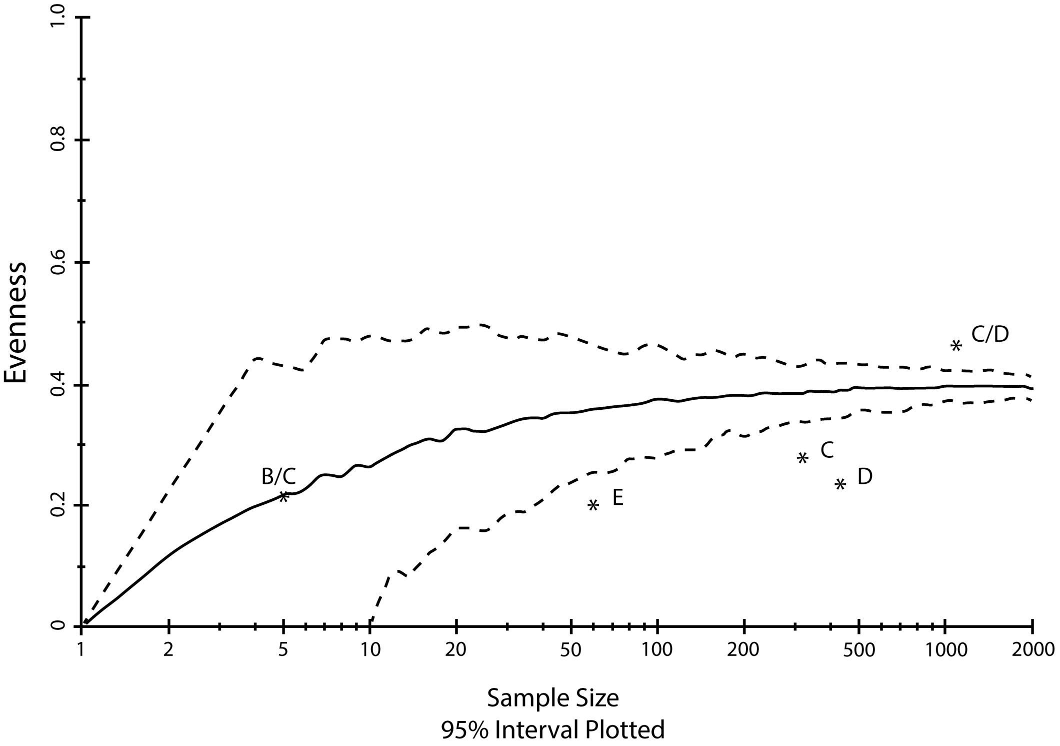

Figure 57. Plot of DIVERS evenness values by phase. Produced using DIVERS and DIVPLT software. Dashed lines mark limits of the 95% confidence interval.

DIVERS results complement and enrich the outcomes of the Shannon-Weaver Index analysis. Although relative rankings of assemblages differ in some cases (Table 28), these discrepancies can be easily attributed to the better control that DIVERS has over expectations for different assemblage sizes. For example, DIVERS appears to produce more reasonable results for the Conchas B/C subphase, outputting richness and evenness estimates that are better calibrated to its low sample size. While the Shannon-Weaver Index places this assemblage as the most equitable by far, DIVERS calculates both richness and evenness values to be roughly as expected and within the confidence envelope. This outcome aligns well with the low richness values produced by the Shannon-Weaver index, while better adjusting the equitability/evenness value. Conchas B/C can thus be seen as an era when La Blanca inhabitants exploited a low diversity of resources in a somewhat unequal fashion, but not necessarily with strong interest in one particular resource. Conchas C and D are subphases in which residents focused much more heavily on food use to support the growing population, though the distribution is much more equitable if we combine the two subphases. Both the Shannon-Weaver and DIVERS analyses agree that richness and equitability decrease by Conchas E as population waned.

Table 28. Ranking of Richness and Equitability Values Generated by DIVERS and the Shannon-Weaver Index.

	Richness		Equitability	
Phase	DIVERS	Shannon-Weaver Index (H')	DIVERS	Shannon-Weaver Index (V')
Conchas B/C	4	4	2	1*
Conchas C/D	1*	1*	1*	2
Conchas C	3	2	3	4
Conchas D	2	3	4	5-
Conchas E	5-	5-	5-	3

* Highest ranking

\- Lowest ranking

Minimum Richness Value. Finally, I integrate microbotanical remains into the assessment of plant diversity by returning to another measure used in Chapter 6. This measure, Minimum Richness Value (MRV), produced problematic results for neighborhoods due to problems with heavily sampled features and low loci counts (see Chapter 6). Nevertheless, MRV has value as it is one of the only quantitative measures available for combining macrobotanical and microbotanical results. Outcomes, presented in Table 29, align more sensibly with macrobotanical diversity results for phases than those for neighborhoods. Conchas B/C has a moderately high MRV, but mostly due to small sample size. Richness decreased during Conchas C as residents begin to rely on high-producing taxa to prevent subsistence shortfalls. But, as expected from the results of previous analyses, richness progressively increased during the Conchas C and D phases (see C/D combined and D in Table 29). It then decreased during Conchas E as occupancy declined.

Table 29. Minimum Richness Value (MRV) by Phase at La Blanca.

Phase	Taxa Count	Macrobotanical Loci	Microbotanical Loci	MRV
Conchas B/C	5	2	2	1.250
Conchas C/D	39	45	3	0.812
Conchas C	17	25	1	0.654
Conchas D	28	17	2	1.474
Conchas E	5	10	0	0.500

Plant Use at La Blanca Across Time and Space

Botanical remains from La Blanca have shed light on spatial and temporal patterning in foodways as this early city rose and fell in prominence. However, these two axes of comparison produce the most detailed results when integrated directly with one another. In this section, I discuss the outcomes of comparing mean count values. Mean count is calculated as count of a selected taxon from features dating to the selected subphase in a single neighborhood divided by the number of features belonging to that same neighborhood and subphase combination. A table with these values is presented in Appendix I. Results are used to assess the relationship between material indicators of social status and insights into daily life provided by botanical remains.

Locales

A summary of locale characteristics by subphase is presented in Table 30. Conchas C and D subphases offer the opportunity for cross-neighborhood comparisons. Tree crops are incorporated into foodways by Conchas C, with primary processing hubs in the north-central area (Satellite Area North and Joyas South Neighborhood). One locale is a major locus of field crop abundance in the north-central and southern portions of the site, respectively (Satellite Area North and Vacas Neighborhood). Notably, these hubs are the closest neighborhoods to the Central Neighborhood, which has the highest-ranking households based on relatively high quantities of jade and quality of house construction (Love and Guernsey 2011). Satellite Area North is the only locale with maize cupules during this period, indicating that processing, not only consumption, is concentrated close to the neighborhood with the highest-ranking households.

Table 30. Summary of La Blanca Subphase Characteristics Based on Mean Count Values.

Subphase	Characteristics
Conchas E	• JNN: o Low maize abundance. o Low maize kernel abundance. o Low maize cupule abundance. o No tree crops.
Conchas D	• VN: o Highest mean count of field crops. o Highest mean count of maize.

	o Highest abundance of maize kernels. o Fourth highest abundance of maize cupules. o Low tree crops. • SAN: o Highest abundance of maize cupules by far. o Fourth highest abundance of maize kernels and maize overall. o Second highest mean count of field crops. • CN: o Lesser use center for field crops. o Third highest abundance of maize cupules. o Second highest abundance of maize kernels. o Low tree crops; higher than VN. • JNN: o Barely any field crops. o Low abundance of maize kernels. • JSN: o Lesser use center for field crops. o Third highest abundance of maize cupules. o Low abundance of maize kernels. o High abundance of tree crops.
Conchas C or D	• JSN: o Field crop abundance slightly exceeds Conchas D value for this neighborhood. o Greatest mean count of tree crops in entire dataset. o Maize abundance slightly exceeds Conchas D value for this neighborhood. o Low abundance of maize cupules. o Maize kernel abundance slightly exceeds Conchas D value for this neighborhood.
Conchas C	• VN: o Major locus of field crops. o Highest maize abundance. o Highest maize kernel abundance. o Low abundance of tree crops. o No maize cupules. • SAN: o Major locus of field crops. o Second highest maize abundance. o Second highest maize kernel abundance. o Only neighborhood with maize cupules. o Moderate tree crops. • CN: o Moderate abundance of field crops. o Low tree crops. o Moderate maize abundance. o Moderate maize kernel abundance (slightly higher than JSN). o No maize cupules. • JSN: o Low abundance of field crops.

	o Low maize abundance. o Low maize kernel abundance. o Low tree crops. o No maize cupules.
Conchas B/C	• VN: o Low abundance of field crops. o Low maize abundance. o Low maize kernel abundance. o No maize cupules. o No tree crops.

The population at La Blanca soared during the Conchas D subphase, resulting in adaptive changes to foodways. By Conchas D, the Central Neighborhood had the third highest mean count of maize cupules. As the Central Neighborhood began to participate in maize processing, its residents also intensified their tree crop production in comparison to the previous subphase.

Though Conchas D presented the greatest challenge in terms of quantity of subsistence needed to feed the city’s inhabitants, not all neighborhoods needed to participate in food processing to meet the city’s subsistence requirements. Flotation samples from the Joyas North Neighborhood, for example, only included a low abundance of maize kernels for Conchas D subphase. This neighborhood is newly founded and continues to be occupied into the Conchas E subphase so a slow decline to complete disuse seems an unlikely explanation. Instead, a more plausible theory is that its residents simply produced far fewer resources for the city, instead primarily relying on resources from other neighborhoods engaged in food processing. Similarly, the Vacas Neighborhood had few maize cupules during Conchas D but had the highest abundance of maize kernels during Conchas D. These two neighborhoods are notably at the far ends of the site, suggesting that the outermost residential nodes were supported by the more central neighborhoods during Conchas D, at least in terms of subsistence economy. Analyses of ceramics and other artifacts classes are ongoing, so it is not yet possible to compare these results with material indicators of status.

Neighborhoods tend to shift in function, and perhaps size, many times throughout La Blanca's history. For example, the Vacas Neighborhood served as a locale for cooking/nixtamalizing maize during Conchas B/C, but there is no evidence of maize cupules dating to this subphase. By Conchas C, inhabitants integrated tree crops into their pre-existing strategy of maize cooking. Later during Conchas D, the Vacas Neighborhood transformed again, adding maize processing to its repertoire. Needs changed over the course of La Blanca's life as an incipient city, with neighborhoods like Vacas reinventing themselves at least partially in response to demographic changes. Another example is Satellite Area North, which continued to be a major locale of maize cooking and processing over the course of the Conchas C and D subphases but ceased processing of tree crops by Conchas D, around the same time as Joyas South Neighborhood became deeply invested in this role.

Integrating Botanical and Faunal Data

La Blanca residents subsisted on not only plants, but also animals. Thomas Wake has had a long-term investment in the analysis of animal bones and teeth recovered from the La Blanca site (Wake and Harrington 2002). His latest findings reveal an emphasis on aquatic resources, including over 50 species of fish, six species of shark, three species of stingrays, fresh and saltwater turtles, frogs/toads, crocodiles, and lizards (Thomas Wake, personal communication 2022). Most of the counts in the assemblage belong to fish, but domestic dog (*Canis familiaris*) is also well-represented. More unusual taxa identified by Wake include ocelot, red-tailed boa, and mantled howler monkey. Considering the incredible number of taxa represented in the faunal assemblage, the Shannon-Weaver Index offers the best method for comparing diversity between the macrobotanical and faunal assemblages.

Diversity analysis offers a straightforward means of identifying whether dietary breadth of plant or animal remains change during different periods of a site's occupation (see VanDerwarker 2010). Shannon-Weaver Index values for La Blanca botanical and faunal assemblages are presented in Table 31. Faunal data are organized by phase, but not context, preventing any neighborhood-based comparisons at this time. Certain identifications—mammal and small, medium, and large mammal—are excluded from the calculation of diversity values because specific taxa have been identified for each of these groups; the same selection process was carried out in designing the diversity analysis for the botanical assemblage. As faunal remains from contexts possibly dating to Conchas C or D (Joyas South Neighborhood only) have yet to be analyzed, macrobotanical results for these contexts are excluded from Table 31. Similarly, Conchas E results are excluded as animal bones from contexts dating to this period have yet to be analyzed.

Table 31. Shannon-Weaver Index Values for La Blanca Faunal and Macrobotanical Datasets.

Data Type	Phase	H'	V'
Faunal	Conchas B/C	0.285	0.071
Faunal	Conchas C	0.177	0.037
Faunal	Conchas D	0.144	0.031
Macrobotanical	Conchas B/C	0.673	0.971
Macrobotanical	Conchas C	0.867	0.349
Macrobotanical	Conchas D	0.735	0.287

Animal assemblages have much lower richness and equitability values than the macrobotanical assemblages. This discrepancy is mostly a product of sample size. Fish dominate faunal counts during all periods, contributing to lower equitability values than the plant assemblages. Moreover, high fish counts drive up overall counts, which are much higher than botanical counts, producing lower richness values across the board.

Over time, the richness (Figure 58) and equitability (Figure 59) of faunal assemblages decreases. The plant richness values follow a different path, with richness increasing during the Conchas C subphase and decreasing by Conchas D. Plant equitability values decrease over time, matching the trend in the faunal equitability values.

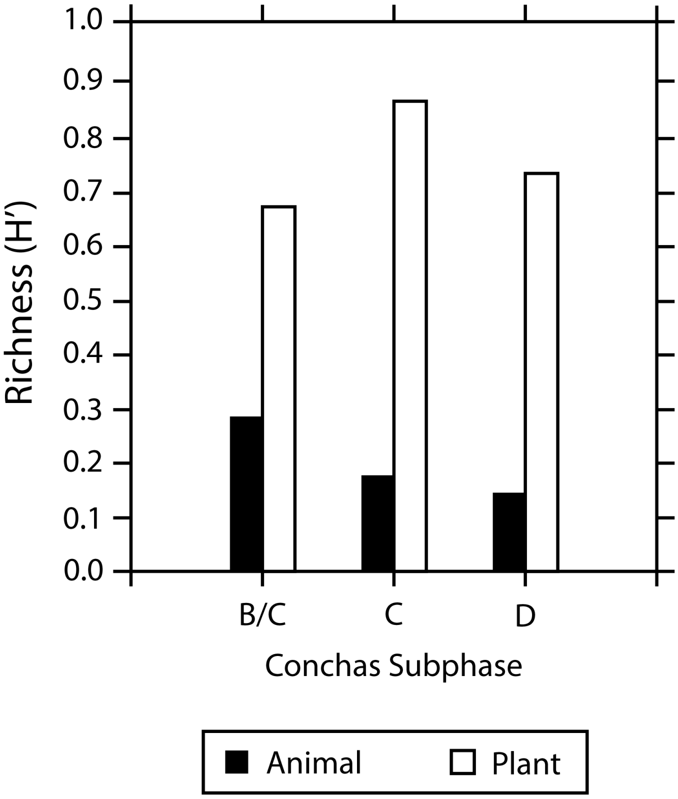

Figure 58. Bar graph of Shannon-Weaver Index richness values for macrobotanical and faunal remains, organized by Conchas subphase.

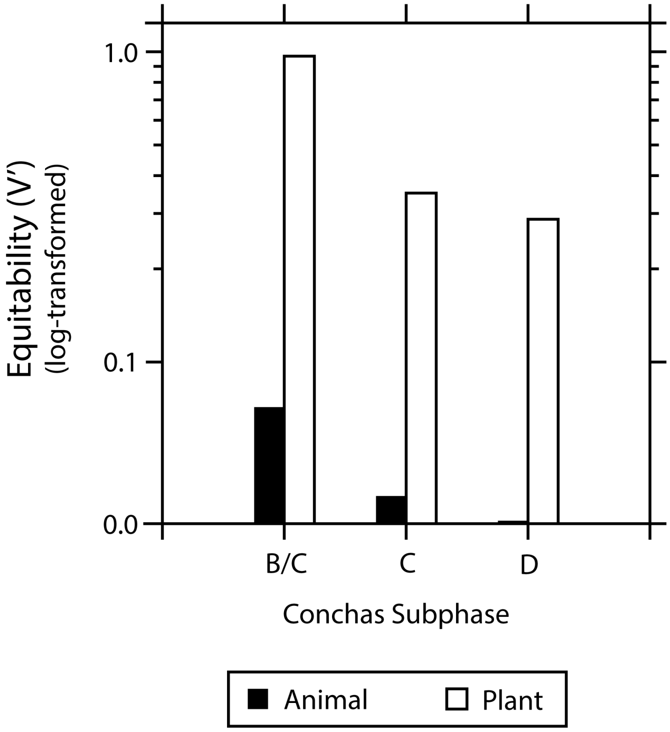

Figure 59. Bar graph of Shannon-Weaver Index equitability values for macrobotanical and faunal remains, organized by Conchas subphase. Y-axis is log-transformed.

At first, La Blanca residents evenly exploited a wide variety of animals that they discovered on the landscape. Plant richness is lowest during this exploratory phase. Over time, it appears they became more selective about animal exploitation, selecting some more often than others. Certain animal taxa used during the Conchas C and D subphases reflect a newfound interest in taxa with a history of ceremonial and political significance in the Maya world—including jaguar, ocelot, and stingrays (Haines et al. 2008; Saunders 1991, 1998). Stingray spines, for example, are used at El Ujuxte during the Late Preclassic period as part of public bloodletting ceremonies that emphasize the connection between elites and the gods (Love 2016a:291). Stingrays and jaguar were present at La Blanca during both Conchas C and D subphases, while ocelot was introduced during Conchas D.

The acquisition of everyday subsistence also changes over time. Macrobotanical richness increases in Conchas C as inhabitants diversified the types of plants exploited in conjunction with increased focus on fishing as illustrated by higher raw counts of fish species during this period. The stepwise decrease in macrobotanical equitability over time, and richness from Conchas C to D, is associated with increased focus on maize to feed the growing population. However, other taxa, like tree crops and nuts, are excluded from this analysis (because Conchas C/D is not incorporated) but increase strongly in abundance during this period of growth. Considering that specialty animals began to be hunted during Conchas C and D, perhaps plants and fish served as a buffer to meet everyday subsistence needs for the growing masses while higher ranking households pursued the acquisition of specialty animals. If true, this hypothesis would mean that La Blanca served as an experimental social space for articulating elite status.

Conclusions

Temporal analysis of plant remains from the early city of La Blanca with respect to intra-site locales has wide reaching implications for understanding Preclassic period foodways on the Pacific Coast. I argue that the intensification of maize agriculture and widespread use among households has its origins in the Early Preclassic period, predating the urbanization of the region. Moreover, intensification of maize occurs in the context of the continued exploitation of foraged resources. At La Blanca, resource diversification, rather than agricultural intensification, appears to have been the amplified factor that contributed to food security and urban sustainability for at least 400 years.

Results presented in this chapter demonstrate that the city of La Blanca had a life of its own, with transformative changes charted by the decisions made by its inhabitants. During Conchas B, the site first emerged as a city with residents living in one area that would later become the Vacas Neighborhood. Its inhabitants exploited a small range of agricultural and foraged resources evenly. Love and Rosenswig (2022:144) estimate that population growth in the Río Naranjo area during the Middle Preclassic period occurred at an average of three percent per year for more than 300 years.

By the Conchas C subphase, a brief period between nine and 30 years at most, the growing population of La Blanca began to expand spatially, adding three new locales: Satellite Area North, the Joyas South Neighborhood, and the Central Neighborhood. Collectively, these four contexts would continue to represent the site's configuration throughout its most populous eras. But during the brief Conchas C subphase, patterned labor organization by neighborhood had already begun. For example, maize processing activities occurred in only the Central Neighborhood and Satellite Area North during this period. The Joyas South Neighborhood served as the primary locus for tree crop use and perhaps oil processing. It is also interesting that during this time there was an increase in plant richness and a decrease in the richness of the animal assemblage. It seems that at La Blanca, efforts at diversification of plant resources became intensified alongside maize agriculture and in conjunction with progressive growth in population density. Although the intensification of maize agriculture at La Blanca over the course of the Conchas phase is *locally* impressive for the time and place, when considered in context with Early Preclassic sites elsewhere on the Pacific Coast it is not surprising. In fact, comparisons with macrobotanical data from San Carlos, Chilo, Paso de la Amada, and Aquiles Serdán revealed that maize mean counts and ubiquities in some cases far exceed those calculated for the La Blanca assemblage. Thus, the emergence of maize intensification on the Pacific Coast is not a phenomenon concurrent with incipient urbanism but is instead its predecessor. The data presented in this chapter critically challenge the idea of maize intensification as exclusively a result of population aggregation and the formation of early cities.

The Conchas D subphase (~128-321 years) marks the high point of the site's demographic fluorescence. Although the same four neighborhoods continue to be occupied, relationships between these neighborhoods began to change. The Vacas District, staying mostly consistent with its previous role, continues to have the highest abundance of maize kernels but adds on maize processing as evidenced by the earliest detection of maize cupules in this neighborhood. The Central Neighborhood also began processing maize during this subphase. Overall, maize processing at the site increased dramatically from the previous subphase, either indicating a shift from off-site to on-site shelling or less dependance on shelled maize received from other sites. However, no hinterland settlements of the La Blanca polity that have been subject to excavation, of which there are few, have also been subject to systematic collection of flotation samples that could be used to evaluate the possibility of tribute. What is presently clear is that La Blanca inhabitants fashioned traditions through social fields during Conchas D. An example of continuity from the Conchas C subphase is the sustained focus of Joyas South Neighborhood residents on tree crop collection and processing.

The demographic decline of La Blanca is evident by Conchas E, with a recently introduced neighborhood, Joyas North Neighborhood, being the only one occupied during this subphase. Nearly all Conchas phase contexts from this neighborhood had subphase E pottery, with the only exception being Rasgo 239 which exclusively yielded Conchas D ceramics. Radiocarbon dates fit well with the interpretation of Joyas North Neighborhood as a primarily Conchas E occupation with perhaps some occupation toward the end of Conchas D as indicated by the ceramic data. Low amounts of maize kernels and cupules from Joyas North Neighborhood indicate that maize was still being cooked and processed on site during its occupation. However, tree crops were no longer part of the subsistence regime and overall richness decreased to below Conchas B/C levels. The stark drops in tree crop use and richness attest to the connection between diversification and population density at La Blanca. I do not mean to imply that this relationship is deterministic, but rather that diversification of plant resources and landscape types exploited is one of the strategies, along with spatial integration of households and acquisition of wild potatoes from the highlands, that La Blanca residents used to maintain food security at times when they had the most mouths to feed.

Plant and carbon stable isotope results from La Blanca do not provide any indications that its abandonment was due to environmental and/or social catastrophe. Instead, its depopulation appears to have been a well-planned process with no signs of a surge in dependence on immediate return foodways, one of the possible manifestations of uncertainty surrounding the prospect of long-term residence (Melton 2018). The opposite pattern exists at La Blanca with a stark drop in tree crop abundance coinciding with gradual disinvestment in delayed-return resources over time. As activities at La Blanca wound down, the state of El Ujuxte emerged only 12 km to the east with at least some former inhabitants of La Blanca ostensibly relocating to found and/or join this new polity.

CHAPTER 8: COMPLEXITIES OF DAILY LIFE

Many aspects of daily life can be linked to defined social fields where knowledge is stored, cultivated, and retooled. Cities represent an arena where these social fields play out across countless interactions between individuals, sometimes over the course of centuries. The archaeological site of La Blanca, occupied for over 400 years, represents one of the earliest cities in Mesoamerica. This site presents an exceptional opportunity to study the everyday strategies used to sustain ancient cities. Excavations of over twenty households provide access to ample vestiges of daily life that can be used to track change across space and time. I have used plant remains from these households to conduct an analysis of inter-household social relations that identified neighborhoods, each with its own history. By examining urbanism as a moving target rather than a fixed social phenomenon, I argue that cities have lives akin to those of their human inhabitants, with periods of emergence, growth, and decline. Using Bourdieu's framework of social fields to examine bottom-up relationships between households opens new doors for understanding the interplay between daily life and the development of social complexity. In this chapter, I discuss how botanical research at La Blanca serves to rewrite regional histories of the relationship between subsistence and the emergence of incipient social stratification.

Revisiting Middle Preclassic Subsistence Paradigms on the Pacific Coast

La Blanca unquestionably had a transformative effect on the Río Naranjo area, ushering in the incipient emergence of social hierarchy and a more aggregated way of living.

But how do foodways at La Blanca compare to those practiced at contemporary sites located elsewhere on the Pacific Coast? Moreover, how does plant use at La Blanca represent a continuation of or a break from earlier ways of life? Inter-site comparisons across space and time have great potential to shed light on important parts of the human experience such as relationships between status differentiation, urbanism, and maize intensification. This section will use a broad survey of archaeobotanical data to comment on fundamental social paradigms related to the Conchas phase and Early to Middle Preclassic developments on the Pacific Coast more generally.

Maize Intensification

The emergence of social hierarchy has long been linked to intensification of one staple crop of the Americas, maize (for discussion of this relationship, see Kellner and Schoeninger 2012; Killion 2013; Schurr and Schoeninger 1995; Rosenswig et al. 2015; VanDerwarker et al. 2017). Although its returns are delayed, maize can provide sizeable and filling harvests that are storable and capable of sustaining large populations. Surpluses of maize can then be co-opted by elites to be used in various types of feasts and communal events, perhaps to enhance their prestige or foster communal ties (Dietler 2001; Morehart and DeLucia 2015). Thus, maize intensification has sometimes been interpreted as going hand in hand with the beginnings of sustaining dense populations and incipient social stratification, particularly in Mesoamerica (Ford 1986; Joyce 2004:5). On the Pacific coast, analysis of archaeobotanical remains from Cuauhtémoc provides evidence of maize intensification by the Middle Preclassic period (Rosenswig et al. 2015). What is less clear is whether maize intensification increased with the beginnings of urbanism at sites like La Blanca. Moreover, is maize intensification a purely Conchas phenomenon that correlates with the emergence of household differences based on economic rank? In recent years, the body of archaeobotanical evidence from Pacific Coast sites has grown, enabling the broad inter-site analyses needed to answer these questions.

I compile macrobotanical maize data (Table 31) from Early to Middle Preclassic sites in Chiapas, Mexico (Cuauhtémoc, San Carlos, Aquiles Serdán, Paso de la Amada, Chilo) and Guatemala (La Blanca). Density values are not calculated as volume data for flotation samples reported in Feddema 1993 is not available. Moreover, density has not proven to be an effective means of comparison for patterning in the La Blanca assemblage due to poor preservation, which almost certainly impacted other sites on the Pacific coast.

Table 32. Maize Mean Count and Ubiquity Values for Early to Middle Preclassic Sites on the Pacific Coast.

Site	Phase	Period	Maize mean count	Features Analyzed	Maize ubiquity	Flotation Samples Analyzed	Reference
La Blanca	Conchas	Middle Preclassic	15.50	64	81.76%	159	-
Cuauhtémoc	Conchas	Middle Preclassic	7	3	33.30%	21	Rosenswig et al. 2015
Cuauhtémoc	Jocotal	Early/Middle Preclassic	-	0	100%	1	Rosenswig et al. 2015
San Carlos	Jocotal	Early/Middle Preclassic	-	0	0%	1	Feddema 1993
Aquiles Serdán	Cuadros	Early Preclassic	-	0	60%	10	Feddema 1993
Cuauhtémoc	Cherla	Early Preclassic	24	1	67%	3	Rosenswig et al. 2015
Aquiles Serdán	Cherla	Early Preclassic	129.00	1	63%	19	Feddema 1993
Paso de la Amada	Cherla	Early Preclassic	-	0	100%	1	Feddema 1993
Chilo	Cherla	Early Preclassic	-	0	100%	2	Feddema 1993
Cuauhtémoc	Ocós	Early Preclassic	11	1	67%	3	Rosenswig et al. 2015
Aquiles Serdán	Ocós	Early Preclassic	126.29	7	73%	45	Feddema 1993
Paso de la Amada	Ocós	Early Preclassic	-	0	50%	8	Feddema 1993
Chilo	Ocós	Early Preclassic	8.00	1	50%	1	Feddema 1993
Cuauhtémoc	Locona	Early Preclassic	1	1	27%	11	Rosenswig et al. 2015
San Carlos	Locona	Early Preclassic	0.50	2	20%	5	Feddema 1993
Paso de la Amada	Locona	Early Preclassic	0.00	3	27%	22	Feddema 1993
Chilo	Locona	Early Preclassic	16.00	1	92%	12	Feddema 1993
San Carlos	Barra	Early Preclassic	17.67	3	50%	4	Feddema 1993
Paso de la Amada	Barra	Early Preclassic	-	0	100%	2	Feddema 1993

Note : Feature and sample counts only consider analyzed samples containing plant remains. Ubiquities calculated based on flotation samples.

La Blanca has a higher mean count and ubiquity of maize than the only other contemporary site with analyzed plant remains, Cuauhtémoc. During the Conchas phase, Cuauhtémoc was much smaller in population than La Blanca, the largest regional center. However, what is more surprising is that the mean count for La Blanca is overshadowed by mean counts for several Early Preclassic occupations including those of Cuauhtémoc (Cherla), Aquiles Serdán (Cherla), Aquiles Serdán (Ocós), Chilo (Locona), and San Carlos (Barra). Sample size is somewhat responsible for this patterning, as La Blanca has far more analyzed features than any other assemblage (see Table 31). Yet even considering the influence of small sample size, the fact that some Early Preclassic assemblages from hamlets/small villages have similar or larger mean counts of maize than the Middle Preclassic urban center of La Blanca is startling.

Maize intensification on the Pacific Coast is usually firmly situated in the Middle Preclassic period, accompanying the rise of social hierarchy. But this comparative analysis, while it would benefit from greater sample sizes, suggests that maize intensification most likely predated the emergence of social hierarchy and aggregated settlements, with early outputs exceeding those for larger centers based on normalized counts. Other studies have demonstrated that maize became incorporated into foodways on the Pacific coast (just north of the Mazatán region, where the Chiapas sites included in this study are located) as early as 6500 cal. BP, during the Archaic period (Kennett et al. 2010). Thus, it is highly probable that maize could have skyrocketed in abundance at Early Preclassic sites, later decreasing as the focus shifted to incorporating other plants into subsistence regimes. Another possible explanation for the observed patterning, aside from uneven feature counts, is greater emphasis on off-site maize processing at La Blanca leading to lower cupule counts.

Unfortunately, the assemblages published in Feddema 1993 do not separate maize kernels and cupules, making it impossible to further explore this hypothesis.

Ubiquity provides a measure of how many flotation samples at each site contained maize, complementing results of the mean count analysis. This measure can provide a sense of the distribution of maize at any given site, with a higher ubiquity value corresponding to more widespread distribution. When maize ubiquity values are compared across phases, patterning defies traditional expectations (Figure 60). If maize use became more expansive over time as it transitioned to a staple crop, then one would expect ubiquity values to gradually rise over time. That is not the case here, as evidenced by high ubiquity values at the beginning and middle of the sequence. If maize access became more restricted over time in tandem with the rise of social inequality (e.g., elites amassing surpluses), then one would expect maize ubiquity to markedly reduce by the Middle Preclassic period. However, this second scenario is also flawed as maize ubiquity is relatively high at Middle Preclassic sites as well (La Blanca and Cuauhtémoc). Sample size is less of an issue in analyzing ubiquity than mean counts as the number of analyzed flotation samples is generally higher than the number of features (see Table 31). Then how should one interpret the patterns in Figure 60? One plausible approach is to recognize that the emergence of elite status may have influenced site planning and the construction of monumental architecture at sites like La Blanca, but it did not result in restrictions on household production of agricultural resources. Additionally, it is important to highlight that maize use became expansive at the site level much earlier than has been traditionally acknowledged. A growing body of evidence indicates that maize was used by humans on the Pacific coast as early as the Archaic period (Kennett et al. 2010) and becomes a staple grain elsewhere in Mesoamerica by 4000 cal. BP

(Kennett et al. 2020). Thus, it is reasonable to think that it could have become ubiquitous at Paso de La Amada during the Barra phase, with use becoming more widespread at other sites across the Pacific coast by the Ocós and Cherla phases.

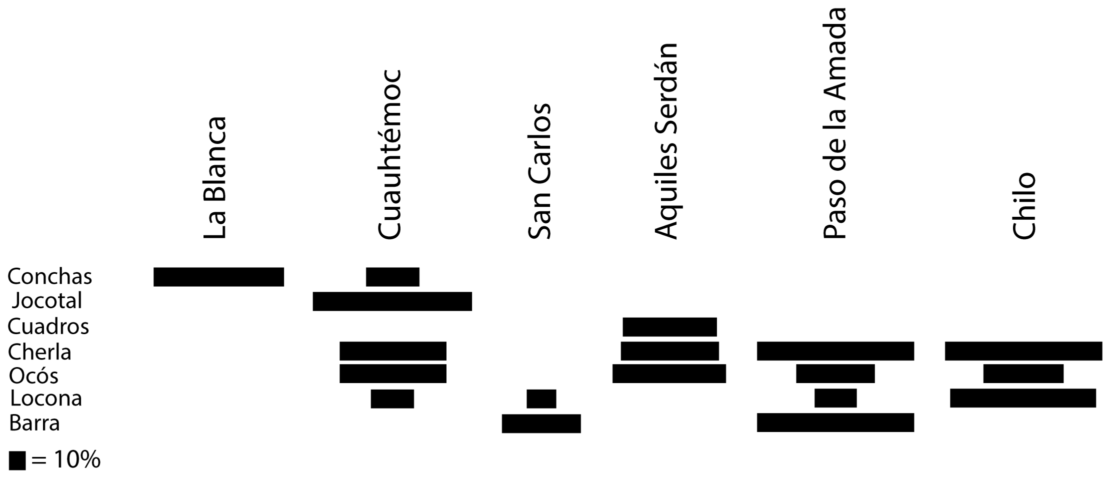

Figure 60. Frequency-Seriation Diagram of Maize Ubiquities for Early to Middle Preclassic sites on the Pacific Coast.

Taxonomic Diversity & Landscape Use

Growing investment in plant foods can take the form of not only resource intensification, but also diversification (Gallagher and Arzigian 1994). Diversification involves using many different types of plants to meet high subsistence needs, spreading out risk in the process. Plant diversity could thus be expected to increase in a stepwise fashion from the Early to Middle Preclassic periods (as regional centers expanded in size) or more dramatically at the La Blanca site, the first urban center in the region. Shannon-Weaver Index diversity values are presented in Table 33 for many of the study sites included in Table 32.

Table 33. Shannon-Weaver Index Values for Early to Middle Preclassic Sites on the Pacific Coast.

Site	Phase	Period	H'	V'
La Blanca	Conchas	Middle Preclassic	1.184	0.368
Cuauhtémoc	Conchas	Middle Preclassic	0.087	0.126
Aquiles Serdán	Cuadros	Early Preclassic	1.347	0.837
Cuauhtémoc	Cherla	Early Preclassic	0.163	0.235
Aquiles Serdán	Cherla	Early Preclassic	0.558	0.402
Chilo	Cherla	Early Preclassic	0.362	0.523
Cuauhtémoc	Ocós	Early Preclassic	0.944	0.681
Aquiles Serdán	Ocós	Early Preclassic	0.528	0.328
Paso de la Amada	Ocós	Early Preclassic	0.078	0.112
Paso de la Amada	Locona	Early Preclassic	0.895	0.645
Chilo	Locona	Early Preclassic	0.329	0.204
San Carlos	Barra	Early Preclassic	0.209	0.301

Note: Certain assemblages have been excluded from the diversity analysis. Cuauhtemoc (Locona) is excluded as eight maize fragments are the only identified plant remains. San Carlos (Jocotal) is excluded as it only has unidentified plants. Paso de la Amada (Cherla) is excluded as one maize fragment is the only identified plant remain. Chilo (Ocós) is excluded as eight maize fragments are the only identified plant remains. San Carlos (Locona) is excluded from the table as there are only three counts (maize, *Mollugo* sp., and *Brassica* sp.), inflating SW Index values (H' = 1.099, V' = 1.000). Paso de la Amada (Barra) is excluded as 30 maize fragments are the only identified plant remains. Cuauhtemoc (Jocotal) is excluded from the table as there are only two counts (maize, cheno/am), inflating SW Index values (H' = 0.693, V' = 1.000).

Like the maize ubiquity data, patterning in the diversity data is not as clear cut as expected. Richness and equitability values are higher for La Blanca than any other Conchas phase site, but they are not the highest in the sequence. In fact, higher richness and equitability values are present at Aquiles Serdán during the earlier Cuadros phase. While this difference could be attributed to the influence of increasing maize intensification at La Blanca, Early Preclassic assemblages dating from the Barra to Cherla phases have much lower richness values than La Blanca. Moreover, the present study has identified a wide variety of other plants besides maize (e.g., tree crops, nuts, tubers, etc.) that La Blanca residents relied on for subsistence.

There are two key conclusions to take away from this comparative analysis of plant diversity at Pacific coast sites dating to the Early to Middle Preclassic periods. First, La Blanca residents exploited a far greater variety of plants than residents of all preceding Early to Middle Preclassic occupations in the region except Aquiles Serdán during the Cuadros phase (which has a much smaller number of flotation samples (n = 10) than La Blanca (n = 159)). This variety would have helped to feed the burgeoning population at this first urban center in the region, particularly during the Conchas C and D subphases when tree crop and nut production took off in the Joyas South Neighborhood. Second, equitability of plant use did not take a measurable hit coinciding with the inception of social inequality at La Blanca. Indeed, equitability is much greater at La Blanca than for the smaller contemporary village of Cuauhtémoc. Diversification appears to be more characteristic of La Blanca than earlier periods, while maize intensification, classically associated with the emergence of social hierarchy and survival of large populations, is perhaps better linked with the Early Preclassic period. Later in time, La Blanca residents continued to grow maize, as had been done in earlier periods. However, they did so in conjunction with gathering and cultivating a wider variety of plants to meet their subsistence needs, particularly during the Conchas C and D subphases when population sizes at the site progressively increased.

The beginnings of maize intensification predate the initial urbanization of the Pacific Coast. In fact, comparisons of local results from La Blanca to plant datasets from Early and Middle Preclassic sites in the region revealed that intensification of maize happened by the Early Preclassic, far earlier than the emergence of the first city. But this finding is not surprising when a broader temporal perspective is considered. Kennett and colleagues (2010) argue that inhabitants of the Acapetua area (Pacific coast of Mexico) began to engage in maize horticulture as early as 6500 cal. BP, with the emergence of agriculture by 3800 cal. BP. Over nine hundred years passed between the approximate start of maize agriculture identified by their study and the founding of the La Blanca site, providing plenty of time for experimentation in agricultural investment. One of the takeaways of the inter-site analysis offered by current study is that, in addition to identifying hallmarks of social complexity, investigating the complexities of daily life is critical to understanding large-scale social processes like urbanization. I argue that these two types of research questions should not be considered mutually exclusive.

Reflections on the Life of an Early City

Integration of neighborhoods at La Blanca contributed to centuries of long-term stability. Urban living is a collaborative process in which the type and degree of integration has implications for a city's permanence (Bradford 2016). While an integrated society with much of the political power instilled in one or few leaders (e.g., the Inca Empire) is more inherently fragile to transformation if there is a change in the status quo, a city that is integrated through heterarchy would benefit from greater resiliency when compared to its less integrated counterparts. The fact that there are at least five discrete neighborhoods at the La Blanca site rather than one conglomerated settlement would have allowed residents to distribute risk across the landscape. If one neighborhood were to fail to provide for its own subsistence needs, another neighborhood could step in to augment their food supply. Indeed, one neighborhood could have provided the same or roughly equivalent plant resources to another neighborhood in times of need. This overlap in resources also suggests that the residents of each neighborhood exploited similar environmental niches and likely communicated with one another to strategize how to best manage their subsistence. I argue that management of subsistence on a citywide scale should be considered an aspect of heterarchy that existed alongside more hierarchical parts of life at La Blanca. Other aspects of heterarchy at La Blanca have been identified such as the use of figurines in domestic ancestor rituals (Love and Rosenswig 2022) and the inclusion of figurine fragments (likely from many different households) as part of the construction fill of Mound 1 (Guernsey 2020), a monumental construction interpreted by Love (2016b) as a communal residence for the ancestors.

Over time, changes in the food-related uses of neighborhoods at La Blanca demonstrate that the city was renovated both spatially and socially over time. During Conchas C, residents added three new neighborhoods flanking the north and south of the Vacas Neighborhood. Some locales, like Satellite Area North and the Vacas Neighborhood, focused on maize cooking and processing while the Joyas South Neighborhood concentrated much more heavily on tree crop use and, potentially, oil extraction from coyol fruits. By Conchas D, Satellite Area North deposits demonstrate investment in maize cooking and processing, but no longer any processing tree crops in this locale. Joyas South Neighborhood remained a powerhouse for tree crop processing over its entire occupation. A diverse array of tubers was also processed in this neighborhood, with tuber diversity having reached its highest level sitewide by Conchas D. Dissecting the various practices involved in foodways (social fields) allows for a fuller picture of social diversity at the site that complements but also transcends data gleaned from inter-household comparisons based on economic status. Although households of the highest rank are concentrated in the Central Neighborhood, no direct relationship is evident between economic status and investment/disengagement in making food.

La Blanca residents looked to non-local resources to supplement their subsistence base at home. I identified starch granules on La Blanca food preparation and cooking equipment that are consistent with wild potatoes from Mexico and Guatemala. These starches derive from residues on artifacts in the Joyas South Neighborhood, Vacas Neighborhood, and Satellite Neighborhood South. Thus, use of these resources occurred in both the northern and southern portions of the site. Nut fragments and wild potato starches recovered from La Blanca represent taxa that must be grown at much higher elevations. Jackson and Love (1991; Love and Jackson 1999) have argued that La Blanca residents had trade relationships with higher elevation locations, such as El Chayal, Ixtepeque, San Martín Jilotepeque, and Tajumulco, to acquire obsidian for production of blades and other tools. These areas fit the altitude criteria for growing the wild potatoes and nuts found at La Blanca. Thus, it seems probable that highly storable and portable resources like nuts and wild potatoes could have also been acquired through these exchanges and later processed at home. This interpretation of multi-purpose exchange could have only been reached through the analysis of different social fields (i.e., processing of starchy tubers, consumption of nuts, and acquisition of raw materials for blade production).

Patterning in food remains indicates that La Blanca's decline was gradual, and not precipitous or catastrophic. Conchas E foodways involved previously practiced techniques, namely maize agriculture, but scaled down diversification, indicated in part by the drop in tree crop abundance. If La Blanca residents became uncertain about their long-term presence during Conchas D (due to social or environmental factors), one would expect that they would have invested less in delayed return resources and instead turn to foraged resources requiring far less long-term investment. However, the opposite pattern is evident at La Blanca, with maize agriculture continuing but use of foraged resources declining during Conchas E. I suggest that intensification through diversification of exploited plant taxa became a key strategy of fulfilling the subsistence needs of La Blanca's burgeoning population during the Conchas C and D subphases. By the time that residents started leaving the city, subsistence needs would have decreased, and remaining residents would have had less of an impetus to invest in as wide a variety of resources to achieve food security. Considering the emergence of Izapa to the north (by 600 BCE) and El Ujuxte to the east (by 500 BCE) at around the same time that La Blanca declined demographically, it seems plausible that former residents would have relocated to found or join these new states. My ongoing research involving strontium assays of human teeth from La Blanca and El Ujuxte will help to shed light on this possibility.

Efforts targeted at maintaining the subsistence needs of early cities such as La Blanca continue to be relevant to aggregated living in modern settings. An imperative goal in the present is to assemble a toolkit of strategies that can be deployed to enhance urban sustainability and safeguard food security during urbanization. The United Nations (2018) projects that 68% of the world's population will live in urban areas by 2050. The same study also found that cities with fewer than one million inhabitants are one of the fastest-growing urban agglomerations (United Nations 2018). Food security challenges in urban environments become even more complex when one considers the progressive effects of climate change on growing conditions and ecological communities.

Looking to the past has great potential to offer viable solutions to modern problems at the intersection of urbanization and climate change. I argue that in a context like the modern municipality of La Blanca, where most native ecosystems have been replaced by industrial agriculture, investment in revitalizing indigenous plants can produce positive outcomes. First, this type of investment would diversify subsistence economies, creating more sustainable food systems while also introducing opportunities for local economic benefit. Second, greater investment in growing native plants would forge new linkages between habitats, avoiding habitat islands and thus increasing the resiliency of these ecosystems to the damaging effects of climate change. A project reintroducing native walnuts into backyard gardens, for example, would represent a strategy gleaned from research at La Blanca that would help to reduce habitat islands while not posing a threat to livelihoods centered on industrial agriculture. Discussing viable strategies based on archaeological findings with local communities is the next phase of this research and ultimately the key to making paleoethnobotanical research translate into sustainable social and environmental impacts.

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APPENDIX A: FLORA NATIVE TO THE SAN MARCOS AND RETALHULEU DEPARTMENTS, GUATEMALA.

Scientific name	Common name(s)	Area[a]	Habitat	Elevation (m)	Reference
Acoelorraphe wrightii	Paurotis palm, Everglades palm, Madeira palm, cubas, tique, papta	Pacific coast	Dry forests		IARNA 2018
Acrocomia mexicana	Coyol	Guatemala			Villar Anléu 2008
Acrostychum daneaefolium	Giant leather fern	Pacific coast	Dry forests		IARNA 2018
Albizia saman	Rain tree, saman, monkeypod	Pacific coast	Dry forests		IARNA 2018
Alseis yucatanensis	Manzanillo	Pacific coast	Dry forests		IARNA 2018
Ampelocera hotleii	Luín	Pacific coast	Dry forests		IARNA 2018
Annona cherimola Mill.		San Marcos	Along stream which flows past town; Moist thickets along quebrada below town	2300	USDA 2011
Annona diversifolia Saff.	Papauce	San Marcos		61	USDA 2011
Annona reticulata L.	Anona	San Marcos, Retalhuleu	Dry thicket; wet thicket; thicket along stream	200-1000	USDA 2011
Aspidosperma cruenta	Malerio colorado	Pacific coast	Dry forests		IARNA 2018
Aspidosperma megalocarpon	Araracanga	Pacific coast	Dry forests		IARNA 2018
Aspidosperma stegomeris	Bayate, bayo blanco, chichi, chichica	Pacific coast	Dry forests		IARNA 2018
Astrocaryum mexicanum	Mexican forest palm, lancetillo	Pacific coast	Dry forests		IARNA 2018
Astronium graveolens	Tigrillo; Ron-ron; Cucaracho; Tolerante; Gonza	Pacific coast	Dry forests		IARNA 2018
Attalea cohune	Cohune Palm, manaca palm	Pacific coast	Dry forests		IARNA 2018
Bernoullia flammea	Amapola blanca, amapola	Pacific coast	Dry forests		IARNA 2018
Bixa orellana L.		Retalhuleu	Dry thickets.	120	USDA 2011

Bixa orellana L. var. leiocarpa (Kuntze) Standl. & L.O. Williams	Achote	Retalhuleu	Thickets.	120	USDA 2011
Brosimum alicastrum	Breadnut, Maya nut, ramón tree, yaxox, ojushte	Pacific coast	Dry forests		IARNA 2018
Brosimum panamense / Brosimum guianense	Guiana brosimum, snakewood, letterwood, bastard breadnut	Pacific coast	Dry forests		IARNA 2018
Bucida buceras	Bullet tree, black olive tree, gregorywood (or gregory wood), Antigua whitewood, oxhorn bucida	Pacific coast	Dry forests		IARNA 2018
Bursera bipinnata	Copal	Pacific coast	Dry forests		IARNA 2018
Bursera diversifolia	Palo jiote, chacaj, indio desnudo, Palo chino, Chacah, Chacah Colorado	Pacific coast	Dry forests		IARNA 2018
Bursera graveolens	Palo santo	Pacific coast	Dry forests		IARNA 2018
Bursera simaruba	Gumbo-limbo, copperwood, chaca, naked Indian, turpentine tree	Pacific coast	Dry forests		IARNA 2018
Bursera steyermarkii / Bursera heteresthes	None found	Pacific coast	Dry forests		IARNA 2018
Byrsonima crassifolia	Nance, nanche, changunga, muruci, murici, nancite, chacunga, craboo, kraabu, savanna serrette (or savanna serret), golden spoon	Pacific coast	Dry forests		IARNA 2018
Caesalpinia vesicaria	Large-leaved Cassia	Pacific coast	Dry forests		IARNA 2018
Calathea macrosepala var. *macrosepala*	Chufle	San Marcos	Dry forests; Collected near Volcano Tajumulco	1500	The Field Museum 2022
Calophyllum brasiliense	Jacareúba, guanandi, Árbol de Santa Maria	Pacific coast	Dry forests		IARNA 2018
Cameraria latifolia	None found	Pacific coast	Dry forests		IARNA 2018

Capsicum annuum L. var. glabriusculum (Dunal) Heiser & Pickersgill	Diente de perro, chiltepe	Retalhuleu, San Marcos	Thickets	120-450	USDA 2011
Capsicum lanceolatum (Greenm.) C.V. Morton & Standl.		San Marcos	Montane cloud forest area; wet mountain forest	1524-2500	USDA 2011
Carica papaya L.		Retalhuleu, San Marcos	Dry thicket; mixed forest; muddy forest in valley	20-120	USDA 2011
Cedrela odorata	Spanish cedar, cuban cedar, cedro	Pacific coast	Dry forests		IARNA 2018
Ceiba aesculifolia	Pochote	Pacific coast	Dry forests		IARNA 2018
Ceiba pentandra	Ceiba; kapok	Pacific coast	Dry forests		IARNA 2018
Cephalocereus maxoni	None found	Pacific coast	Dry forests		IARNA 2018
Chamaedorea arenbergiana	Chim	San Marcos	Rain forest on slopes	100-1800	Henderson et al. 1995
Chamaedorea costaricana	Tenera, Costa Rican bamboo palm	San Marcos	Rain forest	50-2300	Henderson et al. 1995
Chamaedorea fractiflexa		San Marcos	Montane rain forest	2000-2900	Henderson et al. 1995
Chamaedorea nubium		San Marcos	Premontane or montane rain forests on mountain slopes	1500-2500	Henderson et al. 1995
Chamaedorea pachecoana	Pacaya	San Marcos	Montane rain forest	1200-1500	Henderson et al. 1995
Chamaedorea quezalteca Standl. & Steyerm.	Chimp	San Marcos	Along stream tributary to río Suchiate; forested palm slope; middle portion of slopes; upper slopes; wet mountain forest	1300-2500	USDA 2011
Chamaedorea rojasiana	Molinillo, pacaya	San Marcos	Montane rain forest	1200-2600	Henderson et al. 1995
Chamaedorea stricta		San Marcos	Rain forest	850-1900	Henderson et al. 1995
Chamaedorea tepejilote Liebm. ex Mart.	Bojon, pacaya, tepejilote	San Marcos	Wet forest; along river slopes; forest, often on limestone soils	0-1600	Henderson et al. 1995; USDA 2011
Chamaedorea volcanensis		San Marcos	Montane rain forest	1200-2000	Henderson et al. 1995

Chamaedorea vulgata		San Marcos	Pine-oak or montane rain forest on slopes	1300-2350	Henderson et al. 1995
Chrysobalanus icaco	Cocoplum, paradise plum, abajeru, icaco	Pacific coast	Dry forests		IARNA 2018
Cladium jamaicense	Sawgrass	Pacific coast	Dry forests		IARNA 2018
Clusia salvinii	None found	Pacific coast	Dry forests		IARNA 2018
Cochlospermum vitifolium	Palo barril, rosa amarilla	Pacific coast	Dry forests		IARNA 2018
Cordia alliodora	Bocote, Spanish elm, Ecuador laurel, cypre, salmwood	Pacific coast	Dry forests		IARNA 2018
Cordia curassavica	Black sage, wild sage	Pacific coast	Dry forests		IARNA 2018
Cordia dodecandra	Ziricote	Pacific coast	Dry forests		IARNA 2018
Crescentia cujete	Calabash tree	Pacific coast	Dry forests		IARNA 2018
Crotalaria longirostrata Hook. & Arn.	Chipilín	Retalhuleu, San Marcos		10-300	USDA 2011
Crotalaria vitellina Ker Gawl.	Chipilín de caballo	San Marcos	Forma silvestre.	97	USDA 2011
Croton ciliatoglandulosus	Duraznillo	Pacific coast	Dry forests		IARNA 2018
Croton glabellus	Basket hoop	Pacific coast	Dry forests		IARNA 2018
Croton payaquensis	Croton	Pacific coast	Dry forests		IARNA 2018
Crysophila stauracantha	Escoba, root spine palm	Pacific coast	Dry forests		IARNA 2018
Cucurbita argyrosperma C. Huber subsp. sororia (L.H. Bailey) L. Merrick & D.M. Bates	Ayote de caballo; sandía de ratón	Retalhuleu, San Marcos	Dry thickets; sands	0-240	USDA 2011
Cupania belizensis	Grande betty, chac pom, palo de carbon	Pacific coast	Dry forests		IARNA 2018
Cupania prisca	None found	Pacific coast	Dry forests		IARNA 2018
Dendropanax arboreus	Angelica tree	Pacific coast	Dry forests		IARNA 2018
Desmonchus orthacanthos	Climbing palm, masgidubaled, maski, matamba, palma bejuco	Pacific coast	Dry forests		IARNA 2018

Dialium guianense	Paleta	Pacific coast	Dry forests		IARNA 2018
Dioscorea composita Hemsl.		Retalhuleu	Vegetación secundaria de selva alta perennifolia.	50	USDA 2011
Drypetes brownei	None found	Pacific coast	Dry forests		IARNA 2018
Drypetes laterifolia	Guiana plum	Pacific coast	Dry forests		IARNA 2018
Entada polystachya	Callingcard vine	Pacific coast	Dry forests		IARNA 2018
Enterolobium cyclocarpum	Conacaste	Pacific lowlands (Guatemala)			Villar Anléu 2008
Eritrin berteroana	Elequeme, gallito, machete, pernila de casa, pito, palo de pito, poró de cerca	Pacific coast	Dry forests		IARNA 2018
Erythroxylum guatemalense	None found	Pacific coast	Dry forests		IARNA 2018
Eugenia capuli	Árbol de arrayán, capulín, capulín agarroso, capulincillo, capulín de zorrillo, escobillo, palu de temazate	Pacific coast	Dry forests		IARNA 2018
Fraxinus vellerea	None found	Pacific coast	Dry forests		IARNA 2018
Gaussia maya	Maya palm, gausia cimarrona, palma cambo, palma cimarrona	Pacific coast	Dry forests		IARNA 2018
Geonoma interrupta	Chocho blanco	San Marcos	Understory of lowland to premontane rain forest (common); well-drained soils on mountain slopes; poorly drained soils; disturbed forest; secondary forest	0-1400	Henderson et al. 1995
Gliricidia sepium	Quickstick, mata ratón, cacao de nance, cachanance, madre de cacao, madre cacao	Pacific coast (lowlands)	Dry forests		IARNA 2018; Villar Anléu 2008
Gossypium hirsutum L.		Retalhuleu, San Marcos	Sand; flats; along beach; dry thicket	0-5	USDA 2011

Guadua longifolia	American long-leaved bamboo	Pacific coast	Dry forests		IARNA 2018
Guarea excelsa	None found	Pacific coast	Dry forests		IARNA 2018
Guazuma ulmifolia	West Indian elm, bay cedar	Pacific coast	Dry forests		IARNA 2018
Haematoxylon brasiletto	Mexican logwood, palo de brasil, palo de tinto	Pacific coast	Dry forests		IARNA 2018
Haematoxylon campechianum	Blackwood, bloodwood tree, bluewood, campeachy tree, campeachy wood, campeche logwood, campeche wood, Jamaica wood, logwood	Pacific coast	Dry forests		IARNA 2018
Hampea trilobata	Hampea tree	Pacific coast	Dry forests		IARNA 2018
Helicteres guazumifolia	None found	Pacific coast	Dry forests		IARNA 2018
Hippocratea excelsa	Cancerina	Pacific coast	Dry forests		IARNA 2018
Hirtella americana	Garrapato	Pacific coast	Dry forests		IARNA 2018
Hirtella racemosa	None found	Pacific coast	Dry forests		IARNA 2018
Hymenocalis littoralis	Beach spider lilly	Pacific coast	Dry forests		IARNA 2018
Ipomea murucoides	Cazahuate, palo bobo	Pacific coast	Dry forests		IARNA 2018
Ipomoea tiliacea (Willd.) Choisy		Retalhuleu, San Marcos	Wet mountains forest	380-2100	USDA 2011
Ipomoea trifida (Kunth) G. Don		Retalhuleu, San Marcos	Mixed forest; thickets; wet thicket	120-640	USDA 2011
Jacquinia aurantiaca	Flora de niño, palo de las ánimas, palo santo, rosalina, vele-roche, sic-quete	Pacific coast	Dry forests		IARNA 2018
Karwinskia calderonii	Huilihuiste	Pacific coast	Dry forests		IARNA 2018
Laetia thamnia	Conejo colorado; palo blanco	Pacific coast	Dry forests		IARNA 2018
Licania hypoleuca	None found	Pacific coast	Dry forests		IARNA 2018
Lonchocarpus castilloii	None found	Pacific coast	Dry forests		IARNA 2018
Malmea depressa	E'ele'muy	Pacific coast	Dry forests		IARNA 2018

Manilkara zapota	Sapodilla, sapota, chikoo, naseberry, nispero	Pacific coast	Dry forests		IARNA 2018
Matayba oppositifolia	Bastard willow, Chiquirin, Chischiscoy, Cobynancy, Palo de culebra, Zacuayum (Sacuayum)	Pacific coast	Dry forests		IARNA 2018
Metopium brownei	Chechem, chechen, black poisonwood	Pacific coast	Dry forests		IARNA 2018
Mimosa hemendieta	None found	Pacific coast	Dry forests		IARNA 2018
Mimosa skinneri	None found	Pacific coast	Dry forests		IARNA 2018
Mouriri exilis	None found	Pacific coast	Dry forests		IARNA 2018
Ocimum micranthum	Xkakaltun, albahaca del monte, Amazonian basil, wild sweet basil, wild mosquito plant, least basil, Peruvian basil, spice basil, alfavaca-do-campo, manjericao and estoraque	Pacific coast	Dry forests		IARNA 2018
Opuntia decumbrens	Prickly pear (genus)	Pacific coast	Dry forests		IARNA 2018
Oreomunnea guatemalensis (symnonym: *Alfaroa guatemalensis*)		Guatemala, Honduras, Mexico	Evergreen		IARNA 2018
Pachira aquatica	Money tree, guiana chestnut, saba nut, pumpo	Pacific coast	Dry forests		IARNA 2018
Pachyrhizus erosus (L.) Urb.		Retalhuleu	Thickets along fence row.	259-348	IARNA 2018
Panchreatum litorali	None found	Pacific coast	Dry forests		IARNA 2018
Passiflora ligularis Juss.	Granadilla	San Marcos	Thicket; wet thicket	900-2300	USDA 2011
Passiflora mayarum	Granadilla	Pacific coast	Dry forests		IARNA 2018
Passiflora platyloba Killip		Retalhuleu	On dry brushy plains.	120	USDA 2011
Persea americana Mill. Var. Drymifolia (Schltdl. & Cham.) S. F. Blake		San Marcos	In barranco. Originally *Alnus-Quercus-Pinus* region, now largely in maize cultivation.	1800	USDA 2011

Persea *americana* Mill. var. nubigena (L.O. Williams) L. E. Kopp	Aguacate guatemalteco criollo; aguacate de montaña	San Marcos	A orilla de carretera		USDA 2011
Persea americana Mill. var. steyermarkii (C.K. Allen) Scora		San Marcos	Upper slopes	1300	USDA 2011
Persea vesticula Standl. & Steyerm.		San Marcos	Wet mountains forest; top of escarpment along river	1800-2500	USDA 2011
Phaseolus coccineus L.		San Marcos	Disturbed forests of pine and alder; humid locations; forested mountain slopes and ravines on moist bank; volcanic ash and rock soils in mountains; sandy soils in pine-oak woods and on roadside, mostly in grass	1775-2700	USDA 2011
Phaseolus dumosus Macfad.		Retalhuleu, San Marcos		240-1300	USDA 2011
Phaseolus lunatus L.	Ixtapacal	Retalhuleu, San Marcos	Tropical humid forest converted to coffee plantation; dry thickets; forested flats; moist thickets; thickets near streams	5-1600	USDA 2011
Phaseolus vulgaris L.	Frijolito, frijol de venado	Guatemala	Forests (e.g., pine, oak), wet thickets	380-2050	USDA 2011
Phragmites australis	Common reed	Pacific coast	Dry forests		IARNA 2018
Physalis philadelphica Lam.	Miltomate	San Marcos		2020-2400	USDA 2011

Pimenta dioica	Allspice, Jamaica pepper	Pacific coast	Dry forests		IARNA 2018
Piscidia piscipula	Florida fishpoison tree, Jamaican dogwood, fishfuddle	Pacific coast	Dry forests		IARNA 2018
Pistacia mexicana	Mexican pistache, American pistachio, wild pistachio	Pacific coast	Dry forests		IARNA 2018
Poulsenia armata	Abababite	Pacific coast	Dry forests		IARNA 2018
Pouteria amygdalina	None found	Pacific coast	Dry forests		IARNA 2018
Pouteria campechiana	Canistel, yellow sapote, eggfruit	Pacific coast	Dry forests		IARNA 2018
Pouteria campechiana (Kunth) Baehni		Retalhuleu, San Marcos	Dry rocky thicket; thicket along stream	250-300	USDA 2011
Pouteria reticulata	Chupón	Pacific coast	Dry forests		IARNA 2018
Protium copal	Copal	Pacific coast	Dry forests		IARNA 2018
Pseudobombax ellipticum	Shaving brush tree, Dr Seuss tree, amapolla tree	Pacific coast	Dry forests		IARNA 2018
Pseudolmedia spuria	False breadnut	Pacific coast	Dry forests		IARNA 2018
Quararibea funebris	Molinillo, sapotillo, batidor, flor de cacao, cacahuaxochitl, funeral tree, rosita de cacao	Pacific coast	Dry forests		IARNA 2018
Rauvolfia tetraphylla	Be still tree, devil-pepper	Pacific coast	Dry forests		IARNA 2018
Sabal guatemalensis (possibly synonymous with *Sabal mexicana*)	None found	Pacific coast	Dry forests		IARNA 2018
Sabal mauritiiformis	Savannah palm, Bay Palmetto, palma de guagara	Pacific coast	Dry forests		IARNA 2018
Sageretia elegans	Cambuí Cipó de espinho, groselha de espinho, Juazinho de Cipó	Pacific coast	Dry forests		IARNA 2018
Sapindus saponaria	Wingleaf soapberry, western soapberry, jaboncillo, sulluku	Pacific coast	Dry forests		IARNA 2018
Schizolobium parahybum /	Brazilian fern tree, Brazilian firetree, guapuruvu,	Pacific coast	Dry forests		IARNA 2018

Schizolobium parahyba	guapiruvu, bacurubu, ficheira, pau-de-tamanco, umbela, parica				
Sebastiana longicuspis	None found	Pacific coast	Dry forests		IARNA 2018
Simarouba glauca / Simarouba amara	Paradise-tree, dysentery-bark, bitterwood, Lakshmi Taru	Pacific coast	Dry forests		IARNA 2018
Simira salvadorensis	None found	Pacific coast	Dry forests		IARNA 2018
Solanum agrimonifolium Rydb.		San Marcos	Wet mountain forest; damp cloud forest; moist organic soil; mature fir forest; montane cloud forest; pine-fir-hardwood forest; wet forest; along stream in narrow shaded barranco	1800-3400	IARNA 2018
Solanum americanum Mill.	Quilete, macuy, yerba mora, hierba mora	Retalhuleu, San Marcos	Clearing in evergreen forrest; salt meadow; wet mountains	1-2000	USDA 2011
Solanum bulbocastanum Dunal		San Marcos	En areas sombreadas.	3100	USDA 2011
Solanum clarum Correll		San Marcos	Growing on slope in opening in mature pine fores among mosses and shrubby *Potentilla*.	3260-3380	USDA 2011
Solanum morelliforme Bitter & Münch		San Marcos	Growing in organic matter on horizontal branch of old elm tree.	2900	USDA 2011
Solanum nigrescens M. Martens & Galeotti	Hierba mora	San Marcos		2020-3100	USDA 2011
Solanum wendlandii Hook. f.	Quixtan	San Marcos	Dry thicket, wet montane cloud forest area	200-2300	USDA 2011

Spondias mombin	Yellow mombin, hog plum, jocote de corona, amarillo	Pacific coast	Dry forests		IARNA 2018
Spondias purpurea L.	Jocote	San Marcos	Bordering town. Sands.	1	USDA 2011
Spondias radlkoferi Donn. Sm	Jocote	Retalhuleu, San Marcos	Dry thicket.	330-1300	USDA 2011
Stemmadenia donnell-smithii / Tabernaemontana donnell-smithii	Huevos de caballo, cojones de burro, cojón de mico, cojotón	Pacific coast	Dry forests		IARNA 2018
Swartzia cubensis	Katalox	Pacific coast	Dry forests		IARNA 2018
Swietenia humilis (in the south)	Pacific Coast mahogany, caoba, caoba del Pacifico, caoba del Honduras, caobilla, cobano, gateado, sopilocuahuilt, venadillo, zapaton, Honduras mahogany, Mexican mahogany	Pacific coast (lowlands)	Dry forests		IARNA 2018; Villar Anléu 2008
Swietenia macrophylla (in the north)	Mahogany, Honduran mahogany, Honduras mahogany, big-leaf mahogany, West Indian mahogany	Pacific coast	Dry forests		IARNA 2018
Talisia floresii	Coloc	Pacific coast	Dry forests		IARNA 2018
Talisia olivaeformis / Talisia oliviformis	Guaya, fayum, guayo, cotoperis, mamón	Pacific coast	Dry forests		IARNA 2018
Tecoma stans	Yellow bells, Yellowbells, Esperanza, Yellow Trumpetbush, Yellow Trumpetflower, Trumpetbush, Trumpetflower, Yellow Elder	Pacific coast	Dry forests		IARNA 2018
Terminalia amazonia	Roble coral, amarillón, canùx, naranjo, volador, amarillo real, guayabo de charco	Pacific coast	Dry forests		IARNA 2018

Theobroma cacao L.	Cacao	Retalhuleu			IARNA 2018
Thevetia ovata	None found	Pacific coast	Dry forests		IARNA 2018
Tonduzia pittieri	None found	Pacific coast	Dry forests		IARNA 2018
Trichilia minutiflora	None found	Pacific coast	Dry forests		IARNA 2018
Trophis racemosa	White ramoon	Pacific coast	Dry forests		IARNA 2018
Turnera ulmifolia	Ramgoat dashalong, yellow alder	Pacific coast	Dry forests		IARNA 2018
Typha latifolia	Broadleaf cattail, bulrush, common bulrush, common cattail, cat-o'-nine-tails, great reedmace, cooper's reed, cumbungi	Pacific coast	Dry forests		IARNA 2018
Urechitis antrieuxii	None found	Pacific coast	Dry forests		IARNA 2018
Vachellia pennatula	Feather vachellia, feather acacia, fern-leaf acacia, Sierra Madre acacia, tepame	Pacific coast	Dry forests		IARNA 2018
Vasconcellea cauliflora (Jacq.) A. DC.	Papaya de monte	Retalhuleu, San Marcos	Mixed forest; Open cut-over places on slopes 3/4 way up	120-1330	USDA 2011
Vatairea lundelli	Bitter angelim hardwood	Pacific coast	Dry forests		IARNA 2018
Vitex gaumeri	Fiddlewood, walking lady, yax-nik	Pacific coast	Dry forests		IARNA 2018
Vochysia guatemalensis	Chilacayote, cozolmeca, palo de agua, palo de tecolote	Pacific coast	Dry forests		IARNA 2018
Xanthosoma robustum Schott	Kekeshte (Quiche name)	Retalhuleu, San Marcos	Along small quebrada tributary to river.	300-1400	USDA 2011
Xylopia frutescens	Pimientillo	Pacific coast	Dry forests		IARNA 2018
Zanthoxylum culantrillo	None found	Pacific coast	Dry forests		IARNA 2018
Zuleania guidonia	None found	Pacific coast	Dry forests		IARNA 2018

APPENDIX B: UCSB-ISL MICROBOTANICAL EXTRACTION PROTOCOL

MICROBOTANICAL LABORATORY PROCEDURES 2013

Department of Anthropology, University of California, Santa Barbara

1. Preparation. In this step, you will generate your initial laboratory sample, referred to as your *Original Sample,* from a soil sample (1a), or from an artifact (1b). Gloves (non-starched) should be worn and changed between samples to avoid contamination.

1a. Soil Preparation.
-Dry Soils.
-Sieve through 0.5 mm mesh.
-Weigh as accurately as possible. Aim for 5-10 g (more for soils with higher clay content).
-Place soils in 50 ml tubes. These will be your *Original Soil Samples.*
-Add defloculant (e.g., 0.1% alconox), filling vials to 20 ml.
-Put all *Original Soil Samples* on shaker for several hours*.

1b. Artifact Residue Preparation.
-Create *Sediment 1* by thoroughly scrubbing artifact with a clean, wet toothbrush.
-Wash all resulting water and soil into a 50 ml tube. This will be *Original Sediment 1.*
-Create *Sediment 2* by submerging artifact in a water filled sonicator, and running for >10 minutes (artifact may be submerged in a suspended, sealed plastic bag, or placed in a glass beaker). -*Sediment 1* and *Sediment 2* samples will likely exceed 50 ml. To fit them into 50 ml tubes, simply centrifuge, decant, and refill as necessary. Final decant should leave as little water as possible in sample.
-If you are planning to weigh your samples to calculate density, place all *Original Sediment 1* and *Original Sediment 2 Samples* in a furnace at 40˚ C (100˚ F). Once dried (24+ hours), weigh and record sample weights.
*If you are not planning to weigh your samples, you can either refill them with distilled water for Clay Removal (step 2), or transfer them to 15 ml tubes for Starch Flotation (step

3). (Clay removal is only necessary for dirty/opaque samples – most artifact residues will be translucent).

2. **Clay Removal.** The purpose of this step is to clean your *Original Sample* before flotation. Small particles of soil removed in this step will ultimately result in cleaner slides, which will aid in your identification of starch and phytoliths. (If your *Original Sample* is reasonably clear, particularly with artifact residues, this step may not be necessary). Gloves should be worn to avoid contamination. -Shake/vortex vials vigorously (when turned upside down, there should be no soil clumped in the bottom).

-Centrifuge vials for approximately 2 minutes at 1000 rpm.
-Using a syringe or pipette, remove the upper water column, being careful not to disturb the soil clumped at the bottom.
-Refill vial with distilled water.
-Repeat entire process (shake, centrifuge, syringe, refill…) until your *Original Sample* is translucent (this may take 5+ times). After the final removal of the upper water column, do not refill with distilled water.

3. **Starch Flotation.** This step will generate a new set of samples, so that each *Original Sample* will have a paired *Starch Sample*. Gloves should be worn to prevent contamination, and to limit contact with heavy liquid (non-toxic). Remember to keep heavy liquids covered at all times (even with simple saran wrap) to avoid evaporation, as this could increase the specific gravity.

-Transfer *Original Samples* from 50 ml tubes to 15 ml tubes, using a squeeze bottle of distilled water to carefully wash material from the edges of the 50 ml tube into the 15 ml tube. If the 15 ml tube fills up before you have transferred all material, simply centrifuge (2 minutes at 3000 rpm) and decant to create more space. The 15 ml vial should be labeled exactly the same as the 50 ml vial (*Original Sample* #).
-Decant all water from 15 ml tubes, leaving compact soil in the base.
-Add ~4ml of 1.6 sg heavy liquid*.
-Shake/vortex vigorously (when turned upside down, there should be no soil clumped in the bottom).

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Add another ~4ml of 1.6 sg heavy liquid.

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into a new 15 ml tube, labeled as the corresponding *Starch Sample* (including relevant sample number or notes).

-Fill *Starch Sample* with distilled water, so that the vial now contains ~8 ml of 1.6 sg heavy liquid and ~7 ml of distilled water.

-Shake/vortex *Starch Sample* vigorously.

-Centrifuge *Starch Sample* for 3 minutes at 3000 rpm.

-Decant *Starch Sample* into a container of used heavy liquid (for recycling*).

-Add another ~4 ml of 1.6 sg heavy liquid to *Original Sample.*

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into corresponding *Starch Sample.*

-Fill all *Original Sample* vials and *Starch Sample* vials with water.

-Shake/vortex vigorously.

-Centrifuge all vials for 3 minutes at 3000 rpm.

-Decant all vials into a container of used heavy liquid.

-Set aside decanted *Original Sample* vials for Chemical Digestion (step 4).

-Label a corresponding 2 ml vial for each 15 ml *Starch Sample* vial, including all relevant information. -Weigh and record the weight of each empty 2 ml vial, including sample number. This weight will be used in Slide Mounting (step 6).

-Use small disposable pipettes to transfer *Starch Samples* from 15 ml to 2 ml vials. Remember to label and use only 1 pipette for each sample to avoid contamination. If the 2 ml tube fills up before you have transferred all material, simply centrifuge (2 minutes at 3000 rpm) and remove supernatant (with pipette) to create more space.
-Place open 2 ml vials in a furnace at 40˚ C (100˚ F) until dry (12+ hours).

4. Chemical Digestion. In this step, you will remove organics from your original sample in preparation for Phytolith Flotation (step 5). Removing organics will ultimately create cleaner slides. Because phytoliths are silica, they will withstand the harsh chemicals used in this step. However, any organic materials you wish to recover (i.e., starch or pollen) must be removed prior to this step, or they will be destroyed. Proper protection (heavy gloves, goggles, lab coats, closed shoes) should be worn throughout this step, and all chemicals should be kept under a fume hood. Remember to properly dispose of all hazardous chemicals in appropriately labeled containers.

-Place a pot of water on hot plate under the fume hood and heat to ~90˚ C (194˚ F).
-Add a few ml of dilute hydrochloric acid* to *Original Sample* vials and place in hot water bath for ~10 minutes. (Remember these vials should not contain excess water).
-Slowly add strong acid* to sample. The more carbonates there are in the sample, the stronger the reaction will be. If a sample looks red, it is reacting strongly; if a sample looks yellow, it is not. Leave vials in bath for at least 90 minutes (longer if they are reacting). A glass rod can be used to stir up contents within vial. Bubbles indicate that a reaction is still happening.
-Fill tubes with warm water and centrifuge for 2.5 minutes at 2500 rpm in order to rinse acids. Decant and repeat three times. Remember to shake/vortex vigorously between refilling/centrifuging, and remember to decant into an appropriately labeled disposal container.
-Add ~5 ml of household bleach to *Original Sample* vials. Bathe in hot water for 5 minutes only. (If samples do not look very dirty, skip this step and move onto hydrogen peroxide).
-Add ~5 ml of hydrogen peroxide (27-35% strength). Bathe in hot water (lids off) for 20-90 minutes. -Fill *Original Sample* vials with distilled water. Centrifuge for 2.5 minutes at 2500

rpm to rinse chemicals, and decant into an appropriately labeled disposal container. Repeat twice, remembering to shake/vortex vigorously between refilling/centrifuging.

5. Phytolith Flotation. This step will generate a new set of samples, so that each *Original Sample* will have a paired *Phytolith Sample*. This step essentially mirrors Starch Flotation (step 3), except that the heavy liquid will have a higher specific gravity. Gloves should be worn to prevent contamination, and to limit contact with heavy liquid (non-toxic). Remember to keep heavy liquids covered at all times (even with simple saran wrap) to avoid evaporation, as this could increase the specific gravity.

-Add ~4ml of 2.3 sg heavy liquid* to *Original Samples* (which should have been decanted in the previous step to remove all excess water).

-Shake/vortex vigorously (when turned upside down, there should be no soil clumped in the bottom).

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Add another ~4ml of 2.3 sg heavy liquid.

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into a new 15 ml tube, labeled as the corresponding *Phytolith Sample* (including relevant sample number or notes).

-Fill *Phytolith Sample* with distilled water, so that the vial now contains ~8 ml of 2.3 sg heavy liquid and ~7 ml of distilled water.

-Shake/vortex *Phytolith Sample* vigorously.

-Centrifuge *Phytolith Sample* for 3 minutes at 3000 rpm.

-Decant *Phytolith Sample* into a container of used heavy liquid (for recycling*).

-Add another ~4 ml of 2.3 sg heavy liquid to *Original Sample.*

-Shake/vortex vigorously.

-Centrifuge for 1 minute at 3000 rpm.

-Rinse material clinging to sides back into solution by gently tipping the sealed tube back and forth.

-Centrifuge for 3 minutes at 3000 rpm.

-Decant *Original Sample* into corresponding *Phytolith Sample.*

-Fill all *Original Sample* vials and *Phytolith Sample* vials with water.

-Shake/vortex vigorously.

-Centrifuge all vials for 3 minutes at 3000 rpm.

-Decant all vials into a container of used heavy liquid.

-Set aside decanted *Original Sample* vials.

-Label a corresponding 2 ml vial for each 15 ml *Phytolith Sample* vial, including all relevant information.

-Weigh and record the weight of each empty 2 ml vial, including sample number.

-Use small disposable pipettes to transfer *Phytolith Samples* from 15 ml to 2 ml vials. Remember to label and use only 1 pipette for each sample to avoid contamination. If the 2 ml tube fills up before you have transferred all material, simply centrifuge (2 minutes at 3000 rpm) and remove supernatant (with pipette) to create more space.

-Place open 2 ml vials in a furnace at 100˚ C (212˚ F) until dry. If any starch samples are in the furnace, keep temperature to 40 ˚ C (100˚ F).

-If desired, *Original Sample* vials (15 ml) can be similarly transferred to 2 ml vials and dried for Slide Mounting (step 6).

6. Slide Mounting. This step describes how to make a standardized mount for microscope slides. A standardized mount allows one to estimate the density of starch grains/phytoliths within a sample without mounting the entire sample. This process saves time, but also preserves some of your sample for future slides (as slides tend to dry out over time). To make a non-standardized sample, simply ignore the calculations described below. When making slides, one should wear gloves to avoid contamination. All materials are nontoxic.

6a. Mounting Starch.

- Weigh each 2 ml *Starch Sample* vial and subtract the weight of the vial itself (as recorded in step 3).

-Add corn syrup to *Starch Sample* in a 0.05:1 ratio. (Assuming that 0.05 ml of corn syrup weighs

0.0695 g, you should add 0.695 of corn syrup for every mg of extract in the starch vials). Place vial on scale (secured in styrofoam platform) and slowly add corn syrup using a syringe or pipette until desired weight is reached. This most likely will not be exact, so be sure to record the final weight/volume added.

-Use a toothpick to thoroughly stir mixture (several minutes). You can reduce air bubbles by centrifuging samples for 3 minutes at 3000 rpm.

-Use a toothpick to spread a thin layer of your prepared standardized mount onto a glass slide, remembering to stay within the size boundaries of a cover slip.

-Apply a cover slip, slowly laying it down from left to right to avoid bubbles.

-Seal the cover slip to the slide using nail polish. Apply to corners last, to allow air bubbles to escape.

6b. Mounting Phytoliths.

- Weigh each 2 ml *Phytolith Sample* vial and subtract the weight of the vial itself (as recorded in step 5). -Add immersion oil to *Phytolith Sample* in a 0.05:1 ratio. (Assuming that 0.05 ml of immersion oil weighs 0.0462 g, you should add 0.0462 g of immersion for every mg of extract in the starch vials). Place vial on scale (secured in styrofoam platform) and slowly add immersion oil using a syringe or pipette until desired weight is reached. This most likely will not be exact, so be sure to record the final weight/volume added.

-Use a toothpick to thoroughly stir mixture (several minutes). You can reduce air bubbles by centrifuging samples for 3 minutes at 3000 rpm.

-Use a toothpick to spread a thin layer of your prepared standardized mount onto a glass slide, remembering to stay within the size boundaries of a cover slip.

-Apply a cover slip, slowly laying it down from left to right to avoid bubbles.

-Seal the cover slip to the slide using nail polish. Apply to corners last, to allow air bubbles to escape.

This laboratory procedure is written by Kristin Hoppa and is based on procedures used by Deborah Pearsall[1] at University of Missouri, Columbia, and Rob Cuthrell[2] at University of California, Berkeley.

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[1] Chandler-Ezell, K. and D. M. Pearsall. 2003. "'Piggyback' Microfossil Processing: Joint Starch and Phytolith Sampling from Stone Tools." The Phytolitharien 15:2–8.

[2] Cuthrell, Rob. 2012. Personal Communication, July 2012. University of California, Berkeley.

APPENDIX C: PREPROCESSING STEPS FOR MICROBOTANICAL SAMPLES

1. Assemble stand with sieve (in funnel), glass funnel (ring), and 50 mL centrifuge tube labeled with OS# (clamp), in descending order.

2. Use distilled water wash bottle to wet sieve contents of each 50mL sample tube through 250-micron sieve into a new centrifuge tube.

3. If tube is full (~40-45 mL) and remaining sediment needs to go through sieve, centrifuge @ 1000 rpm for 2 minutes.

4. Decant (into sink) when separation is achieved.

5. Repeat steps 2-4, wet sieving until the entire contents of the first tube has been sieved into the second.
    a. *Clean sieve thoroughly with 0.1% alconox solution and distilled water after each tube*

6. After the final decant, add 20 mL of 0.1% alconox solution and gently swirl with hand to fully incorporate.

7. Place tubes in rack on shaker, set to 200 r/min, and leave overnight.

8. Centrifuge @ 1000 rpm for 2 minutes and decant tubes into sink.

9. Add distilled water (~40 mL), centrifuge @ 1000 rpm for 2 minutes, and decant.

10. Repeat step 9 at least twice and continue until water column is clear (see Clay Removal section of ISL Microbot Lab Protocol 2013). Begin Starch Processing when complete.

APPENDIX D: SLIDE MOUNTING PROTOCOL FOR MICROBOTANICAL EXTRACTS

UCSB ISL STARCH SLIDE PREPARATION PROTOCOL

Matthew Medeiros and Mallory Melton

I. Sample Preparation

A. Use a sterilized metal toothpick to crush sample until it is completely pulverized as finely as possible.

B. Add 1 drop of 1:1 Glycerin/DI water mix to pulverized sample. The goal is to add as little Glycerin/DI water mix as possible so that the resulting slides are denser.

C. Mix solution with toothpick until it is homogeneous. If the sample is clumpy, go back and repeat previous step.

D. Place sample in a microcentrifuge tube rack next to tray with lid secure.

II. Slide Preparation

A. Place 2-3 Kimwipes on green cafeteria tray, overlapping slightly. This will serve as your working surface.

B. Remove sterilized slide from mason jar. Using sharpie, write provenience information on frosted portion:

1. OS #
2. SS (Starch Sample)
3. Slide # (only if current sample will be split across more than 1 slide)

C. Place slide on Kimwipes.

III. Pipette Transfer

A. Remove 1 sterilized glass pipette from mason jar and secure it to the green pipettor.

B. Extract solution by rolling downwards on the pipettor knob.

1. Note: The ideal fill line for a slide tends to be just before the conical tip gives way to the body of the pipette.

C. Place filled pipette above the center of the slide and slowly roll upwards to release the solution onto the slide.

D. Once you have pipetted the entirety of your sample (on multiple slides if necessary), discard the glass pipette into the sharps bin.

IV. Slide Creation

A. Apply a sterilized cover slip to the solution on the slide. Lay the slip slowly from one side to the other to prevent bubbles.
B. Use nail polish to paint a thin layer across all four sides of the cover slip. Go slowly and take care not to disrupt the placement of the slide.
C. Allow polish to dry. Identify starch grains immediately.

APPENDIX E: STARCH UBIQUITY BY ARTIFACT

Artifact	Plate rim sherd	Vessel base	Vessel rim/side	Mano	Vessel rim/side	Rim sherd	Vessel rim/side
Object	47	57	58	61	63	64	66
Op/Sub	Op 57 Sub 1	Op 57 Sub 1	Op 55 Sub 2	Op 57 Sub 5	Op 57 Sub 5	Op 57 Sub 5	Op 57 Sub 3
Rasgo	266	266	258	278	278	278	Nivel 9B
Field cultigens							
Maize							
Maize cf.							
Bean family							
Root crops							
Arrowroot	X						X
Arrowroot cf.							
Calathea							
Calathea cf.							
Dioscorea	X						
Manioc							
Manioc cf.							
Sweet potato cf.							
Xanthosoma							
Root crop	X			X			X
Wild tubers							
Wild calathea cf.							
Wild dioscorea				X	X		
Wild potato	X						
Wild potato cf.	X						
Miscellaneous							
Calathea/Wild dioscorea							
Unidentified (granules estimated)							
Unidentified (bell-shaped)							
Unidentified (damaged)	X						
Unidentified	X		X	X		X	
Unidentifiable (heat damaged)	X						
Unidentifiable (damaged)		X					
Unidentifiable (definitely torn, possibly gelatinized)							
Unidentifiable		X				X	

Artifact	Figurine mouth	Rim sherd	Vessel rim/side	Figurine mouth	Grater bowl	Vessel base	Vessel base	Vessel base
Object	69	70	71	73	75	76	78	79
Op/Sub	Op 57 Sub 3	Op 57 Sub 3	Op 57 Sub 5	Op 57 Sub 3	Op 64 Sub 1	Op 64 Sub 1	Op 64 Sub 3	Op 64 Sub 1
Rasgo	Nivel 9B	269	271	269	295	295	291	295
Field cultigens								
Maize				X				
Maize cf.				X				
Bean family								X
Root crops								
Arrowroot	X	X						
Arrowroot cf.								
Calathea								
Calathea cf.				X				
Dioscorea		X		X				
Manioc								
Manioc cf.							X	
Sweet potato cf.			X					
Xanthosoma			X					
Root crop								
Wild tubers								
Wild calathea cf.			X					
Wild dioscorea	X							
Wild potato							X	
Wild potato cf.								
Miscellaneous								
Calathea/Wild dioscorea					X	X		
Unidentified (granules estimated)								
Unidentified (bell-shaped)			X					
Unidentified (damaged)								
Unidentified	X					X		
Unidentifiable (heat damaged)								
Unidentifiable (damaged)								
Unidentifiable (definitely torn, possibly gelatinized)								
Unidentifiable	X				X			

Artifact	Complete vessel	Grinding stone	Grinding stone	Grinding stone	Grinding stone	Vessel rim/side	Grater bowl
Object	80	82	84	85	86	87	89
Op/Sub	Op 64 Sub 1	Op 64 Sub 1	Op 65 Sub 2	Op 64 Sub 1	Op 64 Sub 1	Op 65 Sub 5	Op 66 Sub 1
Rasgo	295	295	297	295	295	299	Nivel 9
Field cultigens							
Maize		X					
Maize cf.		X		X		X	
Bean family							
Root crops							
Arrowroot							X
Arrowroot cf.							
Calathea							
Calathea cf.							X
Dioscorea							
Manioc					X		
Manioc cf.							
Sweet potato cf.							
Xanthosoma							
Root crop							
Wild tubers							
Wild calathea cf.							
Wild dioscorea							
Wild potato					X	X	
Wild potato cf.				X	X		
Miscellaneous							
Calathea/Wild dioscorea				X			
Unidentified (granules estimated)							
Unidentified (bell-shaped)							
Unidentified (damaged)							
Unidentified	X	X		X		X	
Unidentifiable (heat damaged)							
Unidentifiable (damaged)			X	X			
Unidentifiable (definitely torn, possibly gelatinized)				X			
Unidentifiable		X					

Artifact	Stone ball	Figurine mouth	Miniature vessel	Metate	Metate	Stone ball	Vessel rim/side	Metate
Object	95	99	100	106	107	108	111	112
Op/Sub	Op 66 Sub 1	Op 66 Sub 1	Op 66 Sub 4	Op 66 Sub 3	Op 66 Sub 3	Op 66 Sub 3	Op 67 Sub 3	Op 66 Sub 3
Rasgo	Nivel 15	Nivel 11	306	308	308	312	325	324
Field cultigens								
Maize				X				
Maize cf.								
Bean family								
Root crops								
Arrowroot								
Arrowroot cf.	X							
Calathea								X
Calathea cf.								
Dioscorea								
Manioc								
Manioc cf.				X				
Sweet potato cf.								
Xanthosoma								
Root crop	X				X			X
Wild tubers								
Wild calathea cf.								
Wild dioscorea								X
Wild potato			X					
Wild potato cf.			X					
Miscellaneous								
Calathea/Wild dioscorea								
Unidentified (granules estimated)								
Unidentified (bell-shaped)								
Unidentified (damaged)								
Unidentified					X	X	X	
Unidentifiable (heat damaged)								
Unidentifiable (damaged)								
Unidentifiable (definitely torn, possibly gelatinized)								
Unidentifiable		X						

Artifact	Miniature mano	Stone ball	Human face vessel	Jaguar face vessel	Sherd	Jaguar face vessel	Sherd
Object	113	116	131	137	139	143	145
Op/Sub	Op 66 Sub 3	Op 32 Sub 9	Op 34 Sub 2	Op 32 Sub 4	Op 50 Sub 3	Op 32 Sub 3	Op 50 Sub 3
Rasgo	326	Nivel 12B	97	Nivel 16	240	Nivel 5	240
Field cultigens							
Maize							
Maize cf.				X			
Bean family							
Root crops							
Arrowroot		X	X		X		
Arrowroot cf.						X	
Calathea							
Calathea cf.							
Dioscorea		X					
Manioc							
Manioc cf.							
Sweet potato cf.							
Xanthosoma							
Root crop							
Wild tubers							
Wild calathea cf.							
Wild dioscorea							
Wild potato							
Wild potato cf.							
Miscellaneous							
Calathea/Wild dioscorea							
Unidentified (granules estimated)							
Unidentified (bell-shaped)							
Unidentified (damaged)							
Unidentified	X	X	X		X	X	
Unidentifiable (heat damaged)							
Unidentifiable (damaged)							
Unidentifiable (definitely torn, possibly gelatinized)							
Unidentifiable			X				X

APPENDIX F: BASIC CHARACTERISTICS OF IDENTIFIED STARCH GRANULES

Record No.	Rasgo	Common name	Scientific name	Object No.	Sediment No.	Artifact description	Feature type	Op/Sub	Locale
100	Nivel 9B	Root crop	-	66	1	Vessel rim/side	-	Op 57 Sub 3	JSN
101	Nivel 9B	Arrowroot	*Maranta arundinacea*	66	1	Vessel rim/side	-	Op 57 Sub 3	JSN
102	Nivel 9B	Arrowroot	*Maranta arundinacea*	66	1	Vessel rim/side	-	Op 57 Sub 3	JSN
103	Nivel 9B	Arrowroot	*Maranta arundinacea*	66	1	Vessel rim/side	-	Op 57 Sub 3	JSN
104	Nivel 9	Calathea cf.	*Calathea* sp. cf.	89	2	Grater bowl	-	Op 66 Sub 1	VN
105	Nivel 9	Arrowroot	*Maranta arundinacea*	89	3	Grater bowl	-	Op 66 Sub 1	VN
106	Nivel 15	Arrowroot cf.	*Maranta arundinacea* cf.	95	3	Stone ball	-	Op 66 Sub 1	VN
107	Nivel 15	Root crop	-	95	3	Stone ball	-	Op 66 Sub 1	VN
108	Nivel 12B	Arrowroot	*Maranta arundinacea*	116	2	Stone ball	-	Op 32 Sub 9	CN
109	Nivel 12B	Arrowroot	*Maranta arundinacea*	116	2	Stone ball	-	Op 32 Sub 9	CN
110	Nivel 12B	Arrowroot	*Maranta arundinacea*	116	2	Stone ball	-	Op 32 Sub 9	CN
111	Nivel 12B	Arrowroot	*Maranta arundinacea*	116	2	Stone ball	-	Op 32 Sub 9	CN
112	Nivel 12B	Dioscorea	*Dioscorea* sp.	116	2	Stone ball	-	Op 32 Sub 9	CN
113	Nivel 12B	Unidentified	-	116	2	Stone ball	-	Op 32 Sub 9	CN
114	Nivel 12B	Unidentified	-	116	2	Stone ball	-	Op 32 Sub 9	CN
272	266	Unidentifiable	-	57	2	Vessel base	Large trash pit	Op 57 Sub 1	JSN
273	266	Unidentifiable	-	57	2	Vessel base	Large trash pit	Op 57 Sub 1	JSN
274	266	Unidentified (damaged)	-	57	2	Vessel base	Large trash pit	Op 57 Sub 1	JSN
275	258	Unidentified (2, compound granule)	-	58	3	Vessel rim/side	Large trash pit	Op 55 Sub 2	JSN
276	278	Wild dioscorea	*Dioscorea* sp.	61	1	Mano	Large trash pit	Op 57 Sub 5	JSN
277	278	Root crop	-	61	3	Mano	Large trash pit	Op 57 Sub 5	JSN
278	278	Unidentified	-	61	3	Mano	Large trash pit	Op 57 Sub 5	JSN
279	278	Unidentified	-	61	3	Mano	Large trash pit	Op 57 Sub 5	JSN
280	278	Wild dioscorea	*Dioscorea* sp.	63	2	Vessel rim/side	Large trash pit	Op 57 Sub 5	JSN
281	278	Unidentifiable	-	64	2	Rim sherd	Large trash pit	Op 57 Sub 5	JSN
282	278	Unidentifiable	-	64	3	Rim sherd	Large trash pit	Op 57 Sub 5	JSN
284	278	Unidentifiable	-	64	3	Rim sherd	Large trash pit	Op 57 Sub 5	JSN
285	278	Unidentified	-	64	3	Rim sherd	Large trash pit	Op 57 Sub 5	JSN
286	Nivel 9B	Wild dioscorea	*Dioscorea* sp.	69	2	Figurine mouth	-	Op 57 Sub 3	JSN
287	Nivel 9B	Arrowroot	*Maranta arundinacea*	69	2	Figurine mouth	-	Op 57 Sub 3	JSN
288	Nivel 9B	Unidentified	-	69	2	Figurine mouth	-	Op 57 Sub 3	JSN
289	Nivel 9B	Arrowroot	*Maranta arundinacea*	69	2	Figurine mouth	-	Op 57 Sub 3	JSN
290	Nivel 9B	Arrowroot	*Maranta arundinacea*	69	2	Figurine mouth	-	Op 57 Sub 3	JSN
291	Nivel 9B	Unidentifiable	-	69	3	Figurine mouth	-	Op 57 Sub 3	JSN
292	269E	Dioscorea	*Dioscorea* sp.	70	2	Rim sherd	Artifact concentration	Op 57 Sub 3	JSN
293	269E	Arrowroot	*Maranta arundinacea*	70	2	Rim sherd	Artifact concentration	Op 57 Sub 3	JSN
294	271I	Xanthosoma	*Xanthosoma* sp.	71	2	Vessel rim/side	Large trash pit	Op 57 Sub 5	JSN
295	271I	Sweet potato cf.	*Ipomoea batatas* cf.	71	3	Vessel rim/side	Large trash pit	Op 57 Sub 5	JSN
296	271I	Wild calathea sp. cf.	*Calathea* sp. cf.	71	3	Vessel rim/side	Large trash pit	Op 57 Sub 5	JSN
297	269	Calathea cf.	*Calathea* sp. cf.	73	2	Figurine mouth	Artifact concentration	Op 57 Sub 3	JSN
298	269	Maize	*Zea mays*	73	3	Figurine mouth	Artifact concentration	Op 57 Sub 3	JSN
300	269	Maize cf.	*Zea mays* cf.	73	3	Figurine mouth	Artifact concentration	Op 57 Sub 3	JSN
301	269	Dioscorea	*Dioscorea* sp.	73	3	Figurine mouth	Artifact concentration	Op 57 Sub 3	JSN
302	295B	Unidentifiable	-	75	2	Grater bowl	Pit	Op 64 Sub 1	SNS

Record No.	Rasgo	Common name	Scientific name	Object No.	Sediment No.	Artifact description	Feature type	Op/Sub	Locale
303	295B	Calathea/Wild dioscorea	*Calathea* sp./*Dioscorea* sp.	75	2	Grater bowl	Pit	Op 64 Sub 1	SNS
304	295B	Calathea/Wild dioscorea	*Calathea* sp./*Dioscorea* sp.	76	1	Vessel base	Pit	Op 64 Sub 1	SNS
305	295B	Unidentified	-	76	1	Vessel base	Pit	Op 64 Sub 1	SNS
306	291A	Manioc cf.	*Manihot esculenta* cf.	78	1	Vessel base	Pit	Op 64 Sub 3	SNS
307	291A	Wild potato	*Solanum* sp.	78	3	Vessel base	Pit	Op 64 Sub 3	SNS
308	295	Bean family	Fabaceae	79	3	Vessel base	Pit	Op 64 Sub 1	SNS
309	295	Bean family	Fabaceae	79	3	Vessel base	Pit	Op 64 Sub 1	SNS
310	295E	Unidentified	-	80	2	Complete vessel	Pit	Op 64 Sub 1	SNS
312	295E	Unidentified	-	80	2	Complete vessel	Pit	Op 64 Sub 1	SNS
313	295C	Unidentified	-	82	1	Grinding stone	Pit	Op 64 Sub 1	SNS
314	295C	Unidentified	-	82	3	Grinding stone	Pit	Op 64 Sub 1	SNS
315	295C	Unidentifiable (2)	-	82	3	Grinding stone	Pit	Op 64 Sub 1	SNS
316	295C	Maize cf.	*Zea mays* cf.	82	3	Grinding stone	Pit	Op 64 Sub 1	SNS
317	295C	Maize	*Zea mays*	82	3	Grinding stone	Pit	Op 64 Sub 1	SNS
318	297	Unidentified (damaged)	-	84	2	Grinding stone	Ceramic/lithic concentration	Op 65 Sub 2	VN
320	295B	Unidentifiable (definitely torn, possibly gelatinized)	-	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
321	295B	Unidentifiable (damaged)	-	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
322	295B	Calathea/Wild dioscorea	*Calathea* sp./*Dioscorea* sp.	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
323	295B	Unidentified	-	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
324	295B	Maize cf.	*Zea mays* cf.	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
325	295B	Unidentified	-	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
326	295B	Unidentified	-	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
327	295B	Maize cf. (2)	*Zea mays* cf.	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
329	295B	Wild potato cf.	*Solanum* sp. cf.	85	3	Grinding stone	Pit	Op 64 Sub 1	SNS
330	295B	Unidentified	-	85	3	Grinding stone	Pit	Op 64 Sub 1	SNS
331	295C	Wild potato cf.	*Solanum* sp. cf.	86	2	Grinding stone	Pit	Op 64 Sub 1	SNS
332	295C	Wild potato cf.	*Solanum* sp. cf.	86	2	Grinding stone	Pit	Op 64 Sub 1	SNS
333	295C	Manioc	*Manihot esculenta*	86	3	Grinding stone	Pit	Op 64 Sub 1	SNS
334	295C	Wild potato	*Solanum* sp.	86	3	Grinding stone	Pit	Op 64 Sub 1	SNS
335	295C	Wild potato	*Solanum* sp.	86	3	Grinding stone	Pit	Op 64 Sub 1	SNS
336	299	Unidentified	-	87	2	Vessel rim/side	Offering (bowl with top)	Op 65 Sub 5	VN
337	299	Maize cf.	*Zea mays* cf.	87	2	Vessel rim/side	Offering (bowl with top)	Op 65 Sub 5	VN
338	299	Wild potato	*Solanum* sp.	87	3	Vessel rim/side	Offering (bowl with top)	Op 65 Sub 5	VN
339	Nivel 11	Unidentifiable	-	99	3	Figurine mouth	-	Op 66 Sub 1	VN
340	306	Wild potato	*Solanum* sp.	100	3	Miniature vessel	Ceramic concentration	Op 66 Sub 4	VN
342	306	Wild potato cf.	*Solanum* sp. cf.	100	3	Miniature vessel	Ceramic concentration	Op 66 Sub 4	VN
343	308	Maize	*Zea mays*	106	2	Metate	Ceramic concentration	Op 66 Sub 3	VN
344	308	Manioc cf.	*Manihot esculenta* cf.	106	3	Metate	Ceramic concentration	Op 66 Sub 3	VN
345	308	Unidentified	-	107	2	Metate	Ceramic concentration	Op 66 Sub 3	VN
346	308	Root crop	-	107	2	Metate	Ceramic concentration	Op 66 Sub 3	VN
347	312	Unidentified	-	108	2	Stone ball	Ceramic concentration	Op 66 Sub 3	VN
348	325E	Unidentified	-	111	2	Vessel rim/side	Ceramic concentration	Op 67 Sub 3	VN
349	325E	Unidentified	-	111	2	Vessel rim/side	Ceramic concentration	Op 67 Sub 3	VN
350	325E	Unidentified	-	111	2	Vessel rim/side	Ceramic concentration	Op 67 Sub 3	VN

Record No.	Rasgo	Common name	Scientific name	Object No.	Sediment No.	Artifact description	Feature type	Op/Sub	Locale
351	324	Root crop	-	112	1	Metate	Lithic concentration	Op 66 Sub 3	VN
352	324	Wild dioscorea	*Dioscorea* sp.	112	1	Metate	Lithic concentration	Op 66 Sub 3	VN
353	324	Calathea	*Calathea* sp.	112	1	Metate	Lithic concentration	Op 66 Sub 3	VN
355	326B	Unidentified	-	113	3	Miniature mano	Ceramic concentration	Op 66 Sub 3	VN
356	326B	Unidentified	-	113	3	Miniature mano	Ceramic concentration	Op 66 Sub 3	VN
358	97	Unidentifiable	-	131	3	Human face vessel	Ceramic concentration	Op 34 Sub 2	CN
360	97	Arrowroot	*Maranta arundinacea*	131	3	Human face vessel	Ceramic concentration	Op 34 Sub 2	CN
361	97	Unidentified (14)	-	131	3	Human face vessel	Ceramic concentration	Op 34 Sub 2	CN
362	97	Unidentified (28 estimated granules)	-	131	3	Human face vessel	Ceramic concentration	Op 34 Sub 2	CN
363	Nivel 16	Maize cf.	*Zea mays* cf.	137	3	Jaguar face vessel	-	Op 32 Sub 4	CN
364	240P	Unidentified	-	139	2	Sherd	Intrusive pit	Op 50 Sub 3	SAN
365	240P	Arrowroot	*Maranta arundinacea*	139	2	Sherd	Intrusive pit	Op 50 Sub 3	SAN
366	Nivel 5	Unidentified	-	143	2	Jaguar face vessel	-	Op 32 Sub 3	CN
367	Nivel 5	Arrowroot cf.	*Maranta arundinacea* cf.	143	2	Jaguar face vessel	-	Op 32 Sub 3	CN
369	240K	Unidentifiable	-	145	3	Sherd	Intrusive pit	Op 50 Sub 3	SAN
370	266A	Unidentified	-	47	2	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
371	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
372	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
373	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
374	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
376	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
377	266A	Arrowroot (1) & Unidentified, damaged (1)	*Maranta arundinacea*	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
378	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
379	266A	Dioscorea	*Dioscorea* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
380	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
381	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
383	266A	Arrowroot (1) & Unidentified (numerous)	*Maranta arundinacea* & -	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
384	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
386	266A	Wild potato (1) & Wild potato cf. (2)	*Solanum* sp. & *Solanum* sp. cf.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
387	266A	Wild potato cf. (2) & Unidentified	*Solanum* sp. cf. & -	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
388	266A	Root crop (4)	-	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
389	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
390	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
391	266A	Wild potato	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
392	266A	Unidentified	-	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
393	266A	Unidentifiable, many are heat damaged (22)	-	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
394	97	Unidentified (12 granules minimum)	-	131	3	Human face vessel	Ceramic concentration	Op 34 Sub 2	CN
395	97	Unidentified (35+ estimated granules)	-	131	3	Human face vessel	Ceramic concentration	Op 34 Sub 2	CN
396	266A	Wild potato (9)	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
397	266A	Wild potato (7)	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
398	266A	Unidentified (6)	-	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
399	266A	Wild potato (2)	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
400	266A	Wild potato (4)	*Solanum* sp.	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
401	266A	Unidentified (4)	-	47	1	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN

Record No.	Rasgo	Common name	Scientific name	Object No.	Sediment No.	Artifact description	Feature type	Op/Sub	Locale
429	271I	Unidentified (bell-shaped)	-	71	2	Vessel rim/side	Large trash pit	Op 57 Sub 5	JSN
430	295B	Unidentified	-	85	2	Grinding stone	Pit	Op 64 Sub 1	SNS
431	324	Calathea	*Calathea* sp.	112	1	Metate	Lithic concentration	Op 66 Sub 3	VN
432	Nivel 5	Arrowroot cf.	*Maranta arundinacea* cf.	143	2	Jaguar face vessel	-	Op 32 Sub 3	CN
433	Nivel 5	Arrowroot cf.	*Maranta arundinacea* cf.	143	2	Jaguar face vessel	-	Op 32 Sub 3	CN

APPENDIX G: BASIC CHARACTERISTICS OF IDENTIFIED PHYTOLITHS

Record Number	Rasgo	Common name	Object No.	Sediment No.	Artifact description	Feature type	Op/Sub	Locale
402	266A	Unidentified	47	2	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
403	266A	Unidentfied	47	2	Plate rim sherd	Large trash pit	Op 57 Sub 1	JSN
404	240X	Palm family	49	2	Stone ball	Intrusive pit	Op 50 Sub 3	SAN
405	255D	Unidentified	50	3	Bowl rim/base	Large trash pit	Op 55 Sub 4	JSN
434	255D	Unidentified	50	3	Bowl rim/base	Large trash pit	Op 55 Sub 4	JSN
406	254	Unidentfied	56	3	Stone ball	Floor	Op 50 Sub 3	SAN
407	258	Unidentified	58	2	Vessel rim/side	Large trash pit	Op 55 Sub 2	JSN
408	258	Unidentfied (epidermal platelet)	58	2	Vessel rim/side	Large trash pit	Op 55 Sub 2	JSN
409	278	Sedge family cf.	61	1	Mano	Large trash pit	Op 57 Sub 5	JSN
410	278	Unidentfied	61	3	Mano	Large trash pit	Op 57 Sub 5	JSN
411	278	Grass family (wavy top rondel)	61	3	Mano	Large trash pit	Op 57 Sub 5	JSN
412	278	Unidentified	62	1	Grinding stone	Large trash pit	Op 57 Sub 5	JSN
413	269E	Palm family	70	3	Rim sherd	Artifact concentration	Op 57 Sub 3	JSN
414	269E	Grass family (cross body)	70	3	Rim sherd	Artifact concentration	Op 57 Sub 3	JSN
415	269E	Unidentified	70	3	Rim sherd	Artifact concentration	Op 57 Sub 3	JSN
416	295B	Unidentfied	75	3	Grater bowl	Pit	Op 64 Sub 1	SNS
417	295B	Unidentified	75	3	Grater bowl	Pit	Op 64 Sub 1	SNS
418	303	Grass family (short cell, bilobate)	97	2	Stone ball	Burnt floor	Op 66 Sub 1	VN
419	303	Palm family	97	2	Stone ball	Burnt floor	Op 66 Sub 1	VN
420	303	Unidentified	97	2	Stone ball	Burnt floor	Op 66 Sub 1	VN
421	308	Unidentified	106	3	Metate	Ceramic concentration	Op 66 Sub 3	VN
422	312	Unidentified	108	3	Stone ball	Ceramic concentration	Op 66 Sub 3	VN
423	314	Unidentified	110	3	Metate	Ceramic concentration	Op 66 Sub 5	VN
424	325E	Unidentified (amorphous silica/epidermal)	111	1	Vessel rim/side	Ceramic concentration	Op 67 Sub 3	VN
425	335	Grass family (wavy top rondel)	114	1	Mortar	Floor	Op 37 Sub 8	CN
426	240P	Unidentified (silicified tracheid/epidermal)	139	2	Sherd	Intrusive pit	Op 50 Sub 3	SAN
427	240P	Manioc secretory cell cf.	139	2	Sherd	Intrusive pit	Op 50 Sub 3	SAN

APPENDIX H: OXCAL CODE FOR BAYESIAN MODELS

Contiguous Model

```
Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
   Sequence()
   {
    Boundary("Start of Conchas C");
    Phase( )
    {
     R_Date ("UCIAMS255119, Op32 Sub4 N19", 2745, 15);
     R_Date ("UCIAMS255120, Op32 Sub6 N16", 2750, 15);
     R_Date ("UCIAMS255121, Op32 Sub6 N17", 2725, 15);
     R_Date ("AA-75405, Op36 R125A", 2688, 36)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("AA-75404, Op36 R127A", 2678, 39)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("AA-75409, Op37 R142", 2703, 36)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("UCIAMS182750, Op50 Sub1 R226", 2740, 15)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("UCIAMS182747, Op50 Sub1 R226", 2760, 15)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("UCIAMS182751, Op50 Sub1 R226", 2760, 15)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("UCIAMS182748, Op50 Sub1 R226", 2790, 15)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("UCIAMS182753, Op50 Sub1 R240J", 2710, 15)
     {
```

```
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182755, Op50 Sub3 R240I", 2760, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182754, Op50 Sub3 R240M", 2775, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS255128, Op65 Sub5 R305", 2750, 15);
 Interval( "Duration of Conchas C");
};
Boundary ( "Conchas C - D");
Phase ( )
{
 R_Date ("AA-75406, Op34 R83", 2688, 36)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182749, Op50 Sub1 R266", 2755, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS255124, Op55 Sub2 R245A", 2755, 15);
 R_Date ("UCIAMS182758, Op55 Sub4 R255J", 2540, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182759, Op55 Sub4 R255K", 2545, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182760, Op55 Sub4 R255L", 3105, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182763, Op57 Sub1 R266", 2690, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS255126, Op57 Sub1 R266A", 2715, 15);
 R_Date ("UCIAMS182765, Op57 Sub1 R266C", 2645, 20)
 {
  Outlier("Charcoal", 1);
 };
```

```
    R_Date ("UCIAMS182762, Op57 Sub1 R264", 2480, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS255134, Op67 Sub3 R325", 2605, 15);
    R_Date ("UCIAMS255135, Op67 Sub3 R325C", 2590, 15);
    Interval( "Duration of Conchas D");
   };
   Boundary( "End of Conchas D");
  };
 };
};
```

Sequential Model

```
Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
  Sequence()
  {
   Boundary("Start of Conchas C");
   Phase( )
   {
    R_Date ("UCIAMS255119, Op32 Sub4 N19", 2745, 15);
    R_Date ("UCIAMS255120, Op32 Sub6 N16", 2750, 15);
    R_Date ("UCIAMS255121, Op32 Sub6 N17", 2725, 15);
    R_Date ("AA-75405, Op36 R125A", 2688, 36)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("AA-75404, Op36 R127A", 2678, 39)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("AA-75409, Op37 R142", 2703, 36)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182750, Op50 Sub1 R226", 2740, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182747, Op50 Sub1 R226", 2760, 15)
    {
     Outlier("Charcoal", 1);
```

```
 };
 R_Date ("UCIAMS182751, Op50 Sub1 R226", 2760, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182748, Op50 Sub1 R226", 2790, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182753, Op50 Sub1 R240J", 2710, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182755, Op50 Sub3 R240I", 2760, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182754, Op50 Sub3 R240M", 2775, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS255128, Op65 Sub5 R305", 2750, 15);
 Interval( "Duration of Conchas C");
};
Boundary ( "End Conchas C");
Interval ( "Conchas C - D");
Boundary ( "Start Conchas D");
Phase ( )
{
 R_Date ("AA-75406, Op34 R83", 2688, 36)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182749, Op50 Sub1 R266", 2755, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS255124, Op55 Sub2 R245A", 2755, 15);
 R_Date ("UCIAMS182758, Op55 Sub4 R255J", 2540, 15)
 {
  Outlier("Charcoal", 1);
 };
 R_Date ("UCIAMS182759, Op55 Sub4 R255K", 2545, 15)
 {
  Outlier("Charcoal", 1);
 };
```

```
   R_Date ("UCIAMS182760, Op55 Sub4 R255L", 3105, 15)
   {
    Outlier("Charcoal", 1);
   };
   R_Date ("UCIAMS182763, Op57 Sub1 R266", 2690, 15)
   {
    Outlier("Charcoal", 1);
   };
   R_Date ("UCIAMS255126, Op57 Sub1 R266A", 2715, 15);
   R_Date ("UCIAMS182765, Op57 Sub1 R266C", 2645, 20)
   {
    Outlier("Charcoal", 1);
   };
   R_Date ("UCIAMS182762, Op57 Sub1 R264", 2480, 15)
   {
    Outlier("Charcoal", 1);
   };
   R_Date ("UCIAMS255134, Op67 Sub3 R325", 2605, 15);
   R_Date ("UCIAMS255135, Op67 Sub3 R325C", 2590, 15);
   Interval( "Duration of Conchas D");
  };
  Boundary( "End of Conchas D");
 };
};
```

Overlapping Model

```
Plot()
 {
  Outlier_Model("Charcoal",Exp(1,-10,0),U(0,3),"t");
  Phase("Mid-Late Conchas")
  {
   Sequence()
   {
    Boundary("Start of Conchas C");
    Phase( )
    {
     R_Date ("UCIAMS255119, Op32 Sub4 N19", 2745, 15);
     R_Date ("UCIAMS255120, Op32 Sub6 N16", 2750, 15);
     R_Date ("UCIAMS255121, Op32 Sub6 N17", 2725, 15);
     R_Date ("AA-75405, Op36 R125A", 2688, 36)
     {
      Outlier("Charcoal", 1);
     };
     R_Date ("AA-75404, Op36 R127A", 2678, 39)
```

```
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("AA-75409, Op37 R142", 2703, 36)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182750, Op50 Sub1 R226", 2740, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182747, Op50 Sub1 R226", 2760, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182751, Op50 Sub1 R226", 2760, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182748, Op50 Sub1 R226", 2790, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182753, Op50 Sub1 R240J", 2710, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182755, Op50 Sub3 R240I", 2760, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS182754, Op50 Sub3 R240M", 2775, 15)
  {
   Outlier("Charcoal", 1);
  };
  R_Date ("UCIAMS255128, Op65 Sub5 R305", 2750, 15);
  Interval( "Duration of Conchas C");
 };
 Boundary ( "End of Conchas C");
};
Sequence()
{
 Boundary( "Start of Conchas D");
 Phase ( )
 {
  R_Date ("AA-75406, Op34 R83", 2688, 36)
```

```
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182749, Op50 Sub1 R266", 2755, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS255124, Op55 Sub2 R245A", 2755, 15);
    R_Date ("UCIAMS182758, Op55 Sub4 R255J", 2540, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182759, Op55 Sub4 R255K", 2545, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182760, Op55 Sub4 R255L", 3105, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182763, Op57 Sub1 R266", 2690, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS255126, Op57 Sub1 R266A", 2715, 15);
    R_Date ("UCIAMS182765, Op57 Sub1 R266C", 2645, 20)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS182762, Op57 Sub1 R264", 2480, 15)
    {
     Outlier("Charcoal", 1);
    };
    R_Date ("UCIAMS255133, Op67 Sub1 R327B", 2780, 15);
    R_Date ("UCIAMS255134, Op67 Sub3 R325", 2605, 15);
    R_Date ("UCIAMS255135, Op67 Sub3 R325C", 2590, 15);
    Interval( "Duration of Conchas D");
   };
   Boundary( "End of Conchas D");
  };
 };
};
```

APPENDIX I: MEAN COUNTS OF MACROBOTANICAL CATEGORIES ORGANIZED BY NEIGHBORHOOD AND PHASE

Field Crops					
Locale	Conchas B/C	Conchas C	Conchas C or D	Conchas D	Conchas E
CN	-	10.000	-	17.500	-
SAN	-	24.667	-	8.000	-
JNN	-	-	-	0.500	3.250
JSN	-	6.500	12.333	11.357	-
VN	1.000	28.000	-	93.000	-
Maize					
Locale	Conchas B/C	Conchas C	Conchas C or D	Conchas D	Conchas E
CN	-	10.000	-	17.500	-
SAN	-	24.667	-	8.000	-
JNN	-	-	-	0.500	3.250
JSN	-	6.500	11.667	11.357	-
VN	1.000	28.000	-	92.500	-
Maize Kernel					
Locale	Conchas B/C	Conchas C	Conchas C or D	Conchas D	Conchas E
CN	-	10.000	-	17.000	-
SAN	-	23.833	-	6.000	-
JNN	-	-	-	0.500	3.000
JSN	-	6.500	11.333	10.500	-
VN	1.000	28.000	-	92.000	-
Maize Cupule					
Locale	Conchas B/C	Conchas C	Conchas C or D	Conchas D	Conchas E
CN	-	0.000	-	0.500	-
SAN	-	0.833	-	2.000	-
JNN	-	-	-	0.000	0.250
JSN	-	0.000	0.333	0.857	-
VN	0.000	0.000	-	0.500	-
Tree Crops					
Locale	Conchas B/C	Conchas C	Conchas C or D	Conchas D	Conchas E
CN	-	1.500	-	5.500	-
SAN	-	4.667	-	0.000	-
JNN	-	-	-	0.000	0.000
JSN	-	1.500	71.333	1.214	-
VN	0.000	0.500	-	1.000	-

Note : Mean count = count / # of features in that neighborhood dating to the chosen temporal context.