Investigating food plant dynamics in household features from the Amerindian site El Flaco (11th to 15th century), Dominican Republic: macrobotanical and phytolith remains speaks out

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1. Introduction

When the Europeans first arrived in the Caribbean, the indigenous people exploited a lot of different plant taxa to satisfy their subsistence needs (Pagán-Jiménez 2007, 48-58; Las Casas 1909). The botanical knowledge of these people was the product of millennia of interactions between humans and plants that also involved a fusion of multiple older botanical traditions that originated from different source areas (Newsom 2008, 173). The relationships between humans and plants could take many forms. Caribbean indigenous peoples exploited a lot of different plant taxa for food, fuel, medicine, or for ritual activities. Moreover, there was a certain human-plant interdependency. Seasonal plant availability could affect settlement systems, and humans had strong impacts on vegetations and ecologies (Pearsall 2000, 2).

At the time of European contact, a variety of plant taxa was managed in multifunctional home gardens, in forest' agricultural plots and sometimes in huge fields full of agricultural *montones* or mounds (Fernández de Oviedo 1851; Rouse 1992). In these places, combinations of exotic and native crops, quasi-domesticates or cultivars, and other plant taxa were incorporated that were used as food or for producing other products. The indigenous Caribbean people depended on both managed and wild plant resources for their survival. They developed specialised strategies to locate, exploit, and maintain these resources. It seems obvious that the native ethnobotany played a fundamental role in the Amerindian Caribbean' cultural and ecological dynamics. Therefore, it is essential to understand the importance and the roles that plant resources had in the various indigenous societies of the Caribbean in order to understand the cultural and ecological dynamics surrounding Amerindian's ancient subsistence systems (Newsom 2008, 173).

Paleoethnobotany is the scientific field that can be used to study the Caribbean's indigenous ethnobotany. Some authors consider paleoethnobotany as a sub-field within the field of ethnobotany that studies archaeological plant remains, such as macroremains, pollen, starch grains, and phytoliths, in order to elucidate human-plant interactions (Pearsall 2000, 2). Currently, paleoethnobotany is considered as a frontier scientific field between archaeology and botany, nurturing from both disciplines to bring to light unique research problems and explanations on the multifaceted interrelationships amongst ancient peoples and plants (Pagán-Jiménez 2015, 1-5). So, in the regional context of this study, paleoethnobotany 'is the means to discover the deep history of the myriad interactions between particular groups of Caribbean islanders and their local floras, providing an idea of the developmental pathways and processes behind plant-use traditions, as well as some of the elements inherent in human-landscape dynamics at any number of scales' (Newsom 2008, 174). It is essential to combine the different paleoethnobotanical techniques since they can provide data that are complementary to each other. By using multiple lines of evidence, the paleoethnobotanical interpretations become stronger (Pearsall 2000, 9). Due to the scientific performance of paleoethnobotany, we now have a more complete understanding of the ancient ethnobotany of Caribbean peoples in various places and at various times. "The next challenge, as we continue to build on the archaeobotanical database, is to provide a clearer spatial and temporal framework of understanding, on a regional, subregional, and island-by-island basis" (Newsom 2008, 181; see also Pagán-Jiménez 2007, 2013).

The international ERC-synergy research project NEXUS1492 lead from the Faculty of Archaeology at Leiden University has been investigating the impacts of colonial encounters and invasions after the European arrival into the Caribbean. The NEXUS 1492 project has two main objectives. The first objective is to help to build new perspectives on the initial clashes and encounters between the Old and the New World. This is being done by investigating, from dynamic multi-disciplinary perspectives, the histories of the indigenous Caribbean peoples across the historical divide. Importantly, the complex webs of interaction created by the different cultures are addressed to better understand the emergence and consolidation of multiple indigenous identities in the region. The second objective of the project is to raise awareness of Caribbean histories and legacies. To reach this objective, international scholars from the Caribbean and abroad, together with local communities, are being involved in the research agenda. Furthermore, a joint heritage agenda will be designed so that historical awareness would be raised on local, regional, and global scales (European Research Council 2013, 39; www.universiteitleiden.nl).

El Flaco is an archaeological site located in the northwestern part of the Dominican Republic and has been excavated by the NEXUS 1492 project. El Flaco is a precolonial hamlet that has been occupied between the 10th to 15th centuries AD. The site consists primarily out of multifunctional mounds and flattened living areas where large house structures used to stand (Hofman *et al*. 2018, 210-211). The mounds were used for both domestic and ritual activities. They were used as waste deposits, and kitchen floors, but also as extensions of other household activities and for burying the dead (Hofman *et al*. 2018, 211).

With the excavation of El Flaco, one of the goals of the NEXUS 1492 project is to gain new information about the human-plant dynamics of the site. As stated earlier, one of such dynamics, probably the most important one, was the exploitation of plants for food. One way of investigating this is to conduct paleoethnobotanical analysis on hearth features in which food plants, fuel plants, and plant foods were processed, cooked and consumed in different ways. During the excavation of El Flaco, soil samples from multiple hearth features were sampled for macrobotanical and microbotanical analysis, together with the collection and sampling of artefacts for further residue and starch grain analyses.

In this thesis, macrobotanical and phytolith analyses have been conducted on five hearth features from El Flaco. This was done to answer the following research question: *which food plants could have been part of the diet of the former inhabitants of El Flaco?* The results of this research can help to better understand the importance and the role of certain food plant sources in Caribbean indigenous societies. This, in turn, could help gain new knowledge on ancient Caribbean's cultural and ecological dynamics. Moreover, the results here produced can be used by the NEXUS 1492 project to produce new insights in the ways that food plant access and potential foodstuffs changed across the historical divide by comparing them with results from similar studies of sites that were occupied after the European arrival.

The research of this thesis is also used to answer two sub-questions. The first question is: *are there significant differences between hearth features?* This question is being asked to see if certain hearths were used for different purposes, for example, to see if they were exclusively used for the processing of one type of food plant derivatives. The second sub-question is: *is macrobotanical analysis a useful technique in the Neotropics?* Macrobotanical remains are generally poorly preserved in the Neotropics, due to the switching environmental and weather conditions. They can, however, be preserved as charred remains in various cultural features of ancient sites, which is the case with the samples obtained from hearth features (Pagán-Jiménez 2002; Piperno and Pearsall 1998, 33). Nevertheless, this type of preservation leads to certain biases and problems that will be discussed later.

In this thesis, firstly, an overview of the archaeological background of the Greater Antilles is presented. Then, what is currently known about the precolonial site El Flaco is described in the third chapter. After that, the methods and techniques that have been applied as part of the research of this thesis are explained in chapter four. Then, the fifth chapter is devoted to the exposition of the results of this study by using mainly graphs and tables. Chapter six is dedicated to the discussion of the results, and to the answering of the research questions.

2. Archaeological background

This section describes the archaeological background for the Greater Antilles to place the ancient hamlet of El Flaco and its inhabitants within the broader context of the region. The main archaeological model used for the pre-Columbian history of the Caribbean islands is the one devised by Irving Rouse (Rouse 1992). This model was created in the mid-twentieth century and continues to be the foundation for most Caribbean archaeology (Rodríguez Ramos 2010, 4). Rouse created a spatiotemporal framework for the Caribbean based on pottery and other artefacts and radiocarbon dates. Rouse divided the prehistory of the Caribbean in the Lithic, Archaic, and Ceramic ages. Sites with flaked stone tools were part of the Lithic Age, and sites with pecked and ground stone tools and shell artefacts were Archaic sites. The different ages were further subdivided into series (Casimiroid, Ortoiroid, Saladoid, Ostionoid, and Troumassoid). This is a concept that "not only presupposes parallel lines of development but also a singular point of emergence" (Rodríguez Ramos 2010, 13-14). Series are then subdivided into subseries, which are further fragmented into styles. These styles are grouped in general periods (I, II, III, and IV) based on patterns in lithic and ceramic collections and their distribution. These periods were dated using the then available sample of radiocarbon dates (Rodríguez Ramos 2010, 14).

Rodríguez Ramos (2010) has demonstrated that the phylogenetic relationships and temporality of the assumed cultural and social changes in Rouse's model are not supported by the current archaeological data in the Caribbean. Rodríguez Ramos has analysed evidence from Puerto Rico and discovered that various pottery styles coexisted in the different periods of Rouse's model. One requirement of the periods defined by Rouse was their geographical and chronological homogeneity, which this new evidence contradicts (Rodríguez Ramos 2010, 211). Furthermore, Rouse connected social shifts with changes in ceramic styles. However, current evidence shows that changes in pottery styles did not always coincide with societal changes. Moreover, the displacement of the Archaic people by later immigrants is seen as a unidirectional phenomenon in Rouse's model, but the current evidence indicates more symmetrical interactions between those groups that were mutually influential (Rodríguez Ramos 2010, 213).

2.1 The first inhabitants

The first evidence for the presence of humans in the Caribbean at the moment is found at both ends of the archipelago in Trinidad and Cuba. This suggests that there were more than one migration pulses with different origins (Rodríguez Ramos *et al*. 2013, 127). The oldest known archaeological evidence of human occupation in the Caribbean is found at the sites Banwari Trace and St. John in Trinidad. The earliest level of occupation at the Banwari Trace site is dated to circa 5800-5900 BC, and the oldest dates from St. John range between 5790-5760 BC (Tankersley *et al*. 2018, 681; Pagán-Jiménez *et al*. 2015, 232), The earliest archaeological site in Cuba is Canímar Abajo which dates to between circa 4500 and 2700 BC. The oldest evidence for human occupation in the Greater Antilles (besides Cuba) has been found at the site Angostura in Puerto Rico which dates to approximately 4000 BC (Rodriguez Ramos *et al*. 2013, 127).

The sites mentioned above are the earliest evidence for human occupation in the Caribbean, but the Greater Antilles and the northern Lesser Antilles become more densely occupied between 3500 and 2500 BC. Between 2500 and 500 BC, there is an increase in human occupation of the Greater and Lesser Antilles. There are high degrees of variability in the technological organisation and subsistence patterns through time and between islands. This indicates "the great levels of cultural and social plurality that existed and the various forms of adaption to the environmental diversity that were registered by the peoples that inhabited the islands" (Rodrigues Ramos *et al*. 2013, 128).

There are multiple possible source regions for the origins of the early inhabitants of the Caribbean. The Yucatan Peninsula and northeastern South America are the most accepted possibilities. The Yucatan Peninsula has been suggested due to similarities in stone tool technology found in that area and the technology found in Cuba and Hispaniola. Northeastern South America is suggested as the origin of the early colonizers of Trinidad, the Lesser Antilles, and Puerto Rico based on similarities in artefact assemblages. However, there is insufficient evidence that people migrated northward from Trinidad into the Lesser Antilles and Puerto Rico during the earliest phase of the occupation of Trinidad (Rodríguez Ramos 2013, 130).

Another suggested migration source for the early colonisers of Puerto Rico, Hispaniola, and the Virgin Islands is the Isthmo-Colombian area. This area is suggested due to marked similarities in the lithic and botanical assemblages between these areas (Rodríguez Ramos *et al.* 2013, 130). The Yucatan Peninsula is more generally accepted as the migration source of Hispaniola and Puerto Rico. However, many aspects of archaeological assemblages found in the Yucatan Peninsula are not found in Puerto Rico or Hispaniola (Hofman *et al*. 2018b, 85). The southeastern United States has also been proposed as a possible source area for the early inhabitants of the Greater Antilles based on similarities in the microlith traditions of these areas (Rodríguez Ramos 2013, 130).

As stated previously, in Rouse's model, a distinction is made between the Lithic Age and the Archaic Age based on differences in stone tool assemblages. The populations of these periods were traditionally seen as preceramic preagricultural foragers (Keegan 1994, 270). Rodríguez Ramos *et al*. (2013, 132) argue that it is not useful to make a distinction between the Lithic Age and Archaic Age and that there never was a Lithic Age. Moreover, there is clear evidence that the initial settlers of the islands already cultivated plants and ceramics have been found at several Archaic Age sites. This makes it difficult to assign these populations to an Archaic category (Rodríguez Ramos *et al*. 2013, 132-133).

The early Caribbean populations did not develop without external influences. They developed local networks and maintained social relationships with their continental place of origin (Hofman *et al*. 2018b, 71). There were also complex 'maritime webs of interaction that promoted the movement of products and ideas between individuals and social factions within and between islands, as well as with surrounding continents' (Rodríguez Ramos *et al*. 2013, 134).

The initial colonisation of the Caribbean coincides temporally with the spread of domesticated plants in Central and South America. At the St. John site in Trinidad, several domestic plants, cultivars, and wild plants have been identified, such as maize, chili pepper, sweet potato, achira, marunguey, wild ginger, wild yam, jack bean, bean, and possibly wild arrowroot. Later archaeological sites that date between 2430 and 1500 BC have yielded an even wider assemblage of domesticated plants, cultivars and wild plants (Pagán-Jiménez *et al*. 2019, 89-102). The current evidence shows that important continental plants were translocated and introduced from the continental mainland and later dispersed within many of the Caribbean islands (Pagán-Jiménez 2013, 397). This translocation of domestic plants and other cultivars could have served to reduce the risk of migrating to an unknown and possibly initially hostile environment (Pagán-Jiménez *et al*. 2019, 105).

Another indication for early plant cultivation is an increase in fires that have been observed in Puerto Rico, which is a possible indication for the development of slash-and-burn agricultural systems (Pagán-Jiménez 2013, 395). Evidence for some exotic arboreal taxa and some grasses suggest the development of arboriculture and home gardens. There is not enough data to suggest that these plants were the food staples, but some of them were systematically produced. Various production systems could have been used by the early inhabitants, such as horticulture, agriculture, and gathering (Pagán-Jiménez 2013, 395-398). Pagán-Jiménez (2013, 398) argues that these production systems "need to be accepted as interconnected/joint systems that functioned with great variability within a single settlement, according to environmental and social factors."

2.2 The Ceramic Age

Rouse (1992, 32-33) saw the Ceramic Age as a process of continuous divergence from a single ancestral culture that resulted in the Taíno people who greeted Columbus. The ceramic styles that this ancestral culture made were labelled under the Saladoid series. These Saladoid peoples supposedly originated from the Orinoco Valley and reached the West Indies between AD 400-250. In Rouse's model, the Saladoid series developed into the Ostionoid series around AD 600, which is also the pottery that the Taínos eventually made (Rouse, 32-33). According to Rouse, the early "Archaic" inhabitants discussed in the previous section were rapidly replaced or acculturated by the new migrating Cedrosan Saladoids. These new populations supposedly brought agriculture, ceramics, and a sedentary lifestyle to the nomadic bands of hunter-gatherers. However, as stated previously, plant cultivation and pottery were already present before the Saladoid migrations (Oliver 2009, 9).

Rouse thought that the Archaic hunter-gatherers did not contribute anything to the development of the eventual Taíno culture. However, Oliver (2009, 11) argues that these "Archaic" or pre-Arawak population did contribute substantially to the social configurations, cultural patterns, and the material culture of the cultures and societies that were encountered by Columbus. The "Archaic" populations persisted until at least 400 AD. This means that these groups coexisted with Cedrosan Saladoid groups for at least eight centuries (Oliver 2009, 11).

2.2.1 Saladoid and Huecoid

Around 400 BC, a new migration of agricultural ceramic making people entered the Caribbean. These pottery-making communities migrated from the upper Amazon into Puerto Rico and the northern Lesser Antilles, where they interacted with the "Archaic" populations (Keegan and Hofman 2016, 51). Rouse (1992) labelled the ceramics made by these groups the Saladoid series and identified two subseries: the Cedrosan Saladoid and Huecan Saladoid.

However, Oliver (2009, 12) argues that the Saladoid subseries should be treated as two separate and distinct ceramic series: Saladoid (400 BC-AD 500) and Huecoid (190 BC-AD 500). There are clear differences in superstructural practices, lithic technology, and pottery decoration styles between the two series that point to separate origins or developmental history (Rodríguez Ramos 2010, 146). Saladoid pottery is typically distinguished by white-on-red painted designs, while the Huecoid pottery has zone incised decoration (Keegan and Hofman 2016, 51; Oliver 2009, 12). There are also apparent differences in the lithic technology between the Saladoid and Huecoid that seems to be the result of different degrees of social interactions with the coexisting "Archaic" populations. Moreover, Oliver (2009, 12) argues that "the subsequent Ostionoid societies of Puerto Rico emerged as a result of such culturally and socially plural interactions." The Ostionoid series were not the result of a linear development out of the Cedrosan Saladoid series, but it was the result of complex interactions and exchanges between the "Archaic" population and the Saladoid and Huecoid peoples (Oliver 2009, 15).

The new immigrants lived in large sedentary villages with a coastal orientation that were occupied for centuries. These villages consisted of large houses that were arranged around a central plaza that served, in many cases, like a cemetery. The plazas were also a ritual place where communal shamanistic ceremonies took place (Keegan 2000, 141-144). It was traditionally thought that these were the first sedentary communities in the Caribbean. However, there is evidence of postholes in Puerto Rico that might indicate semi-permanent "Archaic" dwelling structures. Moreover, some "Archaic" sites also have burial grounds, which suggests a higher degree of sedentism (Oliver 2009, 16).

Rouse (1992, 58) described the "Archaic" societies as bands of hunter-gatherers or foragers. The new colonists supposedly introduced agriculture to the Caribbean island. However, the migrating Cedrosan Saladoid populations would encounter populations that had already developed a cultivation system, even though a large part of their subsistence economy consisted of hunting, fishing, and gathering. The Cedrosan Saladoid populations most likely incorporated cultivars of the "Archaic" peoples into their suite of plants, and vice versa (Oliver 2009, 16). Paleoethnobotanical evidence suggests that the agricultural systems of the Huecoid and Saladoid communities are similar to subsistence systems in tropical forest environments, such as horticulture, arboriculture, and home gardens. However, there is not enough evidence to determine if more intensive forms of agriculture were used, such as artificial field and/or slash-and-burn agriculture (Pagán-Jiménez 2007, 54).

Based on paleoethnobotanical data, root crops seem to have remained the most important part of the indigenous diets throughout the Ceramic Age and into the contact era (Newsom 2008, 181). Moreover, it was long thought that manioc was the staple crop for the Saladoid and Huecoid communities and the subsequent precolonial peoples. However, recent paleoethnobotanical studies have shown that the presence of manioc is extremely scarce in Caribbean contexts (Pagán-Jiménez 2013, 399).

2.2.2 Ostionoid

According to Rouse (1992), around AD 600, the Ostionoid series developed in Puerto Rico entirely from the Cedrosan Saladoid subseries. The Cedrosan Saladoid subseries diverged into the Elenan Ostionoid subseries in the eastern part of Puerto Rico and the Ostionan Ostionoid subseries in the west according to Rouse's model, and in northwestern Hispaniola into the Meillacan Ostionoid subseries (Oliver 2009, 18; Rodríguez Ramos 2010, 145). However, the late Saladoid culture completely overlaps with the early styles of the Ostionoid series. Moreover, there never was a homogenous Cedrosan Saladoid ancestry from which the Ostionoid supposedly developed. The Ostionoid series rather stemmed from a plurality of sources that resulted from complex forms of exchanges and interactions between Cedrosan Saladoid, Huecoid, and "Archaic" groups (Oliver 2009, 15-17).

Around AD 500-700, noticeable changes occurred in settlement patterns, material culture, and demography in Puerto Rico, and probably also in the adjacent islands. During this time "new identities began to be forged within the island [Puerto Rico] while others continued to be reproduced and reformulated in a context thus characterised by cultural and social plurality rather than homogeneity" (Rodríguez Ramos 2010, 146). Ostionoid settlements continued to be coastal oriented, but new settlements were also established in large interior valleys and in the interior high mountainous region (Keegan and Hofman 2018, 148; Oliver 2009, 19). At this time, there were also changes in the regional interaction spheres. There was a shift from the production and trade of shiny raw materials and finished personal adornments towards the exchange of objects of social hierarchy and/or ethnic identity. "These changes signal marked alterations in the ideological and economic structures upon which those interactions were articulated previously in Puerto Rico, the Antilles, and the Greater Caribbean" (Rodríguez Ramos 2010, 146).

Between AD 700-1200, considerable changes in all spheres of Caribbean society and culture are taking place. At the beginning of the Ostionoid period, houses were still large, but in the end, most sites show that their size had decreased to a capacity for nuclear families. Stone-lined plazas replaced the communal ceremonial plaza from Saladoid settlements (Keegan 2000, 151-153). The stones that demarcated the new rectangular court areas were limestone or metavolcanic monoliths which were often decorated with petroglyphs (Oliver 2009, 19) However, most of the stone-lined plazas are located in Puerto Rico, and some in southeastern Hispaniola, and most of what is known about the Ostionoid period comes from Puerto Rico (Keegan and Hofman 2016, 138).

The public plazas in Hispaniola (except the southeast), Cuba, and Jamaica were not quadrangular or rectangular plazas demarcated with monoliths with petroglyphs displaying ancestors and other potent personages. Instead, plazas at some sites were demarcated by earth embankments. This differs considerably from the predominating stone-lined ball courts of Puerto Rico, southeastern Hispaniola, and the Virgin Islands (Oliver 2009, 23).

Moreover, the central communal ceremonial plaza was often used as a burial ground in Saladoid settlements, but this ceased with the change toward the stone-lined plazas. The plazas were used for various ceremonial or ritual activities, and because of their use as a burial ground during Saladoid times, it is suggested that those rituals were linked with the remains of the ancestors. During the subsequent Ostionoid times, the focus shifted towards the iconographic personages portrayed in the petroglyphs on several monoliths demarcating the central plaza. This shift in mortuary practices is hypothesised to indicate a shift from egalitarian societies to stratified societies (Oliver 2009, 20).

The above-described shifts and changes are only a small part of the complex social and cultural changes and interactions that started around AD 500. It is not sufficient to explain all this in terms of stylistic typologies of ceramics or by explaining it as the result of divergence from a homogeneous Cedrosan Saladoid ancestry (Oliver 2009, 23).

The Capá and Esperanza styles of pottery started to be produced on Puerto Rico around AD 1000-1100, which were attributed by Rouse (1992) to the Chican Ostionoid subseries, which belonged to the Taino ethnic subgroup. These pottery styles seem to have decorative motifs similar to those found on early “Archaic” pottery. This indicates the continuous reproduction of “Archaic” elements until the latest period of the precolonial history (Oliver 2009, 191-192). After AD 1200, pottery of the Chican Ostionoid subseries is increasingly incorporated in Puerto Rican societies, which co-occurs with an increase in elements associated with public displays of power and prestige, including ball courts. “The reproduction of some of these elements across the island indicates that there was a more pronounced formalisation of some of the emblems of power that were being deployed in most communities, which serves as an indication of the higher levels of regional political and/or ideological integration observed in different parts of the island" (Rodríguez Ramos 2010, 195).

Paleoethnobotanical research has shown that during the Ostionoid period, the subsistence economy included horticulture, arboriculture, and harvesting. Horticulture and crop production seem to intensify during this period (Newsom and Pearsall 2003, 399). Macrobotanical data of this period show a greater diversity of (domestic) plant and tree taxa than in the previous periods (Pagán-Jiménez 2007, 58-59). As stated earlier, root crops remained the mainstay of subsistence during this period (Newsom 2008, 181).

2.3 The Taíno

The Taíno were described by Rouse (1992, 185) as the "ethnic group that inhabited the Bahamian Archipelago, most of the Greater Antilles, and the northern part of the Lesser Antilles in the time of Columbus." Rouse identified three Taíno culture areas based on the distribution of ceramic subseries. The Western Taíno was located in Cuba, Jamaica, and the Bahamas; the Central Taíno could be found in Hispaniola and Puerto Rico; and the Eastern Taíno were located in the Virgin Islands and the islands north of Guadalupe (Oliver 2009, 8). According to Rouse, these Taínos made ceramics labelled under the Ostionoid series. The Western Taíno made pottery belonging to the Meillacan Ostionoid subseries, the Classic Taíno to the Chican Ostionoid subseries, and the Eastern Taíno to the Elenan Ostionoid subseries. All these subseries had supposedly developed from the Cedrosan Saladoid subseries of Puerto Rico and the Lesser Antilles (Rouse 1992, 32-33).

However, as previously stated, Rouse's unilinear developmental culture history model is inherently flawed. The "Taíno" are seen as a singular "ethnic group." However, there is a lot of variability of elements within what is commonly seen as the "Taíno". For example, ball courts are seen as a defining feature of the "Taíno", but they are mostly found in Puerto Rico and significantly less in Hispaniola, Cuba, the Bahamas, and Antigua, while they are not at all found in other Taíno areas. Moreover, there are significant dissimilarities between the ball courts in different locations. This is also the case for other "Taíno" objects such as stone belts and elaborated three-pointed cemíes. Furthermore, there is a lot of variability in prestige goods, sumptuary objects, and ceremonial artefacts (Rodríguez Ramos 2010, 196-197).

In Antillean archaeology, the Taíno have long been seen as an ethnically unified group of people that developed from a Cedrosan Saladoid ancestry, even though there clearly is a lot of variability (Oliver 2009, 8-9). However, as stated previously, the cultural geography of the islands in which the Ostionoid series developed consisted out of continuously interacting "Archaic", Cedrosan Saladoid, and Huecoid communities (Oliver 2009, 15-17). Rodríguez Ramos (2010, 200) argues that the variability in the group of elements described above that are distinctive of the Taíno, reflect "the different ways in which peoples of distinct ancestral traditions negotiated this set of features within their own communities on the basis of the particular historical contingencies," instead of stylistic variations within an ethnically homogeneous group. Rodríguez Ramos (2010, 200) suggests that what is traditionally seen as the "Taíno" reflects the ideological thread which made it possible for people to interact with each other despite their differences.

Ethnohistoric sources indicate that when the Spanish arrived in the Antilles in 1492, the "Taínos" used specially prepared fields to grow tropical root crops, particularly manioc (Newsom 2008, 174). However, recent paleoethnobotanical research suggests that manioc was not as important as previously thought (Mickleburgh and Pagán-Jiménez 2012, 2474-2475). Ethnohistoric sources also indicate that groves of fruit trees were cultivated, and other useful plants were grown in home gardens. Plant taxa that have been indicated in these sources are a variety of root crops, maize, legumes, peppers, pineapple, narcotics, and utilitarian taxa, such as cotton (Newsom 2008, 174-177). In the Caribbean paleoethnobotanical record, more types of plants and with a wider range of different uses have been identified. By 2008, at least 42 economically important plant taxa had been identified thus far from Caribbean archaeological deposits. These taxa include different trees, shrubs, herbs, and vines with different uses. These taxa were used for consumption, as containers, dyes, construction materials, beverages, or narcotics, and for consumption, and health care (Newsom 2008, 182-184).

2.4 Columbus

The first Caribbean island that Christopher Columbus discovered on 12 October 1492 was named San Salvador, one of today's Bahamian archipelago islands. There are twelve other islands suggested being the location that Columbus reached first. However, Columbus had written detailed descriptions of the islands in his diary, which do not support any of the other islands to be the location of Columbus's first landfall. The Columbus diary, *Diario*, has been used by historians, anthropologists, and archaeologists as a starting point for interpreting the precolonial Caribbean (Keegan and Hofman 2016, 239).

Columbus and a few other Spaniards wrote descriptions about the indigenous communities living on the Caribbean islands. These chroniclers divided the indigenous practices into two separate societies. This division was based on their interactions with the indigenous communities. The Indios of the Greater Antilles and Bahamas were, according to the early chroniclers, relatively friendly and the interactions with the Indios of the Lesser Antilles were hostile (Keegan and Hofman 2016, 243-244). The indigenous communities of the Greater Antilles did not have an encompassing name for the entire region, but for individual populated islands. They used local place names to refer to themselves (Keegan and Hofman 2016, 246). In 1836, Constantine Samuel Rafinesque first used the term "Taínos" to refer to the natives inhabiting most of the Greater Antilles. However, none of the Spanish chroniclers ever used this noun to refer to the natives. They regard them as Indios (Oliver 2009, 6-7). As stated previously, Irving Rouse (1992) divided the Taíno into three Taíno culture areas based on the distribution of diagnostic features: the "Classic Taíno" (Hispaniola, Puerto Rico, and eastern Cuba), the "Western Taíno" (Jamaica and central Cuba), and the "Eastern Taíno" (the Virgin Islands and northern Lesser Antilles) (Oliver 2009, 7-8). Most archaeologists today do not consider the name appropriate anymore (Keegan and Hofman 2016, 246-247).

According to the Spanish chroniclers, the settlements that the indigenous communities of the Greater Antilles lived in were large and the houses were arranged around a central plaza. The subsistence economy consisted out of house gardens and maritime protein sources. There was little terrestrial fauna, but hutias, guinea pigs and iguanas were also eaten (Keegan and Hofman 2016, 250-251). The societies were described as chiefdoms or cacicazgos. On Hispaniola, there was a three-tiered hierarchy consisting out of paramount chiefs, which were the rulers of large territories, regional chiefs, rulers of a few villages, and village headmen (Keegan and Hofman 2016, 252).

With the European arrival came dramatic changes to the ecology of the Caribbean islands. The Spanish wanted to recreate the Iberian homeland on the islands, and to do so, they introduced a variety of animals (cattle, pigs, goats, sheep, horses, chickens, but also rats and mice) and seedstock from Europe, the Middle East, and Asia. However, the climate and soils were unsuited for the cereals, olives, and grapes (Keegan 1996, 268-270).

The Spanish also brought warfare, disease, and many ways of behaviour which resulted in the rapid decline of the indigenous population. However, it was not simply the

Spanish fighting against the “Taínos.” Native chiefs also aided the Spanish invaders to defeat their own native enemies (Oliver 2009, 191). The native peoples were vulnerable to European diseases, like swine flu and smallpox, which certainly contributed to the population decline (Keegan 1996, 268). However, bad treatment, brutality, enslavement, and religious suppression all played a part in the decimation of the indigenous population (Keegan and Hofman 2016, 256). Even though the natives were not completely exterminated everywhere, the human cost was, without a doubt, enormous. No exact demographic numbers for the genocide exist, but it is estimated that the native population of Hispaniola counted roughly 3.8 million inhabitants when the Spanish arrived. By 1510, this population had declined to circa 34,000. This demographic collapse constituted a serious break with the cultural, social, and linguistic plurality of the Pre-Columbian history of the Greater Antilles (Oliver 2009, 192).

3. El Flaco

The site of El Flaco is located in Hispaniola in the southern foothills of the Cordillera Septentrional, at an elevation of 300 meters above sea level. The site is situated circa 12 kilometres from the coast and overlooks the Cibao Valley. El Flaco is located along the *Ruta de Colon*, which is the route that Columbus took in 1494 (Sonneman *et al* 2016, 6). El Flaco has been excavated by the ERC-Synergy project Nexus 1492 lead from the Faculty of Archaeology of the Leiden University under the direction of Corinne Hofman and Menno Hoogland (Keegan and Hofman 2016, 128).

Figure 1. The location of El Flaco on Hispaniola (made by the author using Google Earth)

The multi-disciplinary research of El Flaco showed that it consisted of a series of mounds and earthworks surrounding artificially flattened areas with house structures. The site was occupied in the 10th to 15th centuries, but the main occupation dates between the 13th and 15th centuries (Hofman *et al*. 2018, 210-211). The inhabitants created platforms in the hillside for the construction of houses. These areas were flattened by removing the underlying limestone and depositing it to the side where mounds and earthen walls were located. The postholes of two large house structures (9 metres in diameter) and a number of small round huts (3-4 metres in diameter) were found in the flattened areas. The small huts had fireplaces and hearths and are identified as cooking huts (Keegan and Hofman 2016, 129). Other features found in the levelled areas belonged to shelters, cages, drying racks and other structures (Hofman *et al*. 2018, 210).

Surrounding the flattened areas were artificial mounds, which had a complicated stratigraphy, which suggests that they were used for both domestic and ritual activities. Some layers represent the deposition of waste, which was occasionally burned. White limestone layers represent the discarded rocky (calcareous) layers that were removed during the flattening of the domestic areas. The mounds were also used for household activities, such as cooking areas and as kitchens (Hofman *et al*. 2018, 211). There are also hearth features present in the mounds with burned ceramics and pieces of griddle, which is evidence for cooking activities (Keegan and Hofman 2016, 129). Moreover, the mounds were used for burials, which reflects the use of the mounds as ancestral spaces. There are burials of infants, sub-infants, adults, and dogs recovered from these sectors (Hofman *et al*. 2018, 211).

The excavations of the site also revealed a variety of tools, adornments, and other artefacts. Lithic artefacts were mostly made out of locally available stones. Beads were made out of shell, bone, stone, and pottery. All these artefacts were found in the mounds or around the houses. It seems that the internal area of the houses was kept very clean (Keegan and Hofman 2016, 130). The ceramics include pottery from the Meillacoid (Meillacan Ostionoid) and Chicoid (Chican Ostionoid) series and a mixture of the two series (Ting *et al*. 2016). However, the main occupation of the site (13th to 15th centuries) is characterised by Chicoid ceramics (Hofman *et al*. 2016, 211).

4. Materials and methods

The paleoethnobotanical research of El Flaco is still ongoing. Within this broad research, the main objective of this thesis is to study the phytolith and macrobotanical content extracted from the soils of 5 ancient hearth features registered at the El Flaco hamlet. In table 1, the provenance information of each sample is given. The aim is to acquire information about food plants to interpret their possible significance as components of the diet of the former inhabitants of the site. Multiple paleoethnobotanical techniques can be used to reach this goal. Some investigators rely only on the investigation of one type of botanical remain. However, this leads to an incomplete and limited perspective on the indigenous diet. Using multiple lines of evidence not only provides more data but a more complete picture of human-plant interrelationship variations through time (Pagán-Jiménez 2007, 64). This is especially important in the Caribbean where species diversity is high, and the preservation of ancient and buried botanical remains is relatively low (Piperno and Pearsall 1998, 31).

Table 1. The provenance information of each sample.

Sample Id	Site	Feature number	inside/ouside sample
1 in	El Flaco	FL73-7	Inside
1 out	El Flaco	FL73-7	Outside
2 in	El Flaco	FL45-33	Inside
2 out	El Flaco	FL45-33	Outside
3 in	El Flaco	FL73-12	Inside
3 out	El Flaco	FL73-12	Outside
4 in	El Flaco	FL55-126	Inside
4 out	El Flaco	FL55-126	Outside
5 in	El Flaco	U70 H1	Inside
5 out	El Flaco	U70 H1	Outside

4.1 Phytoliths

Phytoliths are microscopic particles of hydrated silica that are formed in the stems, leaves, roots, and inflorescences of living plants. They are formed when plants take up groundwater which contains silica, which then is deposited in epidermal tissue and other cells (Pearsall 2018, 16). These particles survive after the natural or human-induced decay of their plant sources (Piperno 2006, 1). Phytoliths are useful because they are produced by certain plants in high quantities, and they preserve well in many different ancient sediments, even for millions of years. Furthermore, they often survive in “difficult” sediments in which other botanical fossils are rarely preserved (Renfrew and Bahn 2012, 253). This is the case of the tropical soils of the Caribbean (Pearsall 2000).

Interestingly, several phytoliths have distinctive shapes and sizes that allow to consider them as diagnostic morphotypes at lower taxonomic levels in the plant kingdom. This makes them reliable fossil indicators for environmental reconstruction, and they have the potential to inform us of aspects of plant use and human plant dispersals in ancient times (Piperno 2006, 1). In general, many plant families produce distinctive phytoliths; on genus-level diagnostic phytoliths are common, and for many plants, species-level identification is possible. Phytoliths are identified based on their three-dimensional morphology, outline, symmetrical features, surface texture, size measurements, and ornamentation (Pearsall 2018, 16).

In archaeological contexts, Poaceae or grass phytoliths are often found, because this family is an abundant phytolith producer. Grasses produce a broad array of phytoliths morphotypes, and several of them can be used to distinguish among grass sub-families. “Genus- and species-level diagnostics have been developed for economically important taxa” including maize (Pearsall 2018, 16). Spherical phytoliths of different sizes are also common in archaeological and environmental contexts. These phytoliths are produced by some woody dicots, palms (Arecaceae), but also in wild, cultivated and domestic herbs such as squashes and gourds (Cucurbitaceae), arrowroot (Marantaceae), gingers (Zingiberaceae), and Canna (Cannaceae) families. Moreover, phytoliths with distinctive features are produced in sedges (Pearsall 2018, 16-19).

4.1.1 Organisation of phytolith data

Arboreal phytoliths have been divided into two groups, “palms” and “other arboreal” because palms are environmentally and culturally significant in the Caribbean. “Palms are multipurpose plants providing in some cases edible fruit, but also wood, thatch, and fibre for cordage and other purposes” (Newsom and Wing 2004, 143). Moreover, palm phytoliths are easily distinguished from other arboreal phytoliths.

Several herbs can be identified in Caribbean contexts with phytolith analysis to different taxonomic levels. Among them, included here within the broad Herbaceous category, most fall within the order Zingiberales (early colonizing plants in tropical forests), such as Zingiberaceae, Heliconiaceae (and *Heliconia* spp.), Marantaceae (and *Maranta* spp., *Calathea* spp.), and also Cannaceae (and *Canna* spp.). Other identifiable herbs are the Bromeliaceae and Asteraceae families.

The Arboreal (palms) category is used to group different phytolith morphotypes belonging to the Arecaceae family level, which are commonly known as palms. Lower taxonomic level identifications of palm phytoliths are not possible at this time in the studied area, and some authors (Piperno 2006) have found that palm phytolith morphotypes are very common (redundant) in many different species. So, for now, they are not useful to identify palms to the genus/species level. The taxa within the Arboreal (others) category include morphotypes from other types of trees including Bombacoideae, woody dicots such as the Chrysobalanaceae family, and more trees producing distinctive, blocky or highly angular phytoliths in the bark.

Poaceae is the grasses family. Phytolith morphotypes from Poaceae can be identified to known sub-family levels such as Panicoideae, Pooideae/Festucoideae, Chloridoideae, and Bambusoideae. However, several morphotypes can also be produced by two or more of these sub-families, so their usefulness for identifying grasses to lower taxonomic levels is ambiguous.

The last and most important floristic group for the scope of this paper has been labelled “Economic Plants”. Precolonial ”economic plants” that could be possibly identified by means of its phytoliths comes from the same broad floristic categories described above: Arboreal (others) (e.g., Annonaceae); Herbaceous (e.g., Cucurbitales-wild, *Cucurbita* spp. -domesticated, *Manihot esculenta*, *Calathea* spp., *Canna* spp., and *Maranta arundinacea*, *Phaseolus* spp.); and Poaceae (e.g., Panicoideae sub-family: *Zea mays*). If early colonial period contexts of the Caribbean were included in this study, then at least plantain/banana (*Musa* sp.) and rice (*Oryza* sp.) could be likely identifiable through phytoliths analysis, being those plants some of the earliest Old-World introductions into Hispaniola.

4.2 Macrobotanical remains

Macrobotanical remains are larger plant structures that are visible to the naked eye. These botanical remains are often preserved in archaeological contexts by becoming charred, desiccated, or waterlogged (Pagán-Jiménez 2003; Pearsall 2000, 11). These macroremains include fruits, nuts, seeds, wood, tubers, roots, and other vegetative materials. Seeds are the reproductive structures of seed-bearing plants and are composed out of an embryonic plant protected by an outer covering (typically the seed coat). In archaeological contexts, the distinguishing features of seeds are not always preserved. The size, shape, colour, texture, attachments, and scars of seeds can be distorted due to natural degradation, or humanly induced (ancient and modern) damaging processes (Pearsall 2018, 4-7). A fruit is the seed-bearing ripened ovary of a plant, and nuts are indehiscent hard and bony fruits that usually only contain one seed. In archaeological contexts, charred wood fragments are often the most abundant macroremains found. Even though roots and tubers had an important role in the subsistence of ancient peoples, their macroremains are rarely found. In order to identify these botanical remains, it is important to count with a comparative collection and auxiliary publications (e.g. catalogues, inventories, etc.) (Pearsall 2018, 7-12).

Macrobotanical remains are often used in archaeological investigations to acquire information about the environment or the diet of ancient peoples. It is also very common to use charred macrobotanical remains (mostly charcoal) for radiocarbon dating. However, macrofossils are only preserved in a number of environmental conditions. They could be better preserved in very dry or waterlogged conditions (Renfrew and Bahn 2012, 274). Unfortunately, the Caribbean islands are part of the Neotropics, which has a very humid environment, and the El Flaco site was not located in waterlogged conditions. Fortunately, macrobotanical remains are also preserved when they are charred. The majority of macrobotanical remains at archaeological sites in the Neotropics are preserved through accidental charring. However, this type of preservation leads to certain biases. Firstly, only food plants (parts of them) that are processed using fire could be potentially preserved. Secondly, only tougher charred remains could survive the burial process, from several decades to thousands of years, and also the action of modern paleoethnobotanical recovery techniques. Lastly, not all charred material that survives can be identified. Only the material of which the distinctive features are still visible can be identified (Piperno and Pearsall 1998, 33). Because of these biases, the obtained data from the macrobotanical analysis will be interpreted using only the presence of taxa and not their absence.

4.2.1 Organisation of macrobotanical data

The macrobotanical remains were organised into specific categories. Firstly, a distinction is made between seeds from weeds and fruits. These two groups are further divided into fragmented and whole seeds. Within these categories, a division is made based on the surface morphology of the seeds. The surface is either smooth or rough. Furthermore, there is a category for charcoal. In this category only basic estimates are made, varying between nothing to very abundant. Lastly, there is a category labelled as “other”. All the other botanical remains found are part of this group, such as peduncles, possible charred bread fragments, and maize cob fragments.

4.3 Sample Acquisition

The soil samples were taken by Dr. J.R. Pagan-Jimenez at the site of El Flaco in the Dominican Republic. After the hearth features were identified, the soil samples for the macrobotanical analysis were collected by taking small pinches of soil from the inside and outside portions of the features. The collection of these groups of samples (inside and outside) per feature was made by cutting small pieces of soil with a hand trowel in respective nodes of an imaginary grid over and around the features, avoiding the scraping of the excavated surface at all times to prevent the damage of macrobotanical remains. Between 1.5 to 3 litres of sediments were taken separately from the inside and outside sections of each hearth feature.

The sample collection for phytolith analysis followed the same steps used for the macrobotanical sampling. The only difference was the way of taking the small pinches of soils from the grid nodes in the inside and outside of the hearth features. First, the hand shovel was rinsed with distilled water after which the surface soil at each sample point was removed. The shovel was rinsed with distilled water again, and a clean soil pinch was taken and stored in new labelled zip lock bags. In sum, the inside sample of a hearth feature is formed by a group of extracted soil pinches mixed together that come from sample points in different grid nodes in the inside of the hearth. The outside sample is taken the same way as the inside sample, except the grid nodes are located outside of the hearth.

4.4 Phytolith analysis

4.4.1 Sample preparation, processing, and phytolith extraction

The soil sample preparation started by grinding the soil samples and then sieving them through a #16 mesh sieve. The sieved material was transferred into clean 50 ml centrifuge tubes. The goal of the grinding and sieving was to discard big sand grains and pieces of gravel and to make the subsequent chemical processing easier.

After each sample was ground and sieved, the chemical processing of the samples began following the protocol of Dr. J.R. Pagán-Jiménez. The first step was to eliminate the carbonates and oxides from the samples by using Hydrochloric acid (37%) and Nitric acid (10%). The next step was to digest the organic matter from the samples using Nitric acid

(67%), Hydrogen peroxide (14%), Potassium hydroxide (10%), and Ethylenediaminetetraacetic acid (0.1 %). Once the carbonates, oxides and organic matter were all discarded, the phytoliths could be recovered. The phytoliths were recovered by flotation using Lithium Metatungstate with a density of 2.3 g/cm3. After the phytoliths were recovered and the Lithium Metatungstate was discarded from the samples, the phytolith samples had to dry. Once they had dried, the samples were homogenised in the tubes and each sample was mounted on a new microscope slide with a new coverslip, using new sterilised and disposable pipettes. The phytolith samples on the microscope slide were mixed with fresh permount.

4.4.2 Microscope analysis and phytolith identification

The microscope used for the phytolith analysis was a Leica DM2700-Pol microscope that was located in the Laboratory of Artefact Studies of the Faculty of Archaeology from the University of Leiden. There was a Leica MC 170 HD camera connected to the microscope. This camera, in combination with a multi-purpose software, was used for image registry and morphometric analysis.

A form with examples of diagnostic phytolith morphotypes created by Nexus 1492 was used for the identification of the phytoliths during the analysis. This form shows diagnostic phytoliths from herbaceous, Arboreal, Poaceae, Sedges and Economic Plants. For each sample, 250 phytoliths were counted using random spots. Random spots were selected by starting in the top right corner of the slide and then moving the slide to the right without looking through the microscope. All the phytoliths that are visible in that spot, through a 400x magnification, are identified and counted. Once this is done the slide is moved again to the right or down to a new random spot where the phytoliths are again identified and counted. This is done until 250 phytoliths have been identified. Using random counts is essential to prevent any possible bias from the analyst and to make sure that the results are truly representative of the sample.

After the 250 phytoliths were counted, the samples were analysed to see if there are any economic plants in the sample that were not part of the 250 count. This was done by scanning the entire microscope slides (left to right) in a lower magnification. If any economic plants were found, it was indicated on the count sheet, separately from the initial 250 counted phytoliths.

4.5 Macrobotanical analysis

4.5.1 Sample preparation and processing

The initial step in the sample preparation of the macrobotanical samples is hand-flotation, which was carried out by Dr. J.R. Pagan-Jimenez in the Dominican Republic. The first step in the hand-flotation protocol is to carefully place the 1.5 to 3 litres of soil sample in a bucket, after which water is gently added in a 1:2 ratio based on the specific soil volumes. Then, the soil sample was carefully mixed with the water and disaggregated. The floated, organic material was collected with a hand sieve with a mesh size of 0.5 mm. The collected material was placed on tables inside the field lab to dry.

The remaining soil sample was sieved by means of water screening with a set of different mesh sizes: 6.35 mm, and 3.175 mm. Clean water was gently directed into the soil sample at each sieve to allow the separation of the organic material (non-floating charred remains) and the soil. The collected organic material was recovered from the sieves and then stored separately for analysis. Once both fractions of the sample had dried, they were stored in labelled bags and eventually sent to the lab of Dr. J.R. Pagan-Jimenez in Leiden for further analysis.

In Leiden, the next steps of the sample preparation and processing were carried out. The weight and volume of the dry samples were first measured. Thereafter, each sample was sieved through four geological sieves with different mesh sizes. These mesh sizes were, from top to bottom, 5.6 mm, 2.0 mm, 1.0 mm, and 0.5 mm. The dry samples were carefully poured into the superior sieve (5.6 mm), and with a soft brush, the sample was carefully moved in order to only keep the particles with the appropriate size in this sieve. The analyst made notes on what could be seen with the naked eye, such as roots, modern vegetal material, and mollusc shells. Then most of the material that was not carbonised was removed and stored together in a single bag because this might be useful for future analysis. The material that was left in the sieve was carefully stored separately in a small container, which was labelled with the appropriate id and mesh size. These steps were repeated for each sieving screen, and with each sample.

4.5.2 Microscope analysis and macrobotanical remains identification

The microscope analysis of the macrobotanical samples was carried out using a Leica KL 200 led stereo microscope from the Botany Lab of the Faculty of Archaeology from the University of Leiden. The sieved material was carefully scanned through the microscope using a petri dish to find macrobotanical remains. The macrobotanical remains that were found were separated, except the charcoal, and grouped together with macrofossils belonging to their corresponding category. The remains of each category were counted, and the results were put in an excel sheet. Lastly, the separated and grouped remains were stored in capsules belonging to their corresponding category and mesh size. Unfortunately, there was no application or camera to take good pictures of the recovered seeds. Therefore, pictures were taken with an iPhone X through the microscope.

Most macrobotanical remains did not have any diagnostic features and therefore, no further taxonomical identification could be made. However, there was a small number of weed seeds that were distinctive and could be identified. This was done using a reference collection from the Botany Laboratory of the Faculty of Archaeology of the University of Leiden. The identification was done with the help and advice of Dr. M.H. Field and Dr. J.R. Pagán-Jiménez.

4.6 Statistical analysis

The statistical procedures used in the analysis are based on descriptive statistics of the samples based on counts per taxonomic group or previously defined categories. These raw counts will be represented using tables and graphs created with excel. The graphs will visually compare the results of the analysis of samples taken from inside and outside of the five hearth features to show differences and similarities between hearth features and between the inside and outside of each hearth feature in order to bring answers to the research questions.

5. Results

5.1 Phytolith results

Overall phytolith analysis results from the studied samples are shown in Figure 2, while figures 3 and 4 illustrate the results obtained separately from the inside and outside samples in each hearth feature. For each sample, 250 phytoliths have been counted and classified according to key morphotypes previously described.

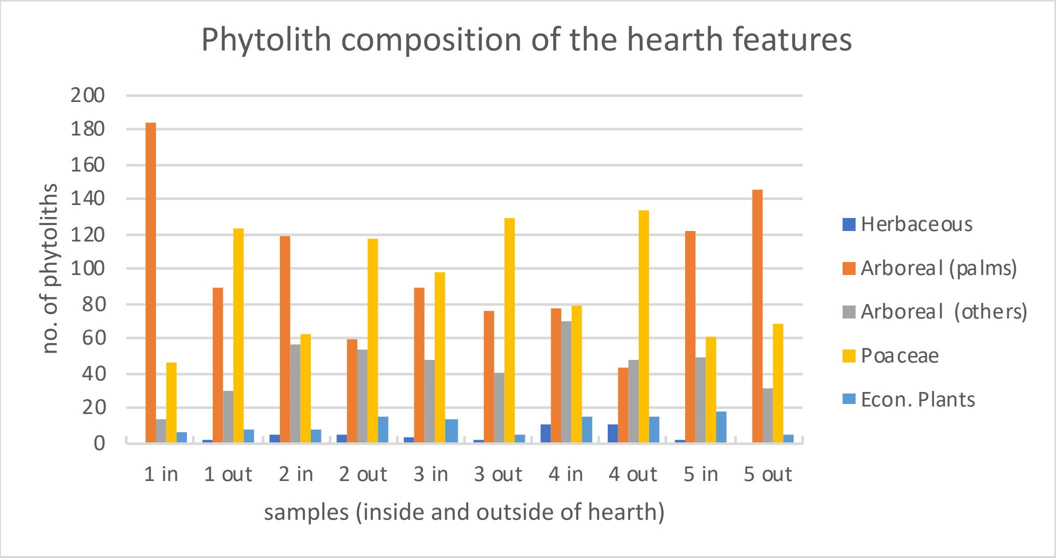

Figure 2. Phytolith composition of all studies samples and their distribution among the used floristic categories.

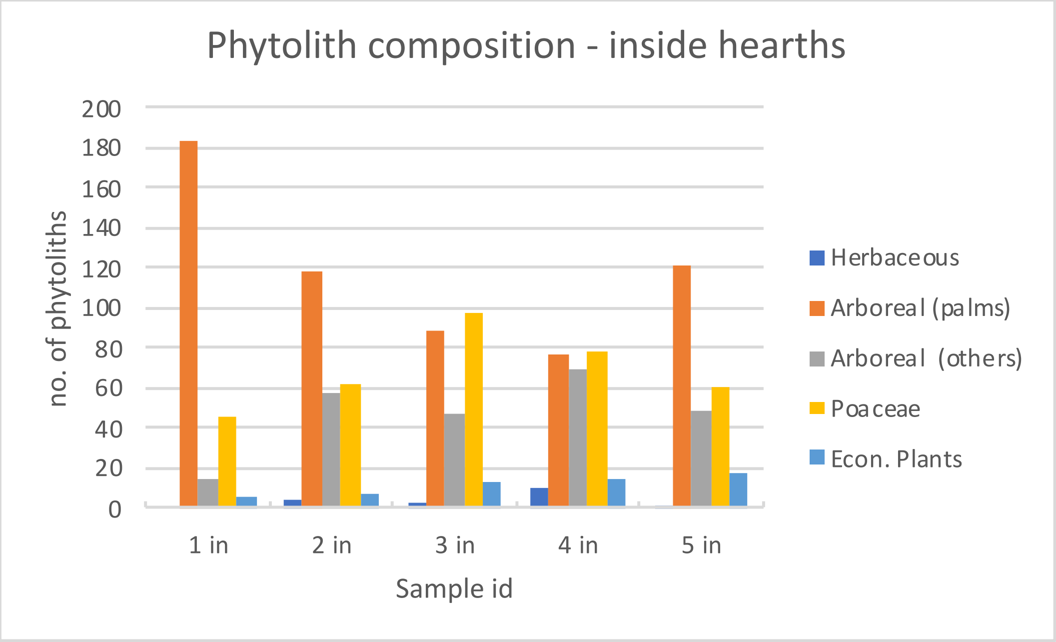

Figure 3. Registered phytolith composition from hearth's inside samples and their distribution among the used floristic categories.

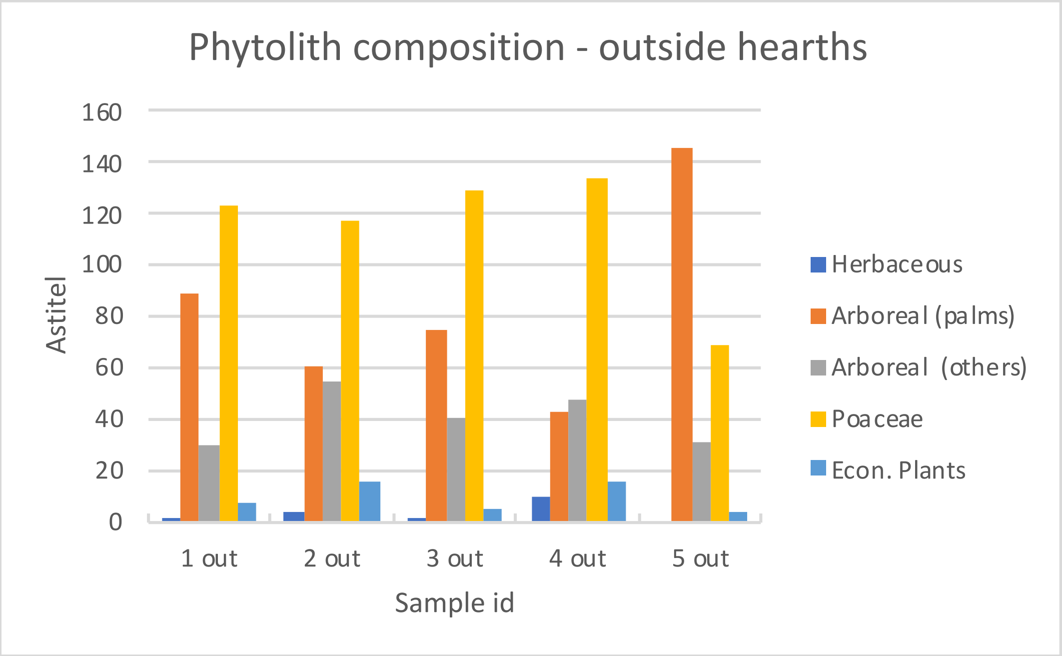

Figure 4. Registered phytolith composition from hearth's outside samples and their distribution among the used floristic categories.

Not all taxa from the used classification system were found during the analysis. Thus, Appendixes 1 to 10 were made to show the detailed phytoliths results. These appendixes also contain the number of registered phytoliths per taxonomic group and/or broader category. Moreover, an additional row was included in the Appendix tables for counting all burned phytoliths found within the 250 phytolith counts per scanned sample. This data has not been used further in the research of this thesis. However, it would be important to observe if the amounts of burned phytoliths correspond to the uses attributed to the studied features to confirm that the assumed functionality of them is right.

5.1.1 Economic plants

In Figure 5 the number of economic plant phytoliths (out of 250 counted phytoliths) of each sample is visualised in a bar graph, while figures 6 and 7 split the results coming from the inside and outside portions of the hearth features. Regarding the scanning and recording of economic plant morphotypes, the standard procedure has been to scan additional (non-scanned) portions of the slides in search of important unregistered specimens. This is done based on the fact that many, if not all the economic plants of interest for the Neotropics produce very low amounts of phytoliths (like *Manihot esculenta*, *Phaseolus* spp., etc.), or could produce high amounts of non-diagnostic phytoliths (like *Zea mays*), but very low amounts of diagnostic morphotypes (Pearsall

2000; Piperno 2006). So, after 250 phytoliths were counted, non-scanned portions of the microscope slides were analysed to see if phytoliths of previously identified economic plants, or from non-identified ones, were present out of the standard count. These results are shown in table 2.

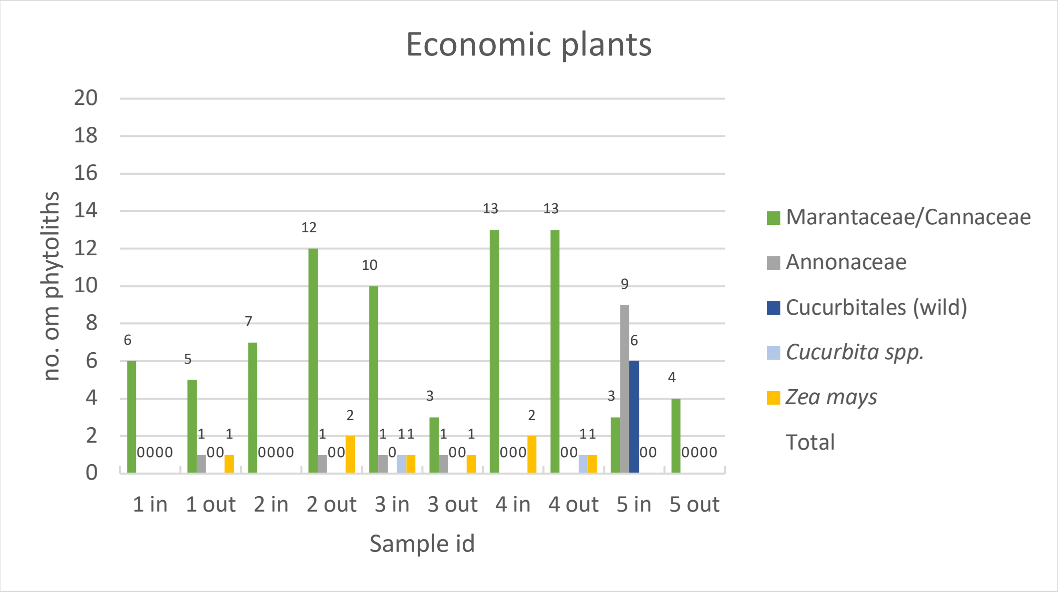

Figure 5. Economic plant phytoliths registered throughout all the studied samples.

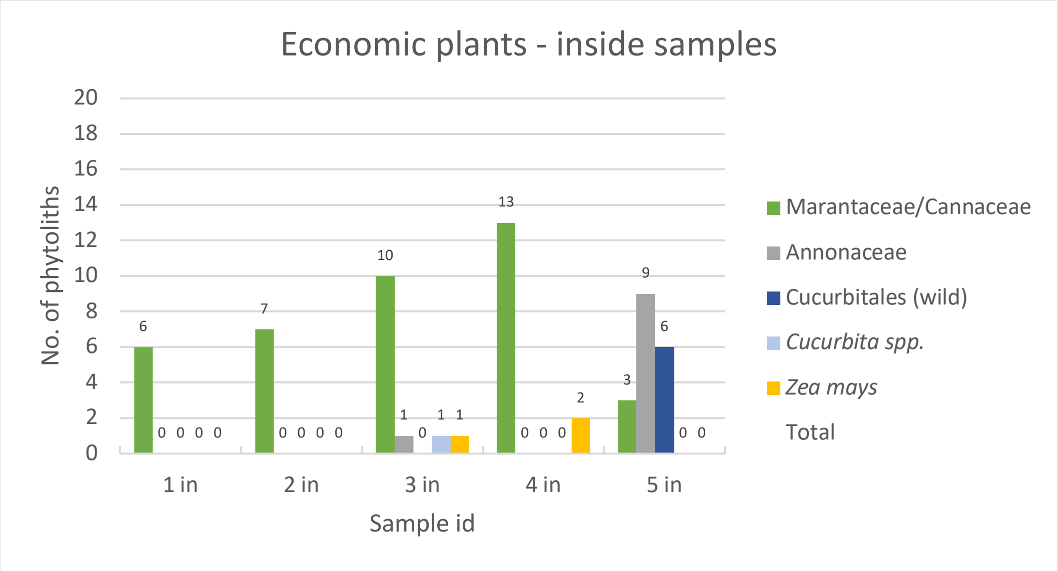

Figure 6. Economic plant phytoliths registered in the inside section of studied hearth features.

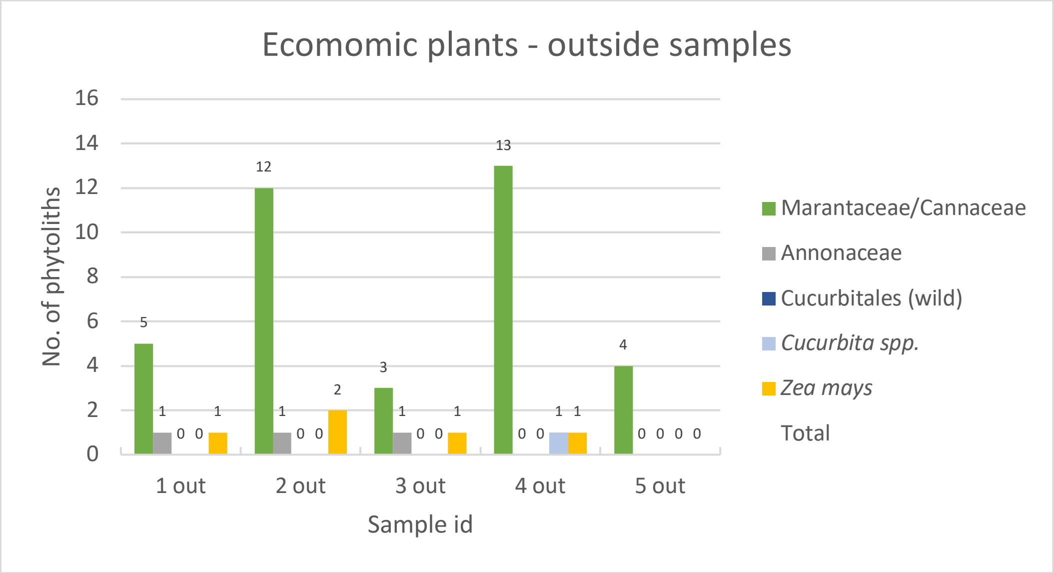

Figure 7. Economic plant phytoliths registered in the outside section of studied hearth features.

Table 2. Economic plant phytoliths identified (with an "X") after the additional scanning of microscope slides.

	Marantaceae/Cannaceae	**Annonaceae**	**Cucurbitales (wild)**	***Cucurbita* spp.**	***Zea mays***
1 in	*Present in 250 count*	**x**	**x**		**x**
1 out	*Present in 250 count*	*Present in 250 count*	**x**	**x**	*Present in 250 count*
2 in	*Present in 250 count*	**x**	**x**	**x**	
2 out	*Present in 250 count*	*Present in 250 count*	**x**		*Present in 250 count*
3 in	*Present in 250 count*	*Present in 250 count*	**x**	*Present in 250 count*	*Present in 250 count*
3 out	*Present in 250 count*	*Present in 250 count*	**x**	**x**	*Present in 250 count*
4 in	*Present in 250 count*		**x**		*Present in 250 count*
4 out	*Present in 250 count*	**x**		*Present in 250 count*	*Present in 250 count*
5 in	*Present in 250 count*	*Present in 250 count*	*Present in 250 count*		**x**
5 out	*Present in 250 count*	**x**	**x**		**x**

Only six economic plant taxa have been identified in the samples and ascribed to different taxonomic levels: order level: Cucurbitales; family level: Marantaceae/Cannaceae, Annonaceae; genus level: *Cucurbita* spp.; and species level: *Zea mays*. Other two broad taxonomical categories are briefly considered here (Herbaceous-Zingiberales, and Arboreal-palms or Arecaceae), because of their potential importance as industrial plants for starting fires or confectioning some foods and beverages in the case of palms, and for wrapping foods in the case of some Zingiberales. In figure 8, pictures are shown of the phytoliths of these plant taxa that were identified during the analysis.

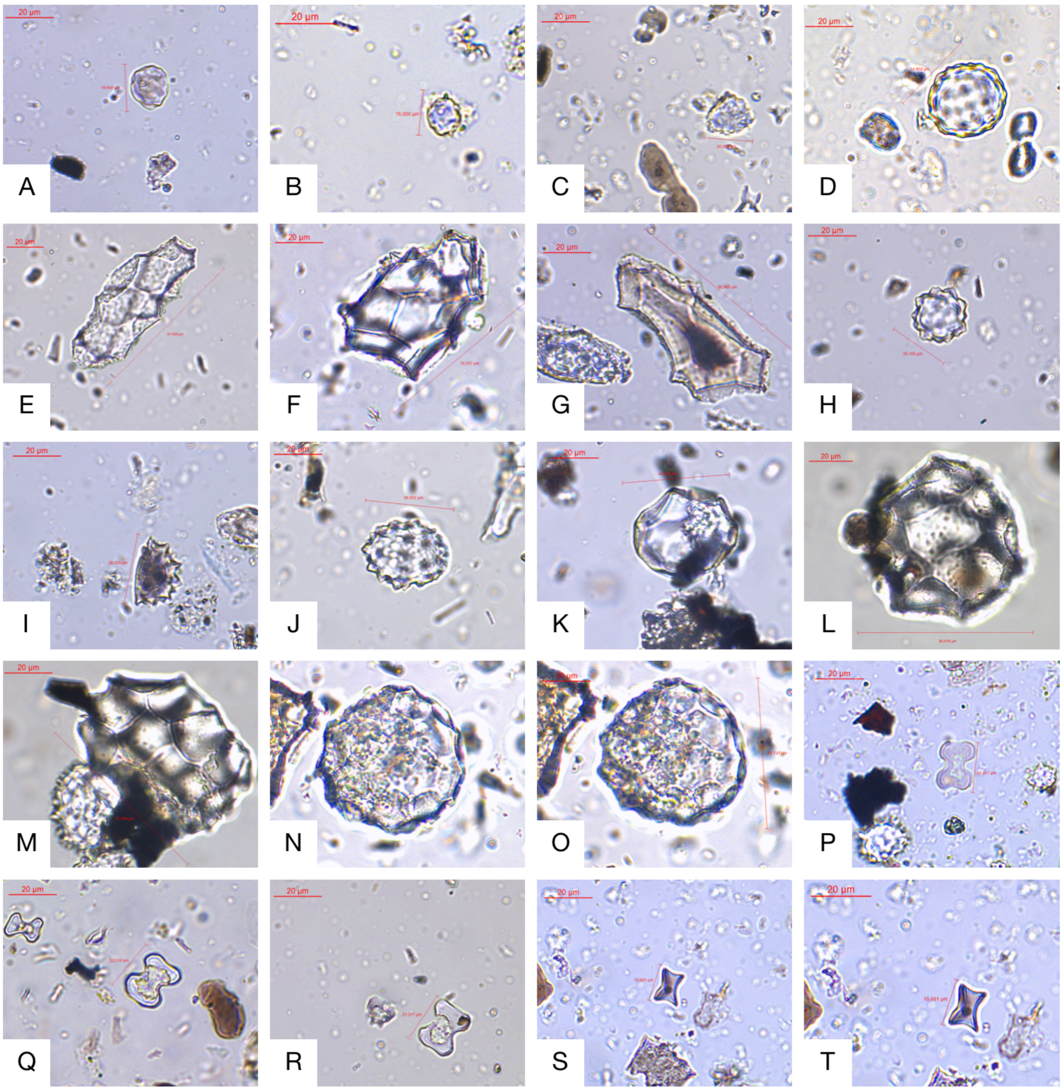

Figure 8. Distinctive phytoliths from economically important taxa registered in the hearth features: (a, b) rugulose sphere (Marantaceae/Cannaceae); (c) globular microechninate (Zingiberales); (d) nodular sphere (Zingiberaceae); (e, f, g) strongly faceted (scalloped) and highly angular phytoliths (Annonaceae); (h) globular echinate (Arecaceae); (i) conical echinate (Arecaceae); (j) elongated echinate (Arecaceae); (k, l, m) scalloped sphere or hemisphere (Cucurbitales); (n, o) heavily scalloped sphere (*Cucurbita* spp.); (p, q, r) cross variant 1, > 20 µm (*Zea mays*); (s, t) wavy top rondels (*Zea mays*, maize cob) (pictures taken by author).

Even though Marantaceae and Cannaceae are two different taxonomic families within the "economic plant" group, they are represented as one category, because the recovered phytoliths morphotypes of them cannot be distinguished. Both of these taxa produce rugulose spherical phytoliths (see figure 8a, 8b), and Marantaceae also produced spherical to flattened phytoliths with nodules and occasional spinules. Phytoliths from this category have been identified in the inside and outside samples of all the hearth features. Out of the 105 economic plant phytoliths identified in all the samples (total of

2500 identified phytoliths), 76 phytoliths belong to Marantaceae/Cannaceae, which makes it, by far, the largest economic plant group in this research.

Globular phytoliths with microechinates and granulate spherical phytoliths (see figure 8c) can be confidently identified to the order Zingiberales. This order consists of eight families, including Zingiberaceae, Heliconiaceae, Marantaceae, and Cannaceae. Phytoliths that can be confidently identified to the order Zingiberales have been found in the inside and outside samples of hearth 2 and 4. Nodular spherical phytoliths (see figure 8d) that are distinctive for Zingiberaceae taxa have been found in the outside sample of hearth 2. Although these phytoliths could not be assigned to lower (more accurate) taxonomic levels, these plants could have been part of the surrounding landscape, but also providers of raw materials (leaves) as to wrap foods in, before cooking them directly over coal. This is a possibility based on the fact that these phytoliths were recovered in hearth features and their immediate periphery.

Strongly faceted (scalloped) and highly angular phytoliths (see figure 8e, 8f, 8g) produced mostly by the leaves of several Annonaceae family specimens were also registered in all samples (inside and outside), except in the inside section of hearth 4. However, in hearth 4, Annonaceae phytoliths were not identified within the initial 250 count, but in the additional scanning of the microscope slides. Out of the 105 economic plant phytoliths identified in all the samples (total of 2500 identified phytoliths), 13 belong to the Annonaceae family.

Globular echinate and spheroidal/flattened/conical echinate phytoliths (see figure 8h, 8i, 8j) produced by Arecaceae were identified in high quantities in all the samples. Although these phytoliths could not be assigned to lower (more accurate) taxonomic levels (genus/species level), these plants could have been part of the surrounding landscape but could also have used as industrial and even food sources. The palms could have been used as a fuel, their leaves and trunks as construction materials and fruits of some Arecaceae taxa could have been used for preparing different foodstuffs.

Another kind of scalloped, spherical or hemispherical phytoliths with smoother and typically smaller depressions (see figure 8k, 8l, 8m) can be confidently identified to the order Cucurbitales and the family Cucurbitaceae, sometimes also to the species level (Piperno 2006). Phytoliths from wild Cucurbitales have been found in all samples, except in the outside sample of hearth 4 (4 out). However, these phytoliths have only been identified in the 250 count of the inside sample of hearth 5 (5 in). In this sample, 6 of the 250 counted phytoliths were produced by wild Cucurbitales. These phytoliths strongly resemble those previously classified by Piperno (2006) as being produced by some of the domestic species, though they seem to better match the morphotypes already described for *Lagenaria siceraria*. However, due to the lack of more morphometric information regarding these phytoliths and their range of variation in the literature, they were classified to the order level.

Additional scalloped spheres were registered and identified as *Cucurbita* spp. because their morphometric characteristics nicely match those already identified as diagnostic to the genus level. The phytoliths produced in the rigid/hard rind of fruits of some *Cucurbita* species are distinguishable from phytoliths of other taxa within the order Cucurbitales. *Cucurbita* spp. phytoliths have been found in the outside sample of hearth 1, in the inside sample of hearth 2, in the inside and outside samples of hearth 3, and in the outside sample of hearth 4. However, *Cucurbita* spp. phytoliths have been identified in the 250 count, though only in the inside sample of hearth 3 and the outside sample of hearth 4. Out of the 105 economic plant phytoliths identified in all the samples (total of 2500 counted phytoliths), only 2 belong to *Cucurbita* spp. (domesticated) group.

Finally, *Zea mays* is a species of the Poaceae family and is commonly known as maize or corn. Because of some small morphometric differences in the phytoliths from maize compared to those from other wild grasses, it is possible to differentiate them (Pearsall 2018, 121), and above all, at least 6 are diagnostic to domestic maize, such as: cross variant 1 (bigger than 20 microns), wide regular IRP, irregular IRP, half decorated rondel, ruffle top rondel (diagnostic to maize husks), and wavy top rondel (diagnostic to maize cob). Of these diagnostic phytoliths of maize, the analysis confirmed the presence of cross variant 1 (bigger than 20 microns) phytoliths, and wavy top rondel phytoliths. The presence of cross variant 1 phytoliths in the sample does not necessarily mean that maize was consumed as a vegetable, but only that the plant was present because these phytoliths are not diagnostic to the maize cobs or husks. In contrast, wavy top rondels or ruffle top rondels are diagnostic for, respectively, maize cobs and husks. Their presence indicates that maize cobs were handled and likely processed. Maize phytoliths have been found in all the samples, excepting the inside sample of hearth 2. However, they have only been identified within the 250 count of the outside sample of hearth 1, the outside sample of hearth 2, the inside and outside samples of hearth 3, and the inside and outside samples of hearth 4. Out of the 105 economic plant phytoliths identified in all the samples (total of 2500 identified phytoliths), 9 were produced by *Zea mays*. However, maize also produces phytoliths that cannot be distinguished from those produced by other Poaceae plants. Therefore, it is possible that more of the registered phytoliths (crenate, trilobes, cross variants 2, 5/6, etc.) were produced by maize.

Of the 9 maize phytoliths, 4 were wavy top rondels. The wavy top rondels were found in the outside sample of hearths 1, 2, and 4, and on the inside sample of hearth 4. The remaining 5 maize phytoliths were cross variant 1 phytoliths bigger than 20 microns. These were found in the inside samples of hearths 3, and 4 and in the outside samples of hearths 2, 3, and 5.

5.2 Macrobotanical results

In Figure 8, the results of the macrobotanical analysis are visualised. The inside and outside samples of hearth 1 have been given a separate graph (Figure 9) because those samples contained much more macrobotanical remains than the other samples. In Figure 10 and Figure 11 the results of the inside and outside of the other respective samples are presented.

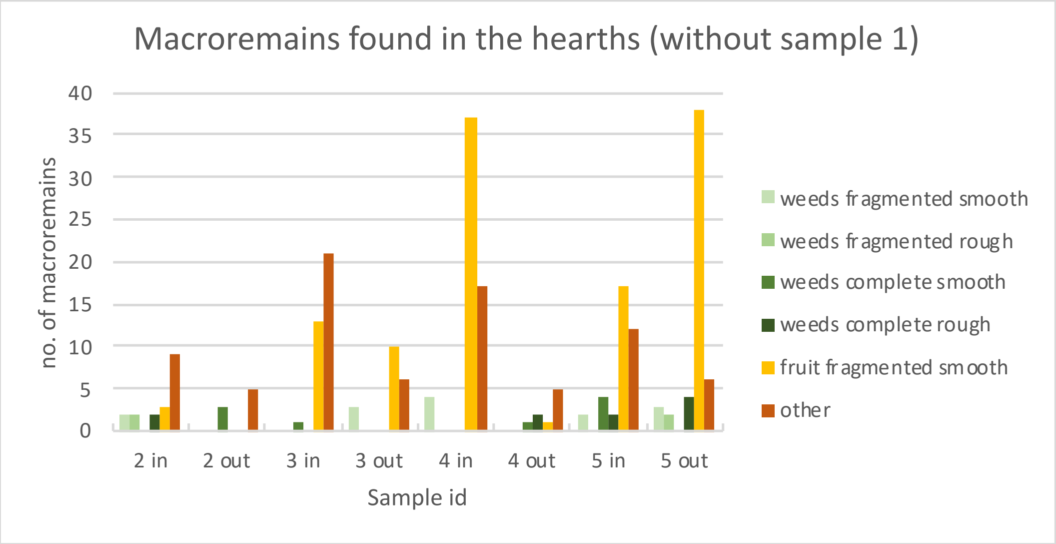

Figure 9. Recovered macroremains from inside and outside samples of hearth 2 to 5 (for hearth 1 sample see Figure 10).

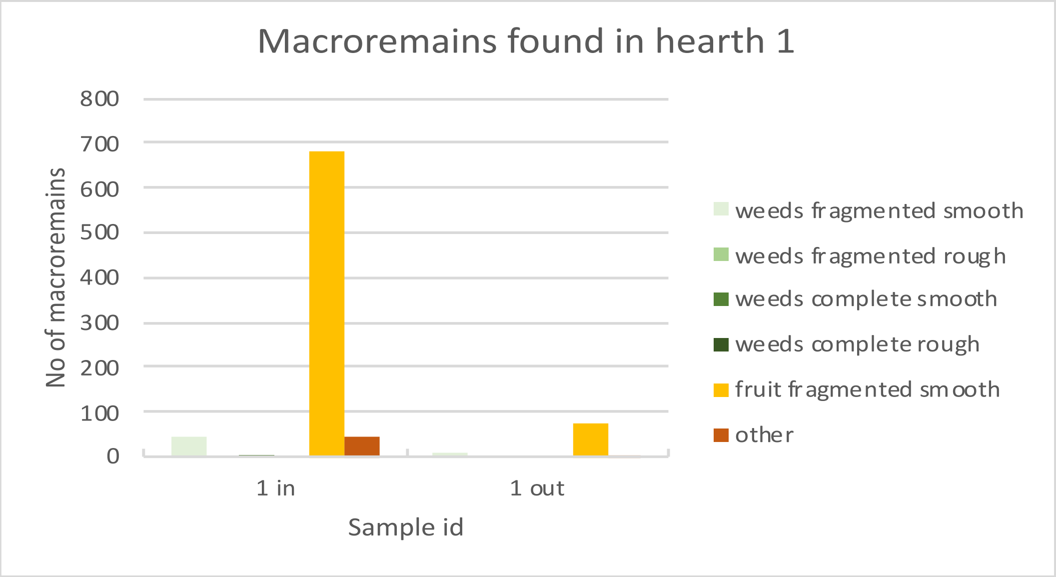

Figure 10. Recovered macroremains from inside and outside samples of hearth 1.

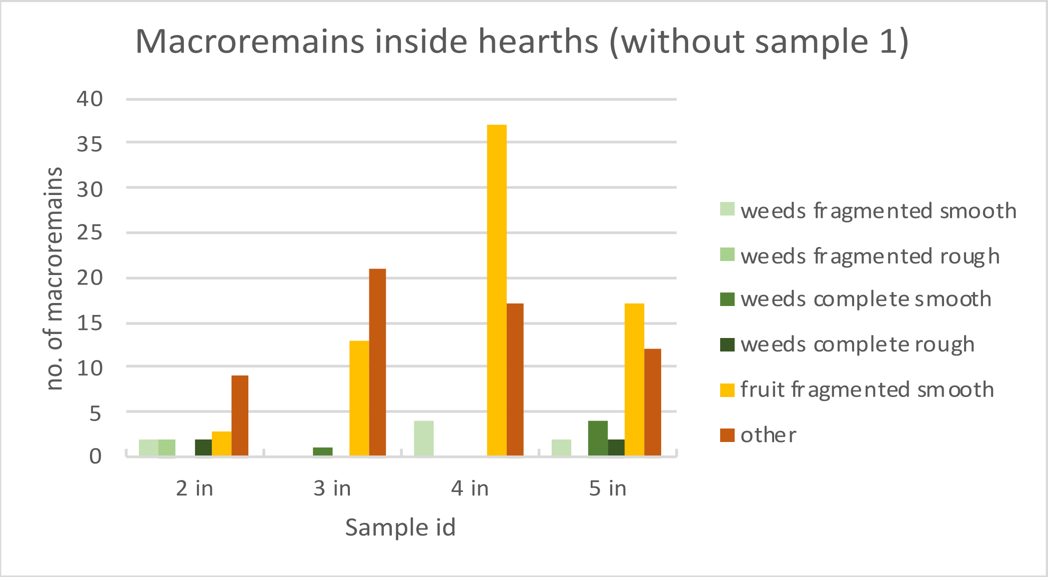

Figure 11. Recovered macroremains only from inside samples of hearths 2 to 5 (see figure 10 for hearth 1 data).

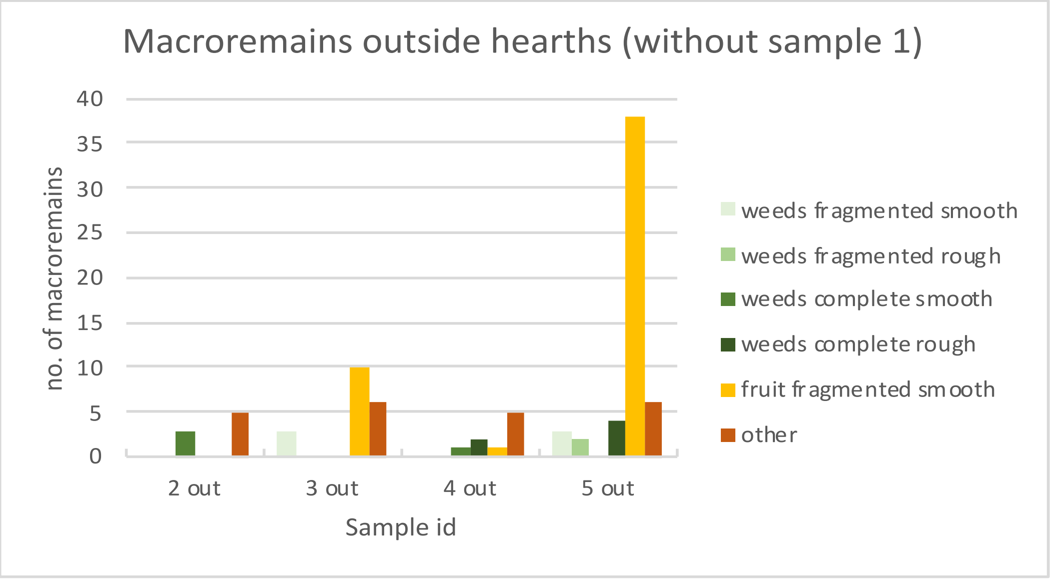

Figure 12. Recovered macroremains only from outside samples of hearths 2 to 5 (see figure 10 for hearth 1 data).

Macrobotanical remains (except wood) were separated and divided into one of the nine groups. First, a distinction was made between weed and fruit seeds. Then between whole and fragmented seeds, and finally a differentiation based on the surface morphology, which could either be smooth or rough. The ninth group consists out of remains that are macrobotanical, but not seeds or wood, such as peduncles, possible pieces of bread, or other botanical fragments that cannot be identified. In the figures, not all of the previously defined groups are represented. This is because no remains were found that belong to those groups in any of the samples. The choice was made not to implement them in the graphs to make the graphs, subjectively, clearer.

There were 20 (almost) complete seeds that still had some diagnostic features. Of only five of these seeds, a taxonomic identification could be made. In total, five *Portulaca* sp. seeds, also known as purslane, were found: two seeds in the inside sample of hearth 2; two seeds in the outside sample of hearth 4; and one seed in the outside sample of hearth 5 (5 out). In figure 13, two of these seeds are presented.

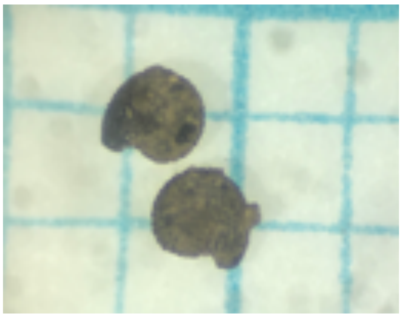

Figure 13. *Portulaca* spp. seeds registered in the hearth features (picture taken by author).

6. Discussion

As previously specified, the main scope of this research is to investigate what foods plants could have been available and used by the former inhabitants of the precolonial site El Flaco. To do this, phytolith and macrobotanical analysis have been carried out on samples taken from the inside and outside of five hearth features. Besides looking only at what was possibly eaten, it is investigated if there are any significant differences between the different hearth features, and between the inside and outside of the hearth features. Because it is generally known that macrobotanical remains are often poorly preserved in the Neotropics (Piperno and Pearsall 1998, 33), this study has also investigated if the macrobotanical analysis was a useful addition to the phytolith analysis.

As stated previously, the results of the macrobotanical analysis are subjected to certain biases. The macrobotanical remains that have been analysed are the result of accidental charring. This means that only food plants that are processed using fire have been preserved. Moreover, only the tougher charred remains have survived the burial and recovery (Piperno and Pearsall 1998, 33). Fruit macroremains are less likely to be preserved than seeds, and accordingly, they have not been found during the macrobotanical analysis. Phytoliths, on the other hand, often survive in sediments in which macrobotanical remains are rarely preserved (Renfrew and Bahn 2012, 253). They do not need to be charred or waterlogged to stay preserved. This is why phytoliths can be identified in the Neotropics that are produced by economic plants that are not processed using fire. However, since the samples of this research have been taken out of hearth features, the same bias is also true for phytolith analysis: only plant foods that are processed using fire are present in the samples.

6.1 What economic plants were found?

The phytolith analysis of the samples has resulted in evidence for the presence of five economic plant groups (six taxa). In each sample, 250 phytoliths have been counted and identified, which makes 2500 phytoliths in total. Out of these 2500 phytoliths, 105 phytoliths belong to economic plants that could have been part of the diet of the former inhabitant of El Flaco. The five economic plant groups that were identified are Marantaceae/Cannaceae, Annonaceae, Cucurbitales, *Cucurbita* spp., and *Zea mays*.

The macrobotanical analysis of the samples has resulted in only one genus identification: *Portulaca* spp. It was impossible to make identification of the other macrobotanical remains because they were either highly fragmented or the diagnostic features were altered too much. Below, relevant data on the origins and the economic importance of the plants and/or broader taxonomic groups identified by means of their phytoliths are discussed.

Marantaceae/Cannaceae

Marantaceae and Cannaceae are two different taxonomic families, but unfortunately, a more precise taxonomic identification could not be made, because both taxa produce the same type of phytoliths. Marantaceae is commonly known as the arrowroot family and the prayer plant family. This family is assigned to the Zingiberales order which consists out of 29 genera and 627 species (Xu and Chang 2017, 913). Marantaceae taxa prefer to live in silty sand or sandy loam soils in partially cleared plots or under light canopies (Pagán-Jiménez 2013, 149). Not all plant species belonging to the Marantaceae family are edible, but since the phytoliths of this family have been identified in the context of a hearth where food is processed, it is likely that they were produced by an edible species (Newsom and Wing 2004, 155).

There are two New World genera belonging to the Marantaceae family that were cultivated for their edible tubers, namely *Maranta* and *Calathea* (Piperno and Pearsall 1998, 115). *Maranta arundiaceae* is the cultivated arrowroot. This species is indigenous to northern lowlands forests of South America. Arrowroot has a high nutritional value and is easily digested. Since it is easily digested, it has been used as food specifically for infants. Arrowroot has also been used as a medication against stomach problems, such as diarrhea, and possibly as an antidote for poisoned arrows (Pagán-Jiménez 2013, 149; Pearsall 2018, 66; Piperno and Pearsall 1998, 115). Arrowroot was also mentioned in the historical chronicles of Fernández de Oviedo. *Calathea* has similar characteristics as arrowroot. This genus consists out of 250 species which all produce rhizomes or tubers that are edible or can be used as medicine (Pagán-Jiménez 2013, 149). There is evidence that *Calathea* species were cultivated and eaten in Precolonial Caribbean contexts (Pagán-Jiménez 2007, 56-58; Piperno and Pearsall 1998, 115). Both arrowroot and the edible *Canna* are native to northern South America and were first introduced by humans early during pre-Saladoid times (ca. 2,100 BC) to the insular Caribbean (Pagán-Jiménez 2009; Pagán-Jiménez 2013, 149-150). The possible use and cultivation of some of these plants are also suggested from the presence of Marantaceae phytoliths in the hearth features from El Flaco.

The Cannaceae family only has one genus: *Canna*. This genus consists out of 10 species that grow in the wild in the Neotropics (Maas-van de Kamer and Maas 2008, 247).

Canna is an herbaceous perennial plant that grows in various climates and elevations. This taxon is not dependent on humans for its reproduction, and it prefers full sun or partially covered settings (Pagán-Jiménez 2013, 150). Canna has been used for multiple purposes. The species have been used for medical purposes. Moreover, the rhizomes of *Canna* have been cultivated for food in the Caribbean (Maas-van Der Kamer and Maas 2008, 266). *Canna indica* is the most important economic species of the Cannaceae family due to its edible rhizomes and usefulness of the leaves for wrapping foodstuffs (Mickleburgh and Pagán-Jiménez 2012, 2472)

Both Marantaceae and Cannaceae taxa are rhizomatous plants. These rhizomatous crops remained an important part of the diet and cultivation practices of pre-Columbian Caribbean peoples (Newsom 2008, 332-333), is consistently identified by means of their starches in several precolonial Caribbean sites up to AD 1,400 (Pagán-Jiménez 2013, 149-150; Pagán-Jiménez and Oliver 2008, 152-155).

Zingiberales/Zingiberaceae

The Zingiberales order includes 68 genera and 2600 species, distributed over eight families. One of these families is Zingiberaceae. The leaves of Zingiberaceae plants could have been potentially used for the wrapping of foods before cooking them directly over coal. The traditional use of the leaves of Zingiberaceae plants has been observed in the making of tamales in Mexico, which is a traditional Mesoamerican dish made of maize-dough steamed in different kind of leaves. Moreover, the leaves of Marantaceae and Heliconiaceae, two other Zingiberales families, were also used in the making of tamales (Lascurain *et al*. 2017, 376-377). No phytoliths were found during the analysis of this thesis that can be identified to the Heliconiaceae family. However, Zingiberaceae and Marantaceae phytoliths were identified. Plants of these taxa could have been part of the surrounding environment of El Flaco, but since they were recovered from the hearth features and their immediate periphery at the site, they could have been providers of raw materials (leaves) to wrap foods.

Annonaceae

Annonaceae is commonly known as the soursop family. The Annonaceae family consists out of 108 genera and approximately 2400 species that are distributed pantropically, but mostly found in rainforests (Richardson *et al*. 2004, 1495). This family contains several Neotropical genera and tree species that produce edible fruits (Piperno and Pearsall 1998, 276). When phytoliths of this family are found in hearth contexts it can be expected that any of the species of the different genera producing this kind of edible fruits contributed the phytoliths into the studied soil matrix. Several species of the Annonaceae family have been important for Caribbean cultures through time, being guanábana (*Annona muricata*) the most important one. Other species of noticeable economic importance for the region are: mangrove annona or *corazón cimarrón* (*A. glabra*), *cherimoya* (*A. cherimola*), sweet sop or *anón* (*A. squamosa*), and custard apple or *corazón* (*A. reticulata*). There is also a wild species of this genus (wild soursop or *A. montana*) naturally distributed in the semi-arid forests of the Caribbean islands. Other genera of the Annonaceae family are also found in the Greater Antilles, though none of them seems to produce edible fruits (Liogier and Martorell 2000, 59-60). Prior to this study, macrobotanical seeds from Annonaceae has been identified by Newsom: Huecoid (Hope Estate 1) context of Hope Estate in Saint Martin (Newsom 1993, 124); Saladoid/Ostionoid site of Barranzas, Ostionoid site of El Bronce, and Ostiones/Capá site of Finca Valencia, all in Puerto Rico (Newsom and Pearsall 2003); and in the Boca Chica site of En Bas Saline in northern Haiti (Newsom and Pearsall 2003) (see Pagán-Jiménez 2007. 55-58).

Arecaceae (palms)

The Arecaceae family or palm family consists out of around 2400 species distributed over 183 genera. Palms are flowering plants that are predominantly found in tropical and subtropical environments. A significant number of palm species thrives in tropical rain forests, but palms are also found in some semi-arid and seasonal environments. Some species even occur in desert habitats. Palms are culturally and economically of great significance. Arecaceae ranks third in overall economic importance, after grasses (Poaceae) and legumes (Fabaceae) (Brokamp 2015, 21-22).

In the precolonial Caribbean, palms were important because they are multipurpose plants. Palms provide wood, leaves, fibre, and in some cases edible fruits. The wood could be used as fuel or as construction material, the leaves could be used as thatch, and the fibre for cordage and other purposes (Newsom and Wing 2004, 142). The palms identified in this study could have been part of the surrounding landscape, but since they were found in and around hearth features, they were most likely used as fuel.

Cucurbitales (wild)

Cucurbitales is a taxonomic order with around 2600 species which occurs mostly in tropical areas in both, the New and Old World (Schaefer and Renner 2011, 122). Almost half of the species of this order is part of the Begoniaceae family. The second largest family is Cucurbitaceae, which comprises 950-980 species in 95 genera. The six smaller families are Anisophylleaceae, Apodanthaceae, Coriariaceae, Corynocarpaceae, Datiscaceae, and Tetramelaceae (Schaefer and Renner 2011, 122).

Cucurbitaceae, also known as the squash or gourd family is possibly one of the most important economic species of the order. Within that family, bottle gourd (*Lagenaria siceraria*) is a species that originated in the semi-dry tropical lowlands of Africa. The seeds of gourds are dispersed by fruits that float away from the parent plant. “Wild African gourds washed out to sea in the south Atlantic would be carried west by the south equatorial current, ending up on the coast of Brazil or the northern South American coast” (Piperno & Pearsall 1998, 140). This probably has been the mechanism that resulted in the dispersal of gourds into the New World. Experiments have been carried out that show that the seeds in gourds are still viable after 224 days of floating in seawater. Once the gourds reached the shores of South America, humans took care of the further dispersal of the gourds (Piperno and Pearsall 1998, 140).

There is a possibility that *Lagenaria siceraria* could have produced the identified wild Cucurbitales phytoliths. The morphology of the phytoliths produced by *Lagenaria siceraria* as described by Piperno *et al*. (2002, 10926) resembles the morphology of the recovered phytoliths identified as wild Cucurbitales. However, due to the lack of more morphometric information regarding these phytoliths and their range of variation in the literature, they were classified to the order level.

***Cucurbita* spp. (domesticated)**

Within Cucurbitaceae there is also an archaeologically remarkable plant genus, *Cucurbita* spp. For more than 12.000 years, cucurbits have been associated with human culture and diet, both in the Old and New Worlds. An important characteristic of the family are the fruits of cultivated cucurbits, which show a lot of variation in shape, colour patterns, and size. Many species produce edible fruits, but cucurbits have also been important in traditional medicines. The fruits can also serve as containers or even as musical instruments (Lebeda *et al*. 2007, 272-273). *Cucurbita* spp. includes five domesticated species which produce phytoliths that are distinguishable from those that are produced by other Cucurbitales plants (Lebeda *et al*. 2007, 293). These five species are: *Cucurbita pepo*, *C. moschata*, *C. argyrosperma*, *C. maxima*, and *C. ficifolia* (Piperno *et al*. 2002. 10923-10924).

The genus *Cucurbita* is only native to the New World and consists out of between 12 and 15 species of bottle gourds and squashes. The domesticated Cucurbita species are, genetically speaking, relatively isolated and thus not derived from a common ancestor. Each species was domesticated independently from the others in different regions (Piperno and Pearsall 1998, 142). These squashes are grown in the dry season because they prefer moderate rainfall. They are adapted to a wide variety of environments in the Neotropics (Piperno and Pearsall 1998, 142-147) Historically, the most important domestic *Cucurbita* species used in the Dominican Republic is *Cucurbita moshata*, locally known by its indigenous name (presumably of Arawak origin) *auyama*. Fruits and plants of this genus were briefly described by Fernández de Oviedo y Valdés (1851) when visiting Hispaniola and the continental lands of South America. To the best of our knowledge, this is the first time that confirmed microbotanical remains (phytoliths) of the genus *Cucurbita* are officially reported and published for the Caribbean islands, confirming its presence and use by indigenous peoples as attested by Fernández de Oviedo y Valdés more than 500 years ago.

Nowadays, in other regions, these vegetables are often grown for their flesh, but the flesh of wild squashes is stingy and bitter. Therefore, initial cultivation of squashes was probably due to the edible, protein-rich seeds or because some were used as containers. These squash species are adapted to a wide variety of environmental conditions in the Neotropics. They can be found from the cool Andean and temperate zones to the humid lowlands (Piperno and Pearsall 1998, 142-147).

Zea mays

Zea mays is a species, commonly known as maize or corn, within the Poaceae family. Maize is a domesticated plant species and for its reproduction and dispersal, it is completely dependent on humans. Maize needs open or cleared spaces and sufficient water to grow. To achieve this, the cultivated plots had to be consistently worked (Pagán-Jiménez 2013, 148). As stated earlier, *Zea mays* produce some phytoliths that can be distinguished from those produced by other Poaceae plants. In this study, diagnostic phytoliths of this plant were registered. One type of registered maize phytoliths (cross variant 1) only indicates the presence of maize, since it is also produced by the leaves of maize. However, another identified phytolith type (wavy top rondel) is only produced in the maize cob, which indicates that they were handled and likely processed.

After the domestication of maize in Mexico around 7500-6800 BC, it was quickly translocated by humans throughout the Neotropics (Pagán-Jiménez *et al*. 2015, 231). The earliest evidence for maize in the Caribbean is found in Trinidad, where recovered starches from grinding stones date to 5790-5670 BC (Pagán-Jiménez *et al*. 2015, 242-244). Additionally, stone processing artefacts, as well as ceramic cooking pots, griddles, shell artefacts and human dental calculus from sites located in Puerto Rico, Cuba, the Dominican Republic, Vieques, Saba and several islands of the Lesser Antilles have been analysed which provided robust and continuous evidence for maize use through all the precolonial ages of the region (Mickleburgh and Pagán-Jiménez 2012, 2470; Pagán-Jiménez 2011, 96-104; Pagán-Jiménez 2013, 148).

Due to the poor preservation of macrobotanical remains in the Caribbean, archaeologists often relied on ethnohistorical sources for information about the plant foods in the diet of the ancient indigenous peoples of the Caribbean. Because of the ethnohistorical sources and the scarcity of archaeobotanical data, it has long been assumed that maize was introduced relatively late to the Caribbean islands and that maize contributed little to the overall diet of the precolonial inhabitants (Mickleburgh and Pagán-Jiménez 2015, 2469). Manioc, on the other hand, has long been thought to have been a staple crop, even though paleoethnobotanical evidence of manioc has been extremely scarce in the Caribbean (Mickleburgh and Pagán-Jiménez 2012, 2474-2475). Figueredo (2015, 122) argues that European settlers promoted the cultivation of manioc, because manioc bread lasted longer than maize bread, and the ethnohistorical sources, therefore, exaggerated its importance.

Recent starch grain and stable isotope studies have given new insights about the importance of maize in the Caribbean (de Armas *et al*. 2015; Laffoon *et al*. 2016; Mickleburgh and Pagán-Jiménez 2012; Pagán-Jiménez *et al*. 2015). Starch grain studies show that maize was more commonly consumed than traditionally thought. However, stable isotope analyses suggest that maize was never a primary crop and its contribution to the overall diet was low, but consistent and ubiquitous throughout the region. Stable isotope analyses also show that many individuals appear to have eaten maize in moderate quantities, which suggests that it was not a restricted food source. Maize seems not to have been restricted to elites, and there are no differences in maize consumption between males and females (Mickleburgh and Pagán-Jiménez 2012, 2475).

***Portulaca* spp.**

Portulaca spp., also known as purslane, is a genus in the Portulacaceae family. Seeds of this genus have been identified in the macrobotanical analysis. This genus is widely distributed in the Neotropics. The genus consists out of between 40 to 100 species

(Coelho *et al*. 2010, 37). Purslane is an herbaceous plant and its parts are edible (Newsom and Wing 2004, 95). It prefers open, disturbed-ground environments, and the seeds of purslane are circa 0.5-1.0 mm. Purslane has been interpreted before as an invasive plant, so accordingly, it is likely that the seeds were accidentally carbonised, and that the plant was never consumed (Newsom 1993, 101).

Thus, archaeobotanical remains from seven different economically important taxa have been identified during the phytolith and macrobotanical analysis. Only the six taxa identified in the phytolith analysis were economically important for the inhabitants of El Flaco. Portulaca spp. was most likely accidentally charred, and not consumed. Some of the taxa were ascribed to higher taxonomic levels, such as order or families. Additionally, phytoliths of two other important taxa, Zingiberales and Arecaceae, have been found.

These taxa comprise a large number of different species of which only a few species are edible or possess other economic qualities. However, since these taxa have been identified in samples taken from hearth features within an archaeological site clearly ascribed as a hamlet (households and associated activity areas), it can be assumed that the former inhabitants most likely consumed them.

6.2 Differences between hearths

6.2.1 Phytolith analysis

When looking at the phytolith composition of the different samples (see figures 2-4), there are clear differences between the inside and outside samples. The inside samples contain more palm phytoliths compared to the outside samples. The only exception is the outside sample of hearth 5, which contains more palm phytoliths than the inside sample of the heart, and second highest amount palm phytoliths overall. It is logical that the inside sample of the hearth features contain more palm phytoliths than the outside samples because palms (but also other trees) were mostly used as fuel, or as fire starters for the hearths, so you would expect a lot of palm phytoliths inside hearth features. Moreover, palms are abundant phytolith producers and are therefore often overrepresented when compared to other wood taxa (Pearsall 2000, 369).

The outside samples contain, overall, more Poaceae (grass) phytoliths. This can be expected because these samples were taken from the area around the hearths. The hearths in El Flaco have been found in small huts, and on multifunctional artificial mounds (Keegan and Hofman 2016, 129). These cooking areas were not likely overgrown by dense vegetation, but rather with low vegetation such as grasses. However, the inside samples of hearths 3 and 4 contain more Poaceae phytoliths than arboreal or palm phytoliths. Grasses are abundant phytolith producers. They produce a lot more phytoliths than trees and are therefore often overrepresented in the phytolith record (Pearsall 2018, 16). Another possibility is that grass leaves (including maize) could have been periodically used as fire starters.

The inside sample of hearth 1 also seems to be different from the other inside samples, because it yielded an unusual amount of palm phytoliths. Arecaceae has produced almost 80% of the recovered phytoliths. To get such a high percentage of Arecaceae phytoliths, a lot of palms organs have to be burned simultaneously or in a short span of time exactly in the same spot. One possible explanation is that large parts of a house could have been renovated and then, old portions could have been discarded here, or intentionally burned as part of termination (Lucero 2003) or renewal (Samson 2010) rituals in this hearth. At the site El Cabo, in eastern Dominican Republic (7th-16th centuries AD), there is evidence that houses were regularly renewed. During this renewal process, the location where the house stood was levelled and cleaned, and the posts of the old house were disassembled. Only significant posts were kept because they were of ritualistic importance. A new foundation was made with a slight lateral displacement, and the old posts were put in new postholes as symbols of continuity (Samson 2010, 267). Since only the significant posts were kept, the rest of the house must have been discarded. It is possible that these materials were simply burned. There is evidence that palm leaves were used as the roofing of some houses in El Cabo (Samson 2010, 55-57). If all these leaves would be burned in one hearth feature, the phytolith composition of that feature would show a high percentage of palm phytoliths. Since El Flaco and El Cabo are both located in the Dominican Republic and they were occupied in approximately the same period, it might be possible that the same practice of house renewal took place in El Flaco. Therefore, one possible explanation for the high percentage of Arecaceae phytoliths in the inside sample of hearth 1, is that the hearth was used for the burning of the roofing of an old house that was getting renewed.

Another explanation comes from modern ethnographic scenarios of the Caribbean. Pottery makers in Saint Lucia typically use lots of palm leaves in noticeably restricted or reduced open spaces (hearths, or open fires) as part of the final firing of new ceramic objects (NEXUS1492, 2019). So, this is another possibility that could help to explain the high amounts of palm phytoliths concentrated in the inside matrix of hearth 1. This is, this hearth could have been dedicated to the firing of ceramic objects by pottery makers of the hamlet, rather than being exclusively a cooking hearth.

There are also some differences visible when looking at the economic plants that were found in the samples (See figure 5 to figure 7). However, since phytoliths of economic plants are found in small quantities, it is hard to say that any difference is meaningful. The only economic taxa that have been found in sufficient numbers is Marantaceae. There are three samples in which more than 10 Marantaceae phytoliths have been found: hearth 2 outside, and hearth 4 inside and outside. Perhaps hearths 2 and 4 were more extensively used for the processing of Marantaceae than the other hearths.

The only other sample that seems to be clearly different is the inside sample of hearth 5 (5 in). In this sample, 9 Annonaceae phytoliths, and 6 Cucurbitales phytoliths have been identified within the 250 count. Only 4 other Annonaceae phytoliths have been identified within the 250 count in the other 4 samples (hearth 1 outside; 2 outside; 3 inside; 3 outside). Cucurbitales phytoliths have not been identified within the 250 count of any other sample. This suggests that Cucurbitales and Annonaceae plants could have been extensively processed in hearth 5, or that some by-products or waste of these taxa were discarded in the fire.

6.2.2 Macrobotanical analysis

Regarding the macrobotanical analysis results, there are some clear differences (see figures 8-11) between hearths and sample provenances. The inside sample of hearth 1 stands out the most. This sample contained almost 700 fruit seed fragments, which is over 600 fruit seed fragments more than any other sample. In fact, this sample has 47 weed seed fragments, which is 40 more than any other sample. This is the same sample as the one with the unusual amount of palm phytoliths. Perhaps a lot of the fruit seed fragments, that range between 5.6 and 0.5 mm (mostly between 1.9 and 0.5 mm), are from the seeds of palm fruits that were deliberately burned in hearth 1. Unfortunately, these seed fragments couldn’t be identified to any taxa.

Furthermore, two hearth samples have a relatively high amount of fruit seeds fragments: hearths 4 inside and 5 outside. However, these differences seem insignificant in comparison with the amount of fruit seed fragments found in the sample from hearth 1 (inside). In all samples, small amounts of weed seeds were found, with some variation in surface and completeness. Moreover, all samples contained macrobotanical remains belonging to the group “other” that couldn’t be identified due to the lack of a reference collection of these kinds of botanical remains.

6.3 Contribution of phytolith and macrobotanical analysis

In this study, phytolith analysis was used as the main technique in order to investigate which food plants were available and potentially used by the former inhabitants of El Flaco. Phytoliths are produced in high quantities by certain plants, and they often survive in sediments and regions in which other archaeobotanical remains are poorly preserved, such as the Neotropics (Renfrew and Bahn 2012, 253). During the phytolith analysis, six taxonomic groups have been identified that correspond to economically important plants. However, some of these taxa could only be identified to a broad taxonomic level. These levels can comprise a larger number of different species of which only a few could be eaten or used for other purposes. However, since the samples were taken from hearth features, it can be assumed that edible plants produced the recovered phytoliths.

Because only hearth features and their immediate surroundings have been investigated for this study, the results could be considered as biased. However, different from other archaeological features usually studied in Caribbean archaeology, hearths seem to be the more suitable archaeological feature to recover and reveal the availability and use of economic plants (Pagán-Jiménez 2003). Unfortunately, if other food plants were not processed using fire, then they most likely are not represented in this analysis. Only if waste or different by-products from these food plants were thrown or discarded in the fire, they can be represented in the phytolith assemblage, which is a possibility.

One inherent problem of phytolith analysis is that not all plants produce phytoliths, and evidence for their presence can therefore not be found in the phytolith assemblage. Moreover, other economic plants were targeted in this study that produces some diagnostic phytoliths, but these phytoliths could not be found. These taxa are *Manihot esculenta* (manioc), *Calathea allouia* (lerén), *Maranta arundinacea* (arrowroot), and *Canna indica* (purple arrowroot). However, *Calathea allouia*, and *Maranta arundinacea* are part of the Marantaceae family and *Canna indica* is part of the Cannaceae family, which have been identified in this study. *Musa* (banana/plantain) and *Oryza* (rice) are also economic plants, but those are only found in colonial contexts.

Moreover, the abundance in which different phytolith-making taxa produce phytoliths varies greatly. This leads to under- and overrepresentation of many taxa compared to their real abundance in the past (Piperno 2006, 104). The under- and overrepresentation of many taxa makes quantitative analysis difficult. It can be said that the same taxa are more abundant in one sample when compared to another sample, but it is difficult to investigate their true abundance in the past (Pearsall 2018, 61). With phytolith analysis, it is impossible to infer how much a certain plant was actually produced, handled or consumed. However, it is a relevant technique for qualitative analysis, because it can determine their presence and variability through time at the site level (Pearsall 2018, 59).

One of the sub-research topics of this study questions if macrobotanical analysis could contribute anything useful in the Caribbean paleoethnobotanical context. As stated earlier, species diversity in the Caribbean is high, while the archaeobotanical remains are often poorly preserved (Piperno and Pearsall 1998, 31). This is why it is important to use multiple lines of evidence. In this sense, it is always useful to use macrobotanical analysis in combination with other techniques such as phytolith and starch grain analyses.

Since macroremains are usually preserved in charred conditions, quite a lot of remains were recovered in this study. However, the problem was that most of the remains were highly fragmented and no longer identifiable. Another problem encountered is that there was no good reference collection available at Leiden University. "Accurate identification of archaeobotanical remains requires one-to-one comparison between unknown archaeological materials and known plant specimens" (Pearsall 2018, 23). There were 20 seeds that were relatively well preserved and still had some morphological features, but since there was no reference collection, only one identification could be made. Perhaps with a better reference collection, and more experience, more identifications could have been made.

Moreover, as stated earlier, there were some initial problems with this technique. Since only charred macroremains are preserved and investigated, not all plants potentially used are represented in the samples. Only food plants that were burned (or mineralized in some instances) could have been preserved. Only the tougher remains are preserved (Piperno and Pearsall 1998, 33).

Finally, if economically important plants are targeted as part of any macrobotanical analysis in the tropics, it must be assumed from the beginning that there is a huge bias dictated from the ancient past: human behaviour surrounding food preparation. Taxonomically important portions of food plants (seeds, leaves, fruits) are commonly submitted to extremely aggressive processes (scraping, grinding, pounding, cooking) during the early stages of food preparation. Thus, many food plant macroremains could have been integrated into the soils in such undesired conditions. If plant organs previously affected by these processes were also integrated (or thrown) into the hearths, then associated destructive processes of these features (heat, fire) certainly affected them, even more. There are no clear indications in the early chronicles about the ancient use of underground silos or other formal storage systems, rather than pots, for storing stuff. Therefore, the chance of finding ancient, unaltered macrobotanical remains in well-preserved silos or storage containers is minimal. If the use of silos or ceramic containers was employed in precolonial times, then another degrading factor is still present in the tropics: the highly changing weather conditions that accelerate the decomposition of plant-derived organs. In sum, when paleoethnobotanists in the lowland tropics uncover macrobotanical remains of important economic plants still possessing enough taxonomical integrity, it is with all probability because of chance rather than standard preservation of these remains.

Overall, in this study, the macrobotanical analysis has not contributed much. The only taxon that has been identified by this means is Portulaca spp., which could be an invasive plant typically found on disturbed areas. Phytolith analysis, on the other hand, has given at least six taxonomic groups of phytoliths from plants that were most likely part of the plant food repertoire of the former inhabitants of El Flaco. However, estimations about the importance of each taxon regarding plant production, or their contribution to the overall diet, are hard to make using this technique.

7. Conclusion

The main research question of this thesis was "which plant foods could have been part of the diet of the former inhabitants of El Flaco?" To answer this question, phytolith and macrobotanical analysis have been carried out on five hearth features. The results of the phytolith analysis showed that five taxonomic groups (six taxa) were likely consumed: Marantaceae/Cannaceae, Annonaceae, Cucurbitales (wild), *Cucurbita* spp. (domesticated), and *Zea mays*. Their presence does not necessarily indicate that they were consumed, since they could have been used for other purposes than consumption, such as the wrapping of food (Marantaceae/Cannaceae) or as drinking container (Cucurbitales). These taxa could also have been part of the surrounding landscape. However, since the evidence for the presence of these taxa has come from samples taken from hearth features and their periphery, they were likely eaten or used for the preparation of food. Moreover, the macrobotanical analysis provided only one identification. In total, five seeds of Portulaca spp. were identified. This plant is edible, but since it's a highly invasive plant, it was likely accidentally charred and not consumed.

Additionally, Zingiberales/Zingiberaceae and Arecaceae phytoliths (registered here out of the "economic plants" group) were consistently registered through all the samples. It is widely known that these plant families are of noticeable importance for lots of human groups across the tropical regions of the world and the Americas. The obtention of foodstuffs (fruits, trunk starch, and rhizomes), but also of industrial material for the construction of houses (trunks, leaves) and the preparation of wrapped foods (leaves) are some of the key ethnobotanical qualities attributed to them (Newsom and Wing 2004, 142; Lascurain *et al*. 2017, 376-377). However, these findings were always treated here outside the "economic plants" group because their presence in the hearths could have also been influenced by the surrounding environment of the site. The natural range of both plant families includes Caribbean's semi-arid, and humid to very humid sub-tropical forests (Acevedo-Rodríguez and Strong 2005; Liogier and Martorell 2000) and El Flaco site was likely situated in forests with such characteristics in the past.

One sub-question of this research questioned if there were any significant difference between hearth features. One noticeable difference is that the phytolith composition of the inside sample of hearth 1 showed an unusually high amount of palm phytoliths. One possible explanation is that the palm roof of a house structure was burned in this hearth as a termination or renewal ritual (Lucero 2003; Samson 2010). Another possibility is that this hearth was also used for the firing of ceramics and that lots of palm leaves were used as part of the final firing of ceramics as is observed in modern ethnographic scenarios (NEXUS1492, 2019).

Moreover, the macrobotanical analysis of the same sample (inside hearth 1) contained an enormous amount of fruit seed fragments. Perhaps there is a correlation between the remarkable quantities of palm phytoliths and fruits seed fragments in this sample, but unfortunately, the fruit seed fragments could not be identified. There was one other differing sample, the inside of hearth 5, in which a remarkable amount of Annonaceae and Cucurbitales (wild) phytoliths were identified. This hearth was possibly used more often for the preparation and processing of these taxa.

The second and last sub-question of this research questioned the usefulness of macrobotanical analysis in the Neotropics because of the problems and difficulties with the preservation of macrobotanical remains. One of the few ways that macroremains stay preserved in the Neotropics, is in charred conditions. This leads to the bias that only food plants that are processed with fire or waste and/or by-products of food plants that are discarded in the hearths can be preserved. However, this bias is also true for the phytolith analysis of hearth features. Moreover, humans used extremely aggressive processes in the preparation of their food, such as scraping, grinding, pounding, and cooking. This would destroy or significantly alter the macroremains beyond recognition. If these plant foods were also integrated into the hearths, then the fire would affect them even more. This makes the chance to find unaltered macroremains of economic plants very small.

Unfortunately for this research, macrobotanical analysis did not contribute much to the overall results. Most of the macrobotanical remains did not have any distinctive features and were often highly fragmented. Some seeds still had some morphological features that could have led to an identification, but the Faculty of Archaeology of Leiden University does not have a good reference collection for New World plants, which made this impossible.

However, even though the macrobotanical analysis did not contribute much to the research of this thesis, it is important to use multiple types of paleoethnobotanical data when possible because they are complementary. In Caribbean contexts, starch grain analysis is another technique that can be used to obtain information about the diet of the indigenous people. However, for the scope of this thesis, it was impossible to conduct starch grain analysis as well because that would take too much time. But in future research, this would be a great technique to use in combination with phytolith analysis.

In a wider context, this research has created new information about the food plants that could have contributed to the diet of indigenous Caribbean peoples. The native ethnobotany played a fundamental role in the Caribbean Indian cultural and ecological dynamics. Therefore, it is essential to understand the importance and the roles that plant resources had in the various indigenous societies of the Caribbean (Newsom 2008, 173). One essential role of plants was as food sources. Through the research of this thesis, new data has been generated about the role that economically important plants had (fuel, construction material, food preparation, consumption, etc.) in the precolonial hamlet of El Flaco. This new information can be used to provide a clearer spatial and temporal framework of understanding of the human-plant interactions and how they changed throughout history in the Caribbean.

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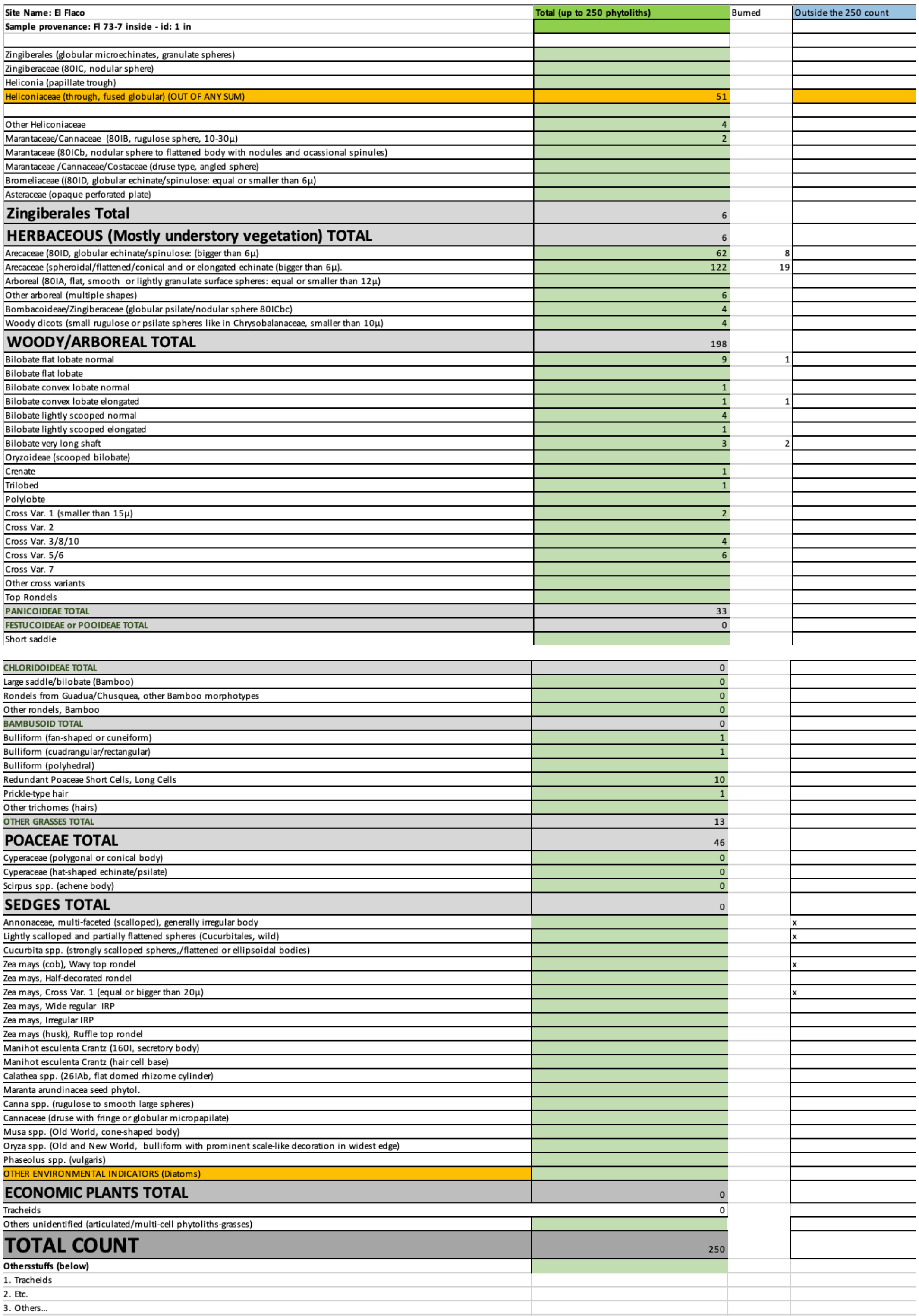
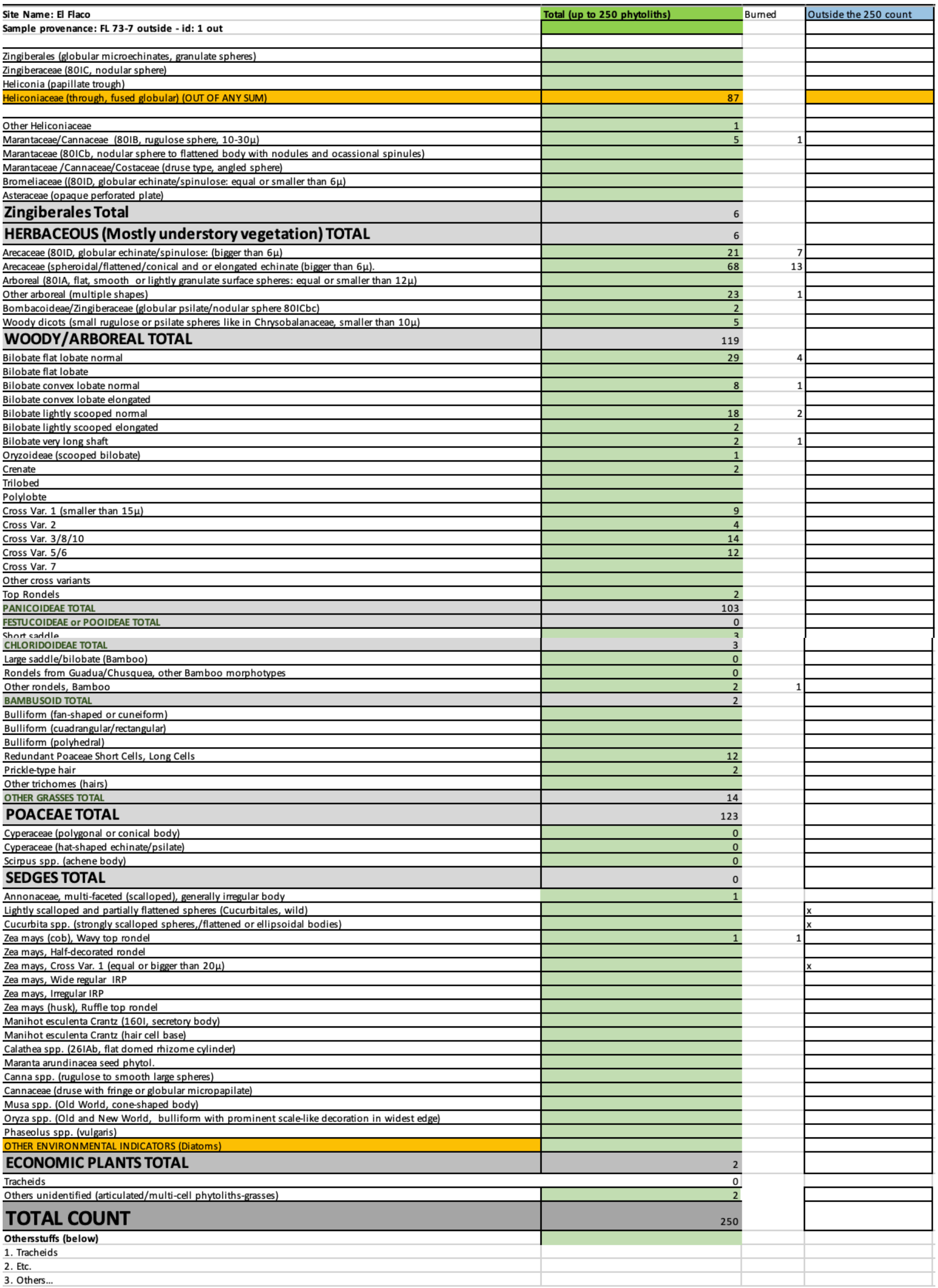
Appendices



Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: Fl 73-7 inside - id: 1 in			
Zingiberales (globular microechinates, granulate spheres)			
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	51		
Other Heliconiaceae	4		
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	2		
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)			
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)			
Zingiberales Total	6		
HERBACEOUS (Mostly understory vegetation) TOTAL	6		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	62	8	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	122	19	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)			
Other arboreal (multiple shapes)	6		
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	4		
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	4		
WOODY/ARBOREAL TOTAL	198		
Bilobate flat lobate normal	9	1	
Bilobate flat lobate			
Bilobate convex lobate normal	1		
Bilobate convex lobate elongated	1	1	
Bilobate lightly scooped normal	4		
Bilobate lightly scooped elongated	1		
Bilobate very long shaft	3	2	
Oryzoideae (scooped bilobate)			
Crenate	1		
Trilobed	1		
Polylobte			
Cross Var. 1 (smaller than 15µ)	2		
Cross Var. 2			
Cross Var. 3/8/10	4		
Cross Var. 5/6	6		
Cross Var. 7			
Other cross variants			
Top Rondels			
PANICOIDEAE TOTAL	33		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle			
CHLORIDOIDEAE TOTAL	0		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)	1		
Bulliform (cuadrangular/rectangular)	1		
Bulliform (polyhedral)			
Redundant Poaceae Short Cells, Long Cells	10		
Prickle-type hair	1		
Other trichomes (hairs)			
OTHER GRASSES TOTAL	13		
POACEAE TOTAL	46		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body			x
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			
Zea mays (cob), Wavy top rondel			x
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)			x
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	0		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)			
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 1. Phytolith composition of the inside sample of hearth 1.



Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: FL 73-7 outside - id: 1 out			
Zingiberales (globular microechinates, granulate spheres)			
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	87		
Other Heliconiaceae	1		
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	5	1	
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)			
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)			
Zingiberales Total	6		
HERBACEOUS (Mostly understory vegetation) TOTAL	6		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	21	7	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	68	13	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)			
Other arboreal (multiple shapes)	23	1	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	2		
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	5		
WOODY/ARBOREAL TOTAL	119		
Bilobate flat lobate normal	29	4	
Bilobate flat lobate			
Bilobate convex lobate normal	8	1	
Bilobate convex lobate elongated			
Bilobate lightly scooped normal	18	2	
Bilobate lightly scooped elongated	2		
Bilobate very long shaft	2	1	
Oryzoideae (scooped bilobate)	1		
Crenate	2		
Trilobed			
Polylobte			
Cross Var. 1 (smaller than 15µ)	9		
Cross Var. 2	4		
Cross Var. 3/8/10	14		
Cross Var. 5/6	12		
Cross Var. 7			
Other cross variants			
Top Rondels	2		
PANICOIDEAE TOTAL	103		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle	3		
CHLORIDOIDEAE TOTAL	3		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	2	1	
BAMBUSOID TOTAL	2		
Bulliform (fan-shaped or cuneiform)			
Bulliform (cuadrangular/rectangular)			
Bulliform (polyhedral)			
Redundant Poaceae Short Cells, Long Cells	12		
Prickle-type hair	2		
Other trichomes (hairs)			
OTHER GRASSES TOTAL	14		
POACEAE TOTAL	123		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body	1		
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			x
Zea mays (cob), Wavy top rondel	1	1	
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)			x
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	2		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)	2		
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 2. Phytolith composition of the outside sample of hearth 1.

Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: FL 45-33 inside - id: 2 in			
Zingiberales (globular microechinates, granulate spheres)	2		
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	46		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	7	1	
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)			
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)	3		
Zingiberales Total	9		
HERBACEOUS (Mostly understory vegetation) TOTAL	12		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	7	1	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	112	16	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)	3		
Other arboreal (multiple shapes)	28	2	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	8		
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	18		
WOODY/ARBOREAL TOTAL	176		
Bilobate flat lobate normal	12	1	
Bilobate flat lobate			
Bilobate convex lobate normal	3	1	
Bilobate convex lobate elongated	2	1	
Bilobate lightly scooped normal	5		
Bilobate lightly scooped elongated			
Bilobate very long shaft			
Oryzoideae (scooped bilobate)			
Crenate	2		
Trilobed			
Polylobte			
Cross Var. 1 (smaller than 15µ)	4		
Cross Var. 2	4		
Cross Var. 3/8/10			
Cross Var. 5/6	9		
Cross Var. 7			
Other cross variants			
Top Rondels	7	2	
PANICOIDEAE TOTAL	48		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle			
CHLORIDOIDEAE TOTAL	0		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)	1		
Bulliform (cuadrangular/rectangular)			
Bulliform (polyhedral)			
Redundant Poaceae Short Cells, Long Cells	11		
Prickle-type hair	2	1	
Other trichomes (hairs)			
OTHER GRASSES TOTAL	14		
POACEAE TOTAL	62		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body			x
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			x
Zea mays (cob), Wavy top rondel			
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)			
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	0		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)			
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

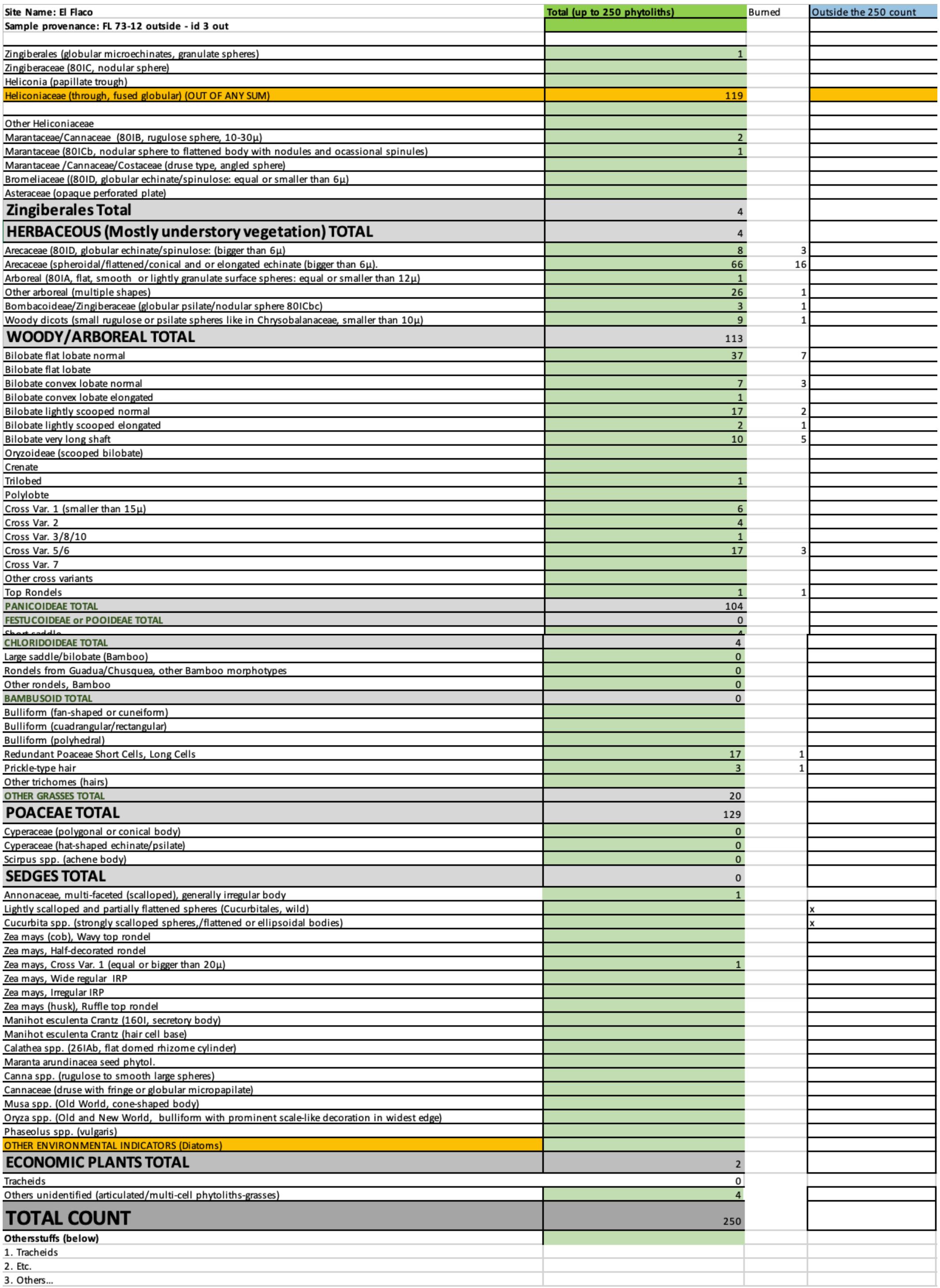
Appendix 3. Phytolith composition of the inside sample of hearth 2.

Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: FL 45-33 outisde - id: 2 out			
Zingiberales (globular microechinates, granulate spheres)	2		
Zingiberaceae (80IC, nodular sphere)	1		
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	50		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	9	2	
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)	3		
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)	1		
Zingiberales Total	15		
HERBACEOUS (Mostly understory vegetation) TOTAL	16		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	8	1	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	53	9	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)	4		
Other arboreal (multiple shapes)	24		
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	9	1	
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	18	1	
WOODY/ARBOREAL TOTAL	116		
Bilobate flat lobate normal	25	15	
Bilobate flat lobate			
Bilobate convex lobate normal	10	6	
Bilobate convex lobate elongated	4		
Bilobate lightly scooped normal	9	5	
Bilobate lightly scooped elongated			
Bilobate very long shaft	5	4	
Oryzoideae (scooped bilobate)	2	2	
Crenate			
Trilobed	9	4	
Polylobte			
Cross Var. 1 (smaller than 15µ)	3		
Cross Var. 2	5	1	
Cross Var. 3/8/10	2		
Cross Var. 5/6	5	1	
Cross Var. 7	1		
Other cross variants			
Top Rondels			
PANICOIDEAE TOTAL	80		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle	5		
CHLORIDOIDEAE TOTAL	5		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	1		
BAMBUSOID TOTAL	1		
Bulliform (fan-shaped or cuneiform)			
Bulliform (cuadrangular/rectangular)	4		
Bulliform (polyhedral)	1		
Redundant Poaceae Short Cells, Long Cells	21	1	
Prickle-type hair	3	1	
Other trichomes (hairs)	1		
OTHER GRASSES TOTAL	30		
POACEAE TOTAL	118		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body	1		
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			
Zea mays (cob), Wavy top rondel	1		
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)	1	1	
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	3		
Tracheids			
Others unidentified (articulated/multi-cell phytoliths-grasses)			
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 4. Phytolith composition of the outside sample of hearth 2.

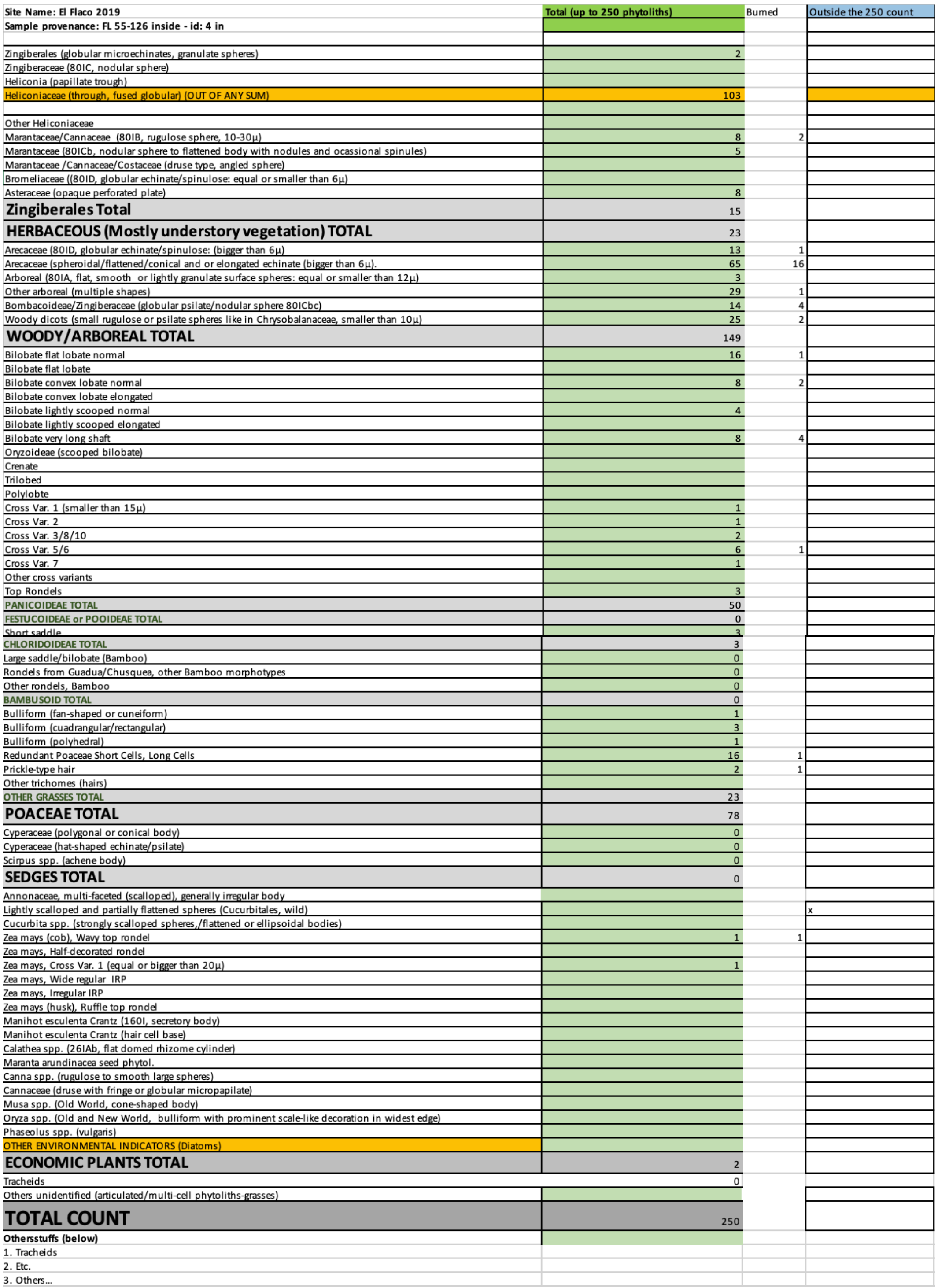
Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: FL 73-12 inside - id: 3 in			
Zingiberales (globular microechinates, granulate spheres)	3		
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	98		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	8		
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)	2		
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)			
Zingiberales Total	13		
HERBACEOUS (Mostly understory vegetation) TOTAL	13		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	10		
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	79	10	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)			
Other arboreal (multiple shapes)	36	5	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	3		
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	9	1	
WOODY/ARBOREAL TOTAL	137		
Bilobate flat lobate normal	18	3	
Bilobate flat lobate			
Bilobate convex lobate normal	7		
Bilobate convex lobate elongated	1	1	
Bilobate lightly scooped normal	7		
Bilobate lightly scooped elongated	2		
Bilobate very long shaft	10	6	
Oryzoideae (scooped bilobate)			
Crenate			
Trilobed	3	1	
Polylobte			
Cross Var. 1 (smaller than 15µ)	7	1	
Cross Var. 2	6	1	
Cross Var. 3/8/10	6		
Cross Var. 5/6	8	1	
Cross Var. 7			
Other cross variants			
Top Rondels	3		
PANICOIDEAE TOTAL	78		
FESTUCOIDEAE or POOIDEAE TOTAL			
Short saddle	1		
CHLORIDOIDEAE TOTAL	1		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)			
Bulliform (cuadrangular/rectangular)			
Bulliform (polyhedral)			
Redundant Poaceae Short Cells, Long Cells	18		
Prickle-type hair	1		
Other trichomes (hairs)			
OTHER GRASSES TOTAL	19		
POACEAE TOTAL	99		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body	1		
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)	1		
Zea mays (cob), Wavy top rondel			
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)	1		
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	3		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)			
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 5. Phytolith composition of the inside sample of hearth 3.



Site Name: El Flaco	Total (up to 250 phytoliths)	Burned	Outside the 250 count
Sample provenance: FL 73-12 outside - id 3 out			
Zingiberales (globular microechinates, granulate spheres)	1		
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	119		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	2		
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)	1		
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)			
Zingiberales Total	4		
HERBACEOUS (Mostly understory vegetation) TOTAL	4		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	8	3	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	66	16	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)	1		
Other arboreal (multiple shapes)	26	1	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	3	1	
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	9	1	
WOODY/ARBOREAL TOTAL	113		
Bilobate flat lobate normal	37	7	
Bilobate flat lobate			
Bilobate convex lobate normal	7	3	
Bilobate convex lobate elongated	1		
Bilobate lightly scooped normal	17	2	
Bilobate lightly scooped elongated	2	1	
Bilobate very long shaft	10	5	
Oryzoideae (scooped bilobate)			
Crenate			
Trilobed	1		
Polylobte			
Cross Var. 1 (smaller than 15µ)	6		
Cross Var. 2	4		
Cross Var. 3/8/10	1		
Cross Var. 5/6	17	3	
Cross Var. 7			
Other cross variants			
Top Rondels	1	1	
PANICOIDEAE TOTAL	104		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle	4		
CHLORIDOIDEAE TOTAL	4		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)			
Bulliform (cuadrangular/rectangular)			
Bulliform (polyhedral)			
Redundant Poaceae Short Cells, Long Cells	17	1	
Prickle-type hair	3	1	
Other trichomes (hairs)			
OTHER GRASSES TOTAL	20		
POACEAE TOTAL	129		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body	1		
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			x
Zea mays (cob), Wavy top rondel			
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)	1		
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	2		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)	4		
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 6. Phytolith composition of the outside sample of hearth 3.

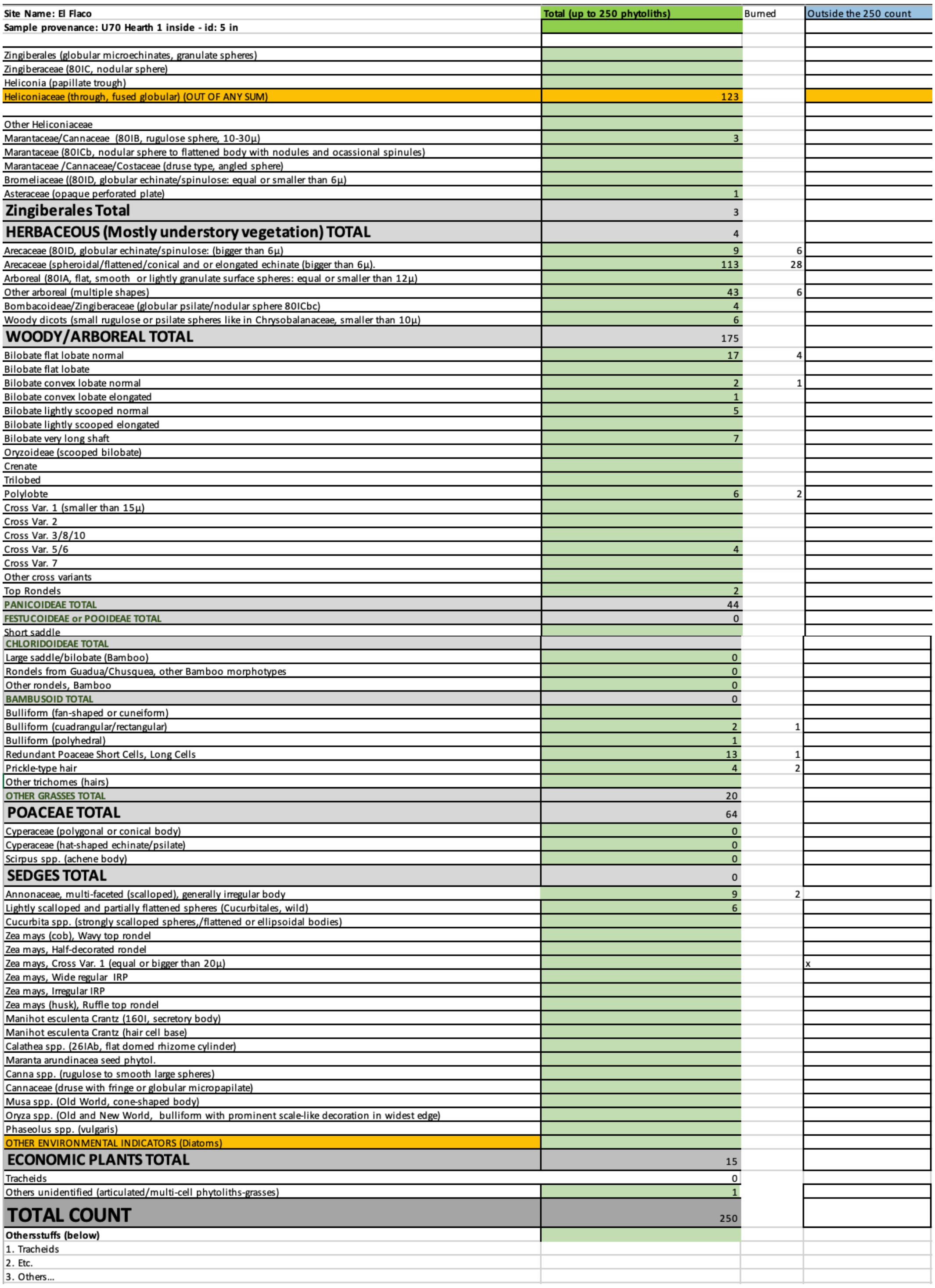


Site Name: El Flaco 2019	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: FL 55-126 inside - id: 4 in			
Zingiberales (globular microechinates, granulate spheres)	2		
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	103		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	8	2	
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)	5		
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)	8		
Zingiberales Total	15		
HERBACEOUS (Mostly understory vegetation) TOTAL	23		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	13	1	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	65	16	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)	3		
Other arboreal (multiple shapes)	29	1	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	14	4	
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	25	2	
WOODY/ARBOREAL TOTAL	149		
Bilobate flat lobate normal	16	1	
Bilobate flat lobate			
Bilobate convex lobate normal	8	2	
Bilobate convex lobate elongated			
Bilobate lightly scooped normal	4		
Bilobate lightly scooped elongated			
Bilobate very long shaft	8	4	
Oryzoideae (scooped bilobate)			
Crenate			
Trilobed			
Polylobte			
Cross Var. 1 (smaller than 15µ)	1		
Cross Var. 2	1		
Cross Var. 3/8/10	2		
Cross Var. 5/6	6	1	
Cross Var. 7	1		
Other cross variants			
Top Rondels	3		
PANICOIDEAE TOTAL	50		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle	3		
CHLORIDOIDEAE TOTAL	3		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)	1		
Bulliform (cuadrangular/rectangular)	3		
Bulliform (polyhedral)	1		
Redundant Poaceae Short Cells, Long Cells	16	1	
Prickle-type hair	2	1	
Other trichomes (hairs)			
OTHER GRASSES TOTAL	23		
POACEAE TOTAL	78		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body			
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			
Zea mays (cob), Wavy top rondel	1	1	
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)	1		
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	2		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)			
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 7. Phytolith composition of the inside sample of hearth 4.

Site Name: El Flaco 2019	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: FL 55-126 outside - id: 4 out			
Zingiberales (globular microechinates, granulate spheres)	3		
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	54		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	8	3	
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)	5		
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)	7		
Zingiberales Total	16		
HERBACEOUS (Mostly understory vegetation) TOTAL	23		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	10	1	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	33	4	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)	1		
Other arboreal (multiple shapes)	23		
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	6	1	
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	18	2	
WOODY/ARBOREAL TOTAL	91		
Bilobate flat lobate normal	29	7	
Bilobate flat lobate			
Bilobate convex lobate normal	13	3	
Bilobate convex lobate elongated	4		
Bilobate lightly scooped normal	9	1	
Bilobate lightly scooped elongated	4	1	
Bilobate very long shaft	8	2	
Oryzoideae (scooped bilobate)			
Crenate	4	1	
Trilobed	2	1	
Polylobte			
Cross Var. 1 (smaller than 15µ)	9		
Cross Var. 2	4		
Cross Var. 3/8/10	5		
Cross Var. 5/6	1		
Cross Var. 7			
Other cross variants			
Top Rondels	4		
PANICOIDEAE TOTAL	96		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle	2		
CHLORIDOIDEAE TOTAL	2		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)			
Bulliform (cuadrangular/rectangular)	3		
Bulliform (polyhedral)	1		
Redundant Poaceae Short Cells, Long Cells	23		
Prickle-type hair	8		
Other trichomes (hairs)			
OTHER GRASSES TOTAL	35		
POACEAE TOTAL	135		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body			x
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)	1		
Zea mays (cob), Wavy top rondel	1		
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)	1		
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	3		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)			
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 8. Phytolith composition of the outside sample of hearth 4.



Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: U70 Hearth 1 inside - id: 5 in			
Zingiberales (globular microechinates, granulate spheres)			
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	123		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	3		
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)			
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)	1		
Zingiberales Total	3		
HERBACEOUS (Mostly understory vegetation) TOTAL	4		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	9	6	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	113	28	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)			
Other arboreal (multiple shapes)	43	6	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	4		
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	6		
WOODY/ARBOREAL TOTAL	175		
Bilobate flat lobate normal	17	4	
Bilobate flat lobate			
Bilobate convex lobate normal	2	1	
Bilobate convex lobate elongated	1		
Bilobate lightly scooped normal	5		
Bilobate lightly scooped elongated			
Bilobate very long shaft	7		
Oryzoideae (scooped bilobate)			
Crenate			
Trilobed			
Polylobte	6	2	
Cross Var. 1 (smaller than 15µ)			
Cross Var. 2			
Cross Var. 3/8/10			
Cross Var. 5/6	4		
Cross Var. 7			
Other cross variants			
Top Rondels	2		
PANICOIDEAE TOTAL	44		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
Short saddle			
CHLORIDOIDEAE TOTAL			
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)			
Bulliform (cuadrangular/rectangular)	2	1	
Bulliform (polyhedral)	1		
Redundant Poaceae Short Cells, Long Cells	13	1	
Prickle-type hair	4	2	
Other trichomes (hairs)			
OTHER GRASSES TOTAL	20		
POACEAE TOTAL	64		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body	9	2	
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)	6		
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			
Zea mays (cob), Wavy top rondel			
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)			x
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	15		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)	1		
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 9. Phytolith composition of the inside sample of hearth 5.

Site Name: El Flaco	**Total (up to 250 phytoliths)**	Burned	Outside the 250 count
Sample provenance: U70 H1 outisde - id: 5 out			
Zingiberales (globular microechinates, granulate spheres)			
Zingiberaceae (80IC, nodular sphere)			
Heliconia (papillate trough)			
Heliconiaceae (through, fused globular) (OUT OF ANY SUM)	84		
Other Heliconiaceae			
Marantaceae/Cannaceae (80IB, rugulose sphere, 10-30µ)	4		
Marantaceae (80ICb, nodular sphere to flattened body with nodules and ocassional spinules)			
Marantaceae /Cannaceae/Costaceae (druse type, angled sphere)			
Bromeliaceae ((80ID, globular echinate/spinulose: equal or smaller than 6µ)			
Asteraceae (opaque perforated plate)			
Zingiberales Total	4		
HERBACEOUS (Mostly understory vegetation) TOTAL	4		
Arecaceae (80ID, globular echinate/spinulose: (bigger than 6µ)	4	1	
Arecaceae (spheroidal/flattened/conical and or elongated echinate (bigger than 6µ).	141	56	
Arboreal (80IA, flat, smooth or lightly granulate surface spheres: equal or smaller than 12µ)			
Other arboreal (multiple shapes)	24	4	
Bombacoideae/Zingiberaceae (globular psilate/nodular sphere 80ICbc)	2		
Woody dicots (small rugulose or psilate spheres like in Chrysobalanaceae, smaller than 10µ)	4		
WOODY/ARBOREAL TOTAL	175		
Bilobate flat lobate normal	19		
Bilobate flat lobate			
Bilobate convex lobate normal	6		
Bilobate convex lobate elongated	2		
Bilobate lightly scooped normal	5		
Bilobate lightly scooped elongated			
Bilobate very long shaft	1		
Oryzoideae (scooped bilobate)			
Crenate			
Trilobed	2		
Polylobte			
Cross Var. 1 (smaller than 15µ)	3	2	
Cross Var. 2	2		
Cross Var. 3/8/10	3		
Cross Var. 5/6	7		
Cross Var. 7			
Other cross variants			
Top Rondels	1		
PANICOIDEAE TOTAL	51		
FESTUCOIDEAE or POOIDEAE TOTAL	0		
CHLORIDOIDEAE TOTAL	0		
Large saddle/bilobate (Bamboo)	0		
Rondels from Guadua/Chusquea, other Bamboo morphotypes	0		
Other rondels, Bamboo	0		
BAMBUSOID TOTAL	0		
Bulliform (fan-shaped or cuneiform)	1		
Bulliform (cuadrangular/rectangular)			
Bulliform (polyhedral)			
Redundant Poaceae Short Cells, Long Cells	16		
Prickle-type hair	1		
Other trichomes (hairs)			
OTHER GRASSES TOTAL	18		
POACEAE TOTAL	69		
Cyperaceae (polygonal or conical body)	0		
Cyperaceae (hat-shaped echinate/psilate)	0		
Scirpus spp. (achene body)	0		
SEDGES TOTAL	0		
Annonaceae, multi-faceted (scalloped), generally irregular body			x
Lightly scalloped and partially flattened spheres (Cucurbitales, wild)			x
Cucurbita spp. (strongly scalloped spheres,/flattened or ellipsoidal bodies)			
Zea mays (cob), Wavy top rondel			
Zea mays, Half-decorated rondel			
Zea mays, Cross Var. 1 (equal or bigger than 20µ)			x
Zea mays, Wide regular IRP			
Zea mays, Irregular IRP			
Zea mays (husk), Ruffle top rondel			
Manihot esculenta Crantz (160I, secretory body)			
Manihot esculenta Crantz (hair cell base)			
Calathea spp. (26IAb, flat domed rhizome cylinder)			
Maranta arundinacea seed phytol.			
Canna spp. (rugulose to smooth large spheres)			
Cannaceae (druse with fringe or globular micropapilate)			
Musa spp. (Old World, cone-shaped body)			
Oryza spp. (Old and New World, bulliform with prominent scale-like decoration in widest edge)			
Phaseolus spp. (vulgaris)			
OTHER ENVIRONMENTAL INDICATORS (Diatoms)			
ECONOMIC PLANTS TOTAL	0		
Tracheids	0		
Others unidentified (articulated/multi-cell phytoliths-grasses)	2		
TOTAL COUNT	250		
Othersstuffs (below)			
1. Tracheids			
2. Etc.			
3. Others...			

Appendix 10. Phytolith composition of the outside sample of hearth 5.

		Seeds												unknown/others	Trees
		Weeds						Fruits						Other	
Sample ID	**Sieve**	**Frag.**			**Whole**			**Frag.**			**Whole**				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. poin	T. striated		charcoal
1 in	5.6 mm							3							18
F73-7 in	2.0 mm							60						0	VA
	1.0 mm	7						273						13	VA
	0.5 mm	40			4			347						32	VA
	Total	47	0	0	2	0	0	683	0	0	0	0	0	45	VA
			N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant												

Appendix 11. Macroremains composition of the inside sample of hearth 1.

		Seeds												unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	**Frag.**			**Whole**			**Frag.**			**Whole**				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
F73-7 out	5.6 mm														5
1 out	2.0 mm							3						1	F/A
	1.0 mm							28						1	F/A
	0.5 mm	7						42						3	F/A
	Total	7	0	0	0	0	0	73	0	0	0	0	0	5	F/A
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 12. Macroremains composition of the outside sample of hearth 1.

		Seeds												unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	Frag.			Whole			Frag.			Whole				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
2 in	5.6 mm														21
F45-33	2.0 mm							2							F/A
	1.0 mm													2	F/A
	0.5 mm	2	2			2		1						7	F
	Total	2	2	0	0	2	0	3	0	0	0	0	0	9	F/A
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 13. Macroremains composition of the inside sample of hearth 2.

		Seeds												Unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	Frag.			Whole			Frag.			Whole				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		**Charcoal**
F45-33 out	5.6 mm														
2 out	2.0 mm														1
	1.0 mm				1										VF
	0.5 mm				2									5	VF
	Total	0	0	0	3	0	0	0	0	0	0	0	0	5	VF
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 14. Macroremains composition of the outside sample of hearth 2.

		Seeds												unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	Frag.			Whole			Frag.			Whole				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
3 in	5.6 mm														22
F73-12 in	2.0 mm							5						8	VA
	1.0 mm							3						8	A
	0.5 mm				1			5						3	A
	Total	0	0	0	1	0	0	13	0	0	0	0	0	21	A
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 15. Macroremains composition of the inside sample of hearth 3.

		Seeds												unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	Frag.			Whole			Frag.			Whole				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
3 out	5.6 mm							1							2
F73-12 out	2.0 mm							2						1	VF
	1.0 mm	1						2						3	VF
	0.5 mm	1						5						2	VF
	Total	3	0	0	0	0	0	10	0	0	0	0	0	6	VF
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 16. Macroremains composition of the outside sample of hearth 3.

		Seeds												unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	Frag.			Whole			Frag.			Whole				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
4 in	5.6 mm														1
F55-126 inside	2.0 mm							0						1	A
	1.0 mm							11						7	A
	0.5 mm	4						26						9	VA
	Total	4	0	0	0	0	0	37	0	0	0	0	0	17	A
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 17. Macroremains composition of the inside sample of hearth 4.

		Seeds												Unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	Frag.			Whole			Frag.			Whole				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
F55-126 out	5.6 mm														N
4 out	2.0 mm														VF
	1.0 mm														F
	0.5 mm				1		2	1							VF
	Total	0	0	0	1	0	2	1	0	0	0	0	0	5	VF
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 18. Macroremains composition of the outside sample of hearth 4.

		Seeds												unknown/others	Trees
		Weeds						Fruits							
Sample ID	**Sieve**	**Frag.**			**Whole**			**Frag.**			**Whole**				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		charcoal
U70 H1 in	5.6 mm														5
5 in	2.0 mm							2						1	F/A
	1.0 mm				3			5						5	A
	0.5 mm	2			1	2		10						6	VA
	Total	2	0	0	4	2	0	17	0	0	0	0	0	12	A
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 19. Macroremains composition of the inside sample of hearth 5.

		Seeds												Botanical unknow	Trees
		Weeds						Fruits						Unknown/others	
Sample ID	**Sieve**	**Frag.**			**Whole**			**Frag.**			**Whole**				
		smooth	T. point	T. striated	smooth	T. point	T. striated	Smooth	T. point	T. striated	Smooth	T. point	T. striated		**Charcoal**
U70 H1 out	5.6 mm														5
5 out	2.0 mm							4						3	VA
	1.0 mm							13						1	A
	0.5 mm	3	2			3	1	21						2	A
	Total	3	2	0	0	3	1	38	0	0	0	0	0	6	
		N = nothing / VF = very few / F = few / F/A = normal / A = abundant / VA = very abundant													

Appendix 20. Macroremains composition of the outside sample of hearth 5