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THE EL GIGANTE ROCK SHELTER, HONDURAS

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Abstract:

The site of El Gigante, La Paz, Honduras is unique in Central America for its very well preserved organic remains and lengthy archaeological sequence. Preliminary analyses of the ceramics, lithics, botanical and faunal material are presented in a cultural sequence beginning at 9,480 B.C. The botanical remains recovered from the site are inventoried and several species are subjected to preliminary morphometric analyses in order to characterize the assemblage, and assess changes in plant phenotypes through time. The operation of "directional" (artificial) selection is evident at the site for several species, including avocado (*Persea americana*), squash (*Cucurbita* sp., cf. *C. pepo*), and bottle gourd (*Lagenaria siceraria*). While varieties of squashes may have been cultivated in the Archaic, clearly domesticated maize and beans appear to have been introduced in the Formative. However, stratigraphic disconformities in the period of *c.* 5,000 – 2,000 B.C., may bias this conclusion. From early in the sequence, botanical diversity is high, despite changing subsistence specialization and generalization evident in other artifact assemblages. Many undomesticated species are utilized prehistorically and are not lost from the diet despite the intensification of field-based food production of domesticated species. An emphasis is placed on suites of plants, both wild and domesticated, annual and perennial, whose use is integrated through time El Gigante. Together these subsistence systems afforded flexible, energetically efficient and risk minimizing choices to prehistoric foragers. Low level food production is evident as early as the Archaic period. Tree crops were one focus of subsistence practices. The augmentation and management of perennials is inferred from their consistency and prominence in the archaeological record. However, there is also evidence for the use of annual grasses during this time. The data invites further investigation into the landscape level paleoecological past around El Gigante.

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CHAPTER 1: THE SITE OF EL GIGANTE

Introduction

This dissertation concerns the material record recovered from a rock shelter known as "El Gigante." The overriding goal here is to provide archaeological documentation of the excavation of the site. Additionally, a general inventory of what was found through each phase of occupation is presented. Finally, some strong inferences can be drawn concerning the evolution of food production and its constraints and possibilities at this site through time.

It is unclear if the name El Gigante (the Giant) derives from the rock shelter's enormous size, or from a local rumor that very large bones were once found inside. The rock shelter lies in the central Southwest of Honduras, north of the town of Marcala, La Paz. This area straddles the *Cordillera Central* or, Continental Divide of Central America, at an elevation of approximately 1,300 meters above sea level. Figure 1 is a map of all the sites in this area of Honduras that were recorded in the current project including El Gigante. Figure 2 is a map of the local Estanzuela River Valley where El Gigante lies and is refered to in Chapter 2. In addition, Figures 3 and 4 are included for the reader's reference and include sites mentioned throughout the text in both the southern Mesoamerican region and across North and South America.

The site lies in the face of a vertical scarp and therefore, must be entered with the help of a ladder. This scarp, itself, is located half way up a steep, east-facing, valley slope (Photo 1). El Gigante measures 42 meters across the mouth and is 17 meters deep. It has more than 12 meters of head room and approximately 357 square meters of roughly horizontal floor area. The floor of the cave slopes upward to the right as one enters, rising at the north end 3-5 meters higher than the south (see Fig. 5). Perched above the Estanzuela River, El Gigante commands an excellent view both up and down the watershed. Potential benefits of this view include the ability to sight animal prey in the valley bottom and its defensive potential (see Photos 1-4).

Inside, the rock shelter the walls are a light tan, fine grained welded ash tuff with angular sand and gravel size inclusions of pumice and volcanic ejecta. In places the rounded surfaces of the walls are rough with wasp nest casings, and many places are soot stained. The floor is covered with loose ash that creates clouds of dust when disturbed. No vegetation grows inside today, though the entire shelter is extremely well lit. Scattered everywhere on the floor are archaeological remains: bones, flaked stone, and ceramics, as well as corn cobs, woven mats (*petates*), leather, and other perishable materials. This remarkable preservation is afforded by the extremely dry conditions within the rock shelter. The morning sun, rising across the valley, shines onto and warms the entire floor of the shelter, while its depth provides protection from the typical afternoon downpours of the tropical summer. I did not observe rain blowing into the shelter on any occasion during four extended visits over a period of five years.

The El Gigante rock shelter is one of very few known sites in southern Mesoamerica that exhibit a lengthy archaeological sequence. The radiocarbon dates for human occupation of the site range from 9,220 BC to AD 230. The early culture history for this peripheral region of Mesoamerica is largely unexplored, and this study attempts to answer archaeologically fundamental questions of when and in what manner hunter-gatherer populations adapted to the variable environmental conditions of the terminal Pleistocene and early Holocene epochs.

The site straddles the pre-ceramic archaeological horizon, and includes a record of the transition to agriculture, the impact of domesticated plants on the overall diet, and the persistence of a foraging way of life. The first difficulty in the examination of subsistence evolution of this kind and at this scale is the ability to identify and date the incorporation of specific domesticated plant species into prehistoric diets. To clarify the relationship between human behavior and plant modification at El Gigante, I have attempted to measure directional selection of plant phenotypes as an independent variable. I use linear regression to assess morphological change within the sample of botanical remains at El Gigante.

The Discovery of El Gigante

In the early 1990's, the late Dr. George Hasemann, then head of the archaeology division of the *Instituto Hondureño de Antropología e Historia* (IHAH), visited the rock shelter. It was immediately obvious to him, given the density of surface artifacts exposed by recent looting, that the site had great potential. Around the entire rear perimeter of the rock shelter are many shallow pits and piles of turned soil, evidence of historic disturbances and ongoing looting. This looting was a major impetus for the project. Disturbance was highest on the peripheries of what might have been the main living area, against the walls of the shelter and in natural depressions in the bedrock, exposed at the north and south ends of the rock shelter. Unfortunately, this peripheral area may have been the preferred location for prehistoric human interments and burial offerings. As a result, a great wealth of prehistoric human skeletal remains and associated artifacts, may have been lost.

In 1993, Hasemann and the IHAH contracted Christine Hensley-Sherman and Anne Jung to excavate portions of the shelter. Collections were made of surface material disturbed by looting, one of the looter's pit walls was "faced up" to reveal a profile from which datable material was sampled, and additional controlled excavations were made. To the author's knowledge, no finished report was submitted to the IHAH. In 1994, Boyd Dixon and Ron Webb inventoried the artifacts recovered during the 1993 season (Dixon 1994). The inventory included substantial amounts of lithic material, including several varieties of rhyolite, andesite, chert, and obsidian. Several kilograms of floral and faunal material were also recorded. However, the provenience information was unclear and this information is not included in this analyses. The artifacts from these excavations remain in the IHAH laboratory in Tegucigalpa. A brief inspection of the ceramic material recovered in 1993 was undertaken by the late LeRoy Joesink-Mandeville and commented on by Dixon (*ibid.*). In this inspection, Joesink-Mandeville and Michael Mucio identified the assemblage as dominated by Middle to Late Formative Period sherds.

Further testing of the rock shelter in 1994 by Hasemann produced more encouraging results (Hasemann 1996; Lara-Hasemann 2000). Over 2 meters of stratified deposits were reported from a one-by-one meter excavation contiguous with Hensley's. Given the dry conditions, a diverse array of organic remains was preserved including undated corn cobs that were suspected to be the remains of early domestication efforts. The report of a Pre-ceramic level containing what was identified as a possible "Fishtail" projectile point, as well as two separate radiocarbon dates ranging from 9,904 - 9,044 and 8,934 - 8,273 BC (calibrated, 2-sigma, ISGS#2965-2 and 2966-3) suggested the possibility of Paleoindian habitation (*ibid.*). Unfortunately, George Hasemann died in 1998 and both the excavation records and the artifacts recovered during these field investigations are unavailable for treatment in this dissertation.

The Current Project

In 1997, George Hasemann contacted Dr. Kenneth Hirth who introduced him to the author. During the summer of 1998, I undertook a key site survey of the region around Marcala, La Paz (see Fig. 1). These informant driven site visits were meant to determine as quickly as possible if more sites existed with preservation and depth equivalent to those observed at El Gigante within a large geographic area. Our survey method included initiating conversations with the municipal leaders or the mayor (*alcalde*) in several villages of the region, including Marcala, Yarula, Sta. Elena, as well as smaller communities in between and to the north of Marcala. Any information gathered in the informant interviews were followed by site visits, led by local guides. We sought information regarding rock shelters (*abrigos rocosos*) and caves (*cuevas, grutas*) and also regarding the locations of rock art (*arte rupestre*) and sources of obsidian (*obsidiana, roca vidria/negra*).

These key site surveys were undertaken by myself and an IHAH technician in a four-wheel drive vehicle provided by the IHAH. More often than not, sites were reached within a short hike of vehicle access. All the sites we visited were located with GPS, mapped using a Brunton transit and tape, and surface collections of diagnostic and site representative artifacts were made. These collections consist mostly of lithic debitage and ceramic shards. The rock shelters documented in this first season of field work served to form a model of cave and rock shelter use in this region. The functions of these rock shelters varied to include habitation, mortuary use, storage, and water catchment. Some of these functions (more specifically, their material remains) were thought to be potential prehistoric analogs.

The devastation of hurricane Mitch in 1999 caused an interruption in the research. Having not found any comparable sites in the key site surveys, I returned in 2000 to carry out pilot excavations exclusively in El Gigante. These test excavations served to refine the research strategy and field goals for the following seasons. Funding from the Foundation for the Advancement of Mesoamerican Studies Inc. (FAMSI) was secured in 2001 and full-scale data recovery excavations were planned and executed in October through December of that year.

Dissertation Goals

This dissertation is the first archaeological investigation in Honduras of an early Holocene site. The needs of cultures inhabiting this area during the time since then changed from those of the first hunter-gatherers entering an uninhabited continent, into those of peasant farmers supporting chiefdoms and states.

Because of the preservation of organic remains spanning approximately the last 10,000 years, the El Gigante site uniquely allows the testing of a range of questions concerning the evolution of human subsistence economies in the New World. Changes in the way that humans produce food have fundamental implications for both the structure of society and the impact of those societies on the environment. The author is not a specialist in paleoecology, paleoethnobotany, or zooarchaeology, and makes no pretense of providing exhaustive evaluations of any of these data sets. This dissertation provides the preliminary framework upon which future research can be based. The evidence for subsistence changes is summarized and general patterns are sought which stimulate debate concerning evolutionary or developmental models of food production.

At this stage of the research program, the approach is empirical rather than model based. This first treatment of the El Gigante site seeks to solidly introduce the context and occupation history. The end result is necessarily the generation of more hypotheses than their testing against the myriad of available models of subsistence behavior.

This dissertation therefore, has two main goals. First, it provides a local cultural-historical picture of human adaptation during the Holocene. This includes describing the occupation zones encountered at El Gigante and their dating, as well as introducing the assemblage of artifacts recovered in the excavations. The second goal is to begin to form a preliminary evolutionary understanding of subsistence change on the basis of the El Gigante material. This begins with establishing when and what kind of plant and animal foods contributed to the diet throughout the occupational sequence and what they look like.

Chapter 2 reviews what is known about the past environmental context of the site and describes the current site area. The geology of the region is summarized with an eye toward establishing the chronology of the geologic structure's formation. That is, an understanding of the regional geological history informs us as to whether, for example, the shelter was as equally large and hospitable throughout all periods of human occupation. I conclude that the rock shelter was relatively unchanged in its physical dimensions throughout the Holocene. I also review the available climatological evidence from the Holocene period in this area. A general trend of warmer and more humid post-Pleistocene conditions is identified; this is followed by a more-or-less equilibrium state between 5,000 and 3,000 years ago. A drying trend, with increasingly intense droughts associated with El Niño events over the past 3,000 years, may have been a factor in changing food production strategies.

In order to compare the environment of the El Gigante region with others across Mesoamerica and to aid in the possible prediction of past local environmental conditions in the future, I present the results of a limited quantitative vegetation survey. This survey describes the current distribution and make-up of the pine-oak habitat. The environmental conditions within which the inhabitants of El Gigante lived and made decisions concerning subsistence were no doubt radically different. In fact, very few of the species we identified in the current landscape show evidence of being present or used by El Gigante's inhabitants.

In Chapter 3, I present the methodologies used in the excavation of the site as well as post-excavation procedures. The most critical of these procedures is the construction of the site stratigraphic concordance. The concordance translates the excavated provenience (Unit, Level, sub-Level) into a chronologically meaningful stratigraphic system (Strata, sub-strata, sub-sub-Stratum). This translation establishes the original context for all of the site's archaeological remains. The concordance is the basis for the construction of all following archaeological "sequences" as related to El Gigante. Other laboratory and statistical methods that are not directly related to the field excavation are discussed as they relate to the specific assemblage.

Chapter 4 presents the results of the excavation including radiocarbon dating, and the description of the features uncovered. Some of the dates are taken directly from unquestionably cultural material using the AMS radiometric technique. Some of the conventional dates were chosen from features if enough datable material was available and others were chosen from specific excavated proveniences to fill in gaps left by the AMS dates. Three clusters of dates are identified, and these are given archaeological phase names. The record is not continuous, three major disconformities (hiatuses) occur within the stratigraphic sequence. A Paleoindian occupation (Esperanza phase) is separated by a hiatus from a Middle Archaic occupation zone (Marcala phase) which is followed (again after a hiatus) by the Early-Late Formative period occupations (Early and Late Estanzuela phase) (See Plate 1). The record from a large portion of the late Archaic is not represented in the current material. Unfortunately, this gap coincides with a period of major subsistence transformation at other Mesoamerican sites.

Next, I turn to the artifactual contents of the site. The descriptions and analyses of Chapter 5 lay out the material cultural record which I attempt to evaluate in terms of the technologies and the (inferred) behavior they represent. The ceramics, for example, are dominated by utilitarian types and do not indicate any significant affiliations with other cultural groups. I describe several large bifacial projectile points for the earliest, Paleoindian, phase of occupation. The flaked stone debris is looked at in terms of its raw materials and technology of manufacture. Ground stone artifacts occur throughout the sequence with little change, and do not display any trends that might help to infer changes in subsistence regime.

Chapter 5 also evaluates the assemblage of bones found in the excavations. Many highly fragmentary faunal remains were collected. These add to our assessment of diet over the occupational period. Bones of large game animals, for example, diminish through time as a proportion of the faunal assemblage. In addition, the patterns of fragmentation suggest that large game was less intensively processed through time.

Chapter 6 is devoted to the examination of the substantial volume of botanical remains recovered from the excavations. As with the botanical remains, the material was cataloged with the help of undergraduate volunteers and partly with the guidance of Dr. Lee Newsom. Overall, many identifications remain at a general level. Many of the categories do not necessarily represent a specific taxon but are grouped by morphological similarity. The result is a "lumping" conservatism rather than a "splitters" precision with respect to the number of identified species. This is consistent with the broad brush approach taken in these preliminary analyses. All the items cataloged are identified and described in order of their first appearance in the chronology set out in Chapter 4. The earliest inhabitants of El Gigante seemed to rely on core staples (agave, avocado, hog-plum, palm fruit and *Manilkara sp* or *Sideroxylon sp.*) supplemented by game. These items continue to appear throughout the sequence. In the Marcala phase, we see the first appearance of squash and bottle gourd, two of six "key crop plants" as traditionally defined (Smith 2005:9444). In the Estanzuela phase, the remains of game are less abundant and the classic Mesoamerican dietary triad of maize, beans and squash (if indeed they are domesticated in this case) is established within a mixed subsistence economy.

Further specific identifications were made by Lee Newsom after she joined the faculty at PSU and this thesis committee. These are indicated in the text when applicable. I was fortunate enough to have her advice on morphometric descriptions of selected species. These physical measurements allowed us to examine whether directional selection of specific plant traits occurred at El Gigante. For example, it is apparent that both avocado and squash seed size increased in size over time and I believe these changes were human influenced. It may not have been seed size that was selected for but, a correlating trait such as fruit mass. Nonetheless, these changes strongly imply non-random, human selection of plant foods.

The evidence for human-directed selection of size, *etc.* of corn is also considered. First, I conclude that maize arrived at El Gigante relatively late in comparison with other known, early Mesoamerican sites. The assemblage of maize remains is described in morphological terms as well. Corn cobs from El Gigante range between 3 and greater than 5 centimeters in length and do not exhibit a statistical growth in average size through time. The most significant morphological aspect of the assemblage is its intra-assemblage variability. The implications of this for subsistence and adaptation at El Gigante are discussed.

In Chapter 7, the concluding chapter, I try to synthesize the variation observed in the excavated materials. I employ ethnographic analogy and other models of subsistence change. These include behavioral-ecological theories that assess risk and food choice, alternate definitions of the domesticate itself, and models of low-level food production systems (*i.e.* the work of Smith 2001b and others). These “frames of reference” (Binford 200?) represent ways of looking at the middle ground *between* foraging and farming that I believe characterize many adaptations at El Gigante

The final discussion necessarily includes a consideration of the seasonal variation that influences foraging and agricultural behavior and how that may have influenced the occupation of the site. Although there were large changes through the Holocene in average annual temperature and rainfall, there are also significant variations in intra-annual patterns that affected food supply decisions. For either a forager or a farmer, the seasonal moisture regime affecting the frequency and duration of rainfall and temperature are just as important, if not more so, than the annual averages. This is particularly so in this tropical region, where climates exhibit extreme wet/dry-seasons. In the concluding chapter, I attempt to provide a glimpse of how life might have changed throughout the year for El Gigante's occupants and how different subsistence strategies and available plant resources may have been used to decrease the effects of seasonal variation.

Figure 1 Project Study Area

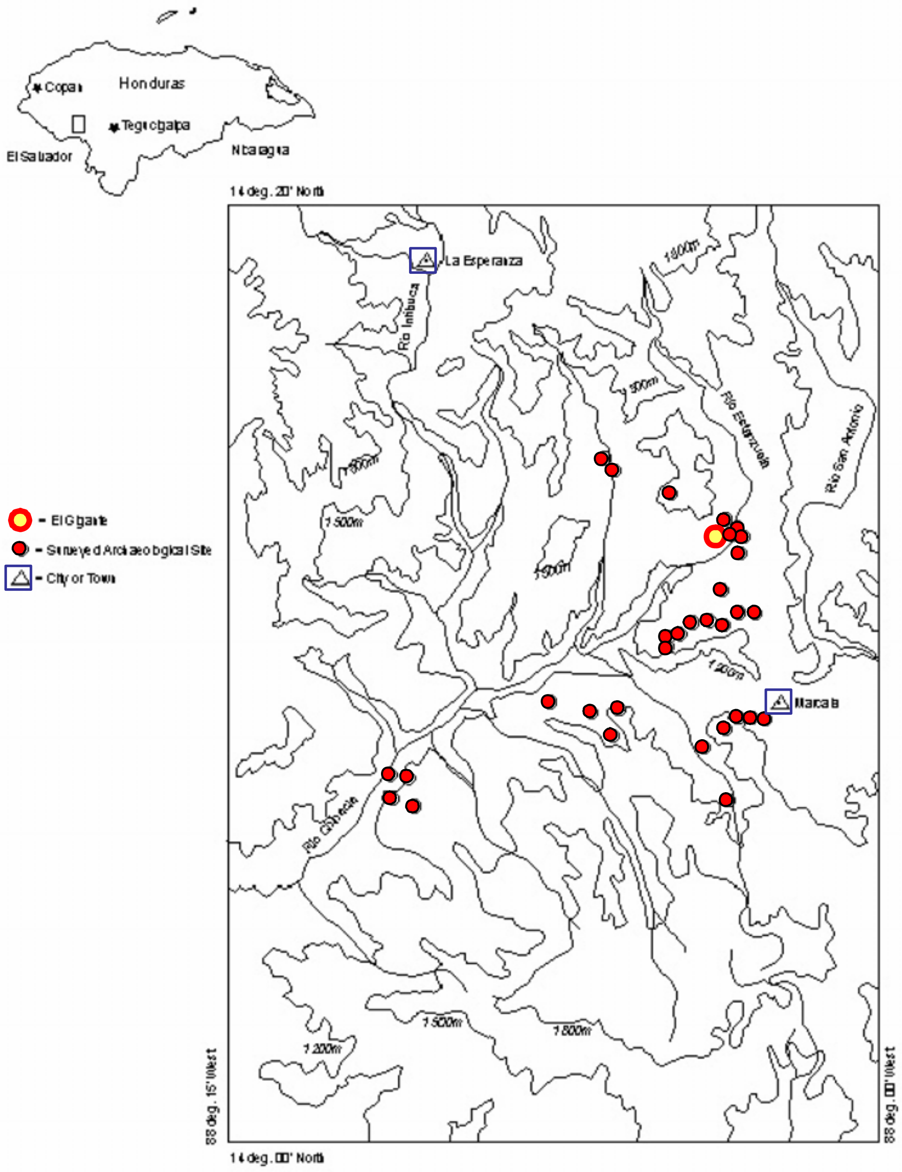


Figure 2 Estanzuela Valley with location of El Gigante and vegetation transects

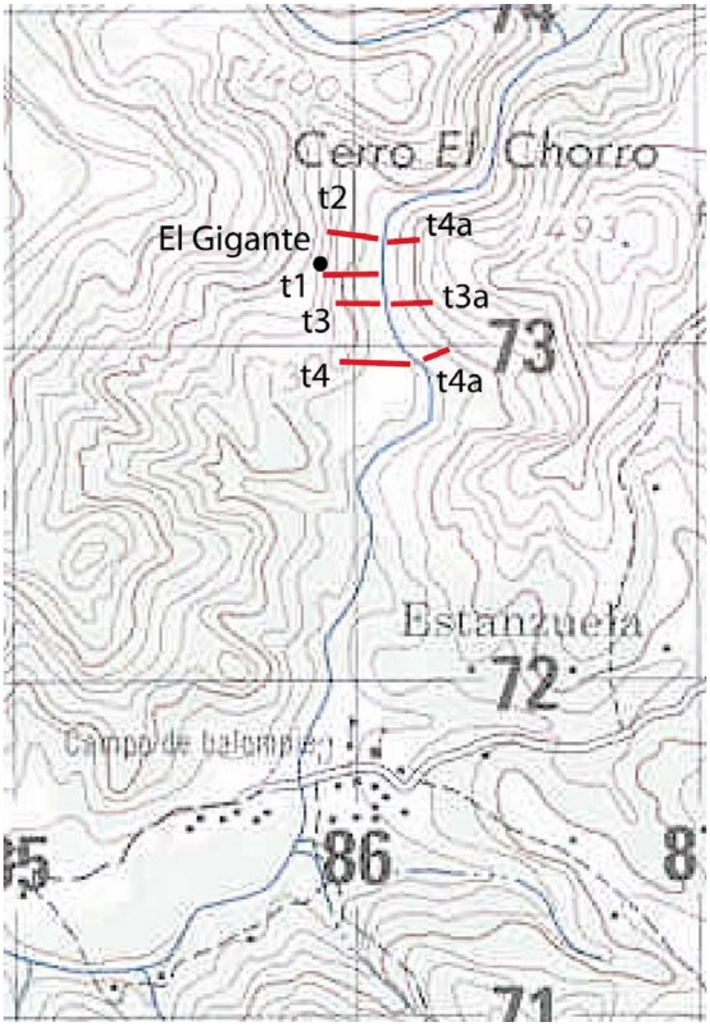


Figure 3 Sites in Lower Mesoamerica mentioned in the text.

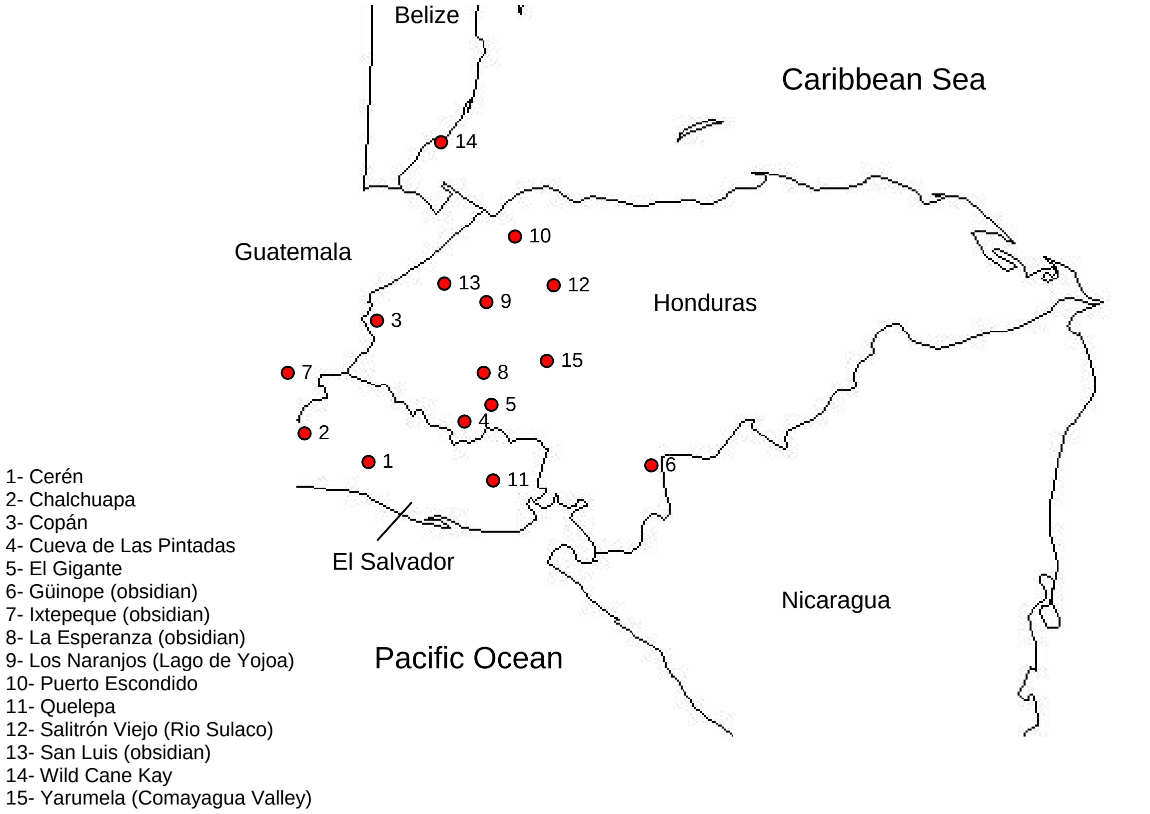


Figure 4 Sites across North and South America mentioned in the text

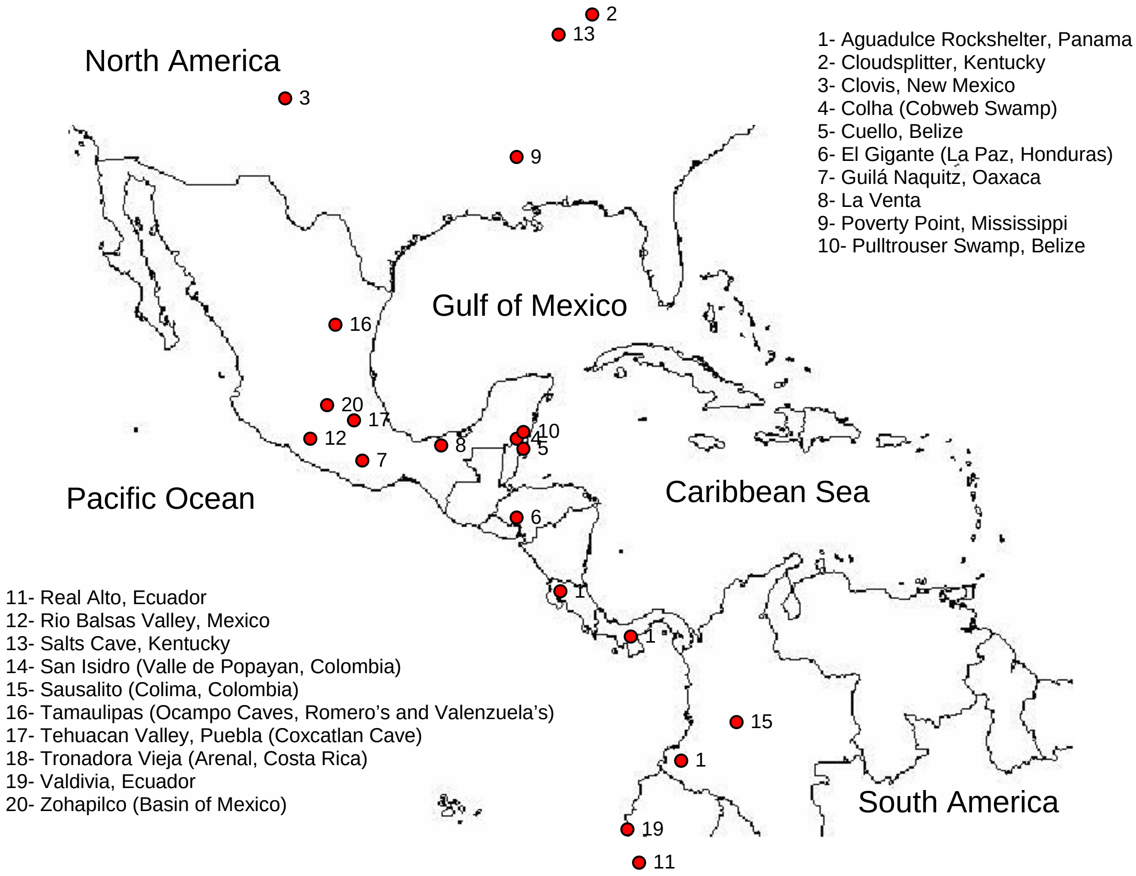


Figure 5 Plan map of the El Gigante rock shelter

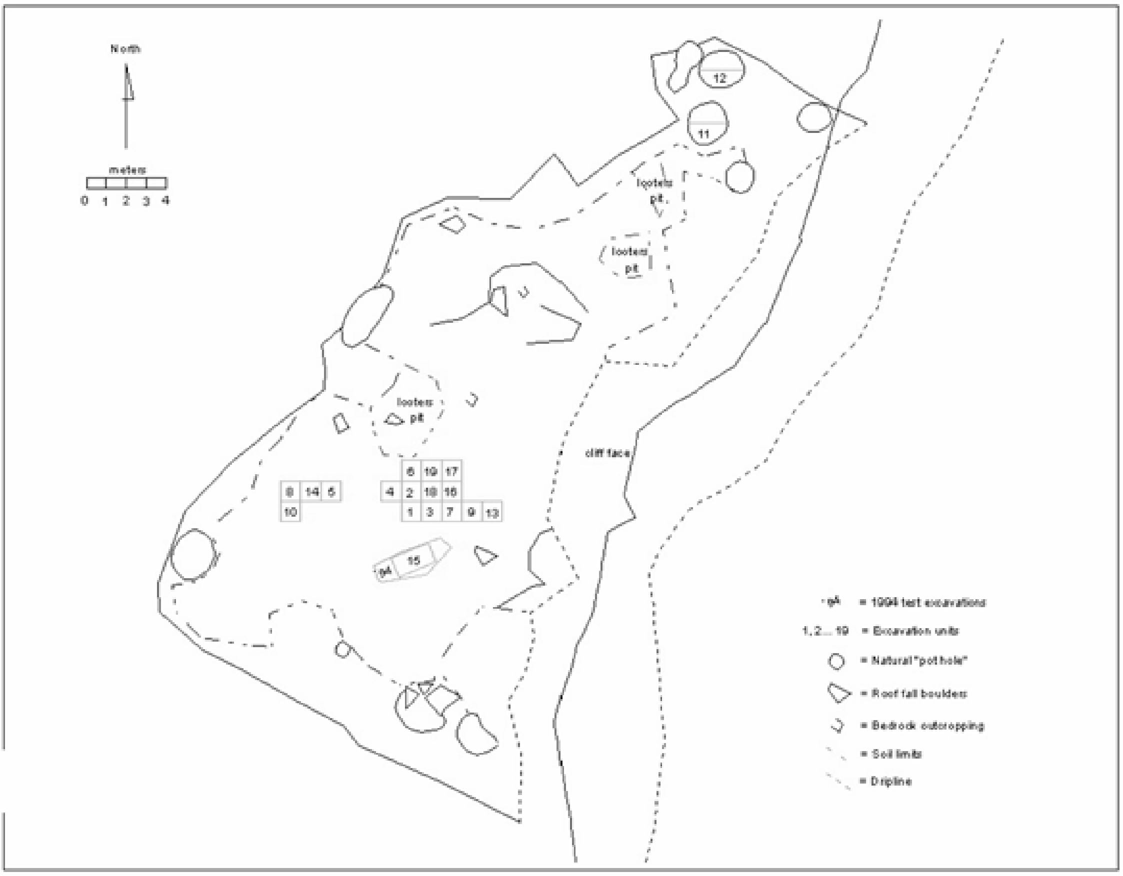
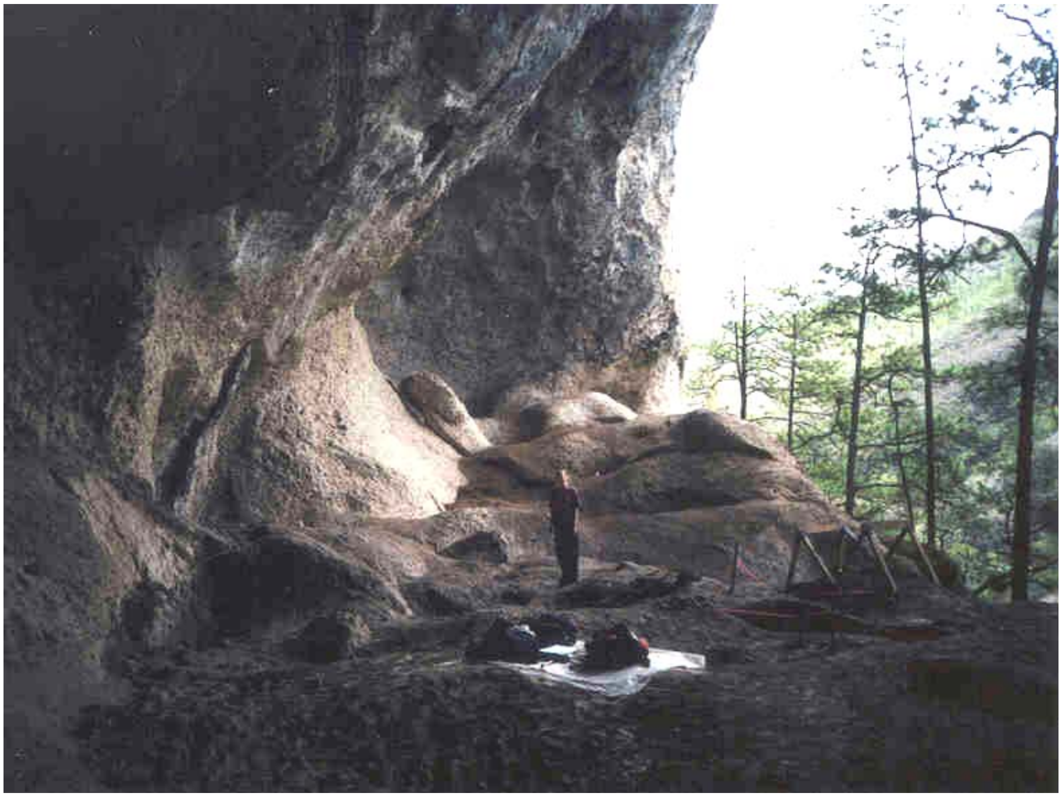


Photo 1 View northwest toward cave from the Estanzuela River

Photo 2 View north above the rock shelter

Photo 3 View south of the interior of El Gigante

Photo 4 View north of the interior of El Gigante



CHAPTER 2: THE ENVIRONMENTAL CONTEXT OF THE EL GIGANTE SITE, PAST AND PRESENT

Environment and subsistence

A local perspective of the changing climate and environment of the Estanzuela Valley since the end of the Pleistocene is necessary if we are to evaluate subsistence adaptations there in any meaningful way. Evaluating what influence local climatic variation could have had on the biota at El Gigante is a necessary step in addressing any changes in food production. The influences of population increase, sedentism, or technological advances can only be identified after controlling for climate changes. Many of the prehistoric patterns we seek to understand hinge on the changing availability and reliability of resources which, while manipulated by human populations, are nonetheless dependent on natural factors outside human control. Unfortunately, there are few paleoenvironmental studies for this geographic area to guide this step. Below, I rely on studies derived mainly from lowland regions of northern Central America and northern South America.

Earth scientists' increasingly fine grained understanding of the global climate system and its impact on particular regions, has given archaeologists new tools in their interpretations of both specific sites and regional cases. For example, McCorristen and Hole (1991:47) make a strong case that in the Fertile Crescent, a change from a pattern of cold winter-hot summer temperatures with even seasonal rainfall characteristic of a continental climate, to a pattern of warm winter-hot summer climate with seasonal rainfall, caused the ecological dominance of annual plants. This increasingly meditearranean climate was a precondition for these plants to become the subject of human exploitation and experimentation. In the Levant, they argue, the synergistic effects of this increasing seasonality with anthropogenic, technological and social innovation led to the formation of sedentary villages and the domestication of wheat and other staple grains at the end of the Pleistocene.

Richerson, *et al.* (2001) have proposed a climate-based model for the rise of worldwide agricultural food production systems. On the basis of long-term, global climate records, they show that in contrast to the erratic glacial and interglacial cycles of the Pleistocene, the Holocene was a period of relative climatic stability. They combine their argument for an ameliorating (*i.e.* predictable) Holocene climate with a mathematical treatment of assumed population pressure. This formulation results in the conclusion that agriculture was essentially compulsory for growing populations of the Holocene.

In Mesoamerica, two large-scale regional project sites serve as archetypes for modeling Archaic period subsistence transitions. These are the Tehuacan Valley sites, including Coxcatlan Cave, that were excavated by Richard MacNeish (1967), and the Guilá Naquitz Cave in the Mitla Valley, described by Kent Flannery (1986). Both these areas are in Mexico. These two sites lie in environmental contexts that are somewhat similar to one another but, quite different than that of the Estanzuela Valley. Both areas in Mexico are arid, situated in broad flat-bottomed valleys with rocky upper slopes. El Gigante, on the other hand, lies atop the continental divide within a highly dissected volcanic plateau containing narrow valley pockets and steep valley walls. The landscape consists of relatively open pine-oak forest with patchily distributed agave (*maguey*, *Agave* sp.). The vegetation community today, and likely in the past, is very different than the broad valleys of mesquite scrub and scattered *cardon* and *saguaro* cacti prominent around Tehuacan and Mitla, Mexico.

I expect that the general subsistence patterns proposed by MacNeish and Flannery resulting in agricultural lifeways in Mexico were different from those at El Gigante, because they are conditioned by a contrasting local environment. That is not to say that the adaptive pathways described in the Mexican situations are not useful in untangling the evolutionary processes at work at El Gigante. In fact, comparing the logical outcomes of model systems developed with the Mexican data but, using different starting assumptions, may one day serve as a useful test case for general theory. At the present, there is much middle-ground to be filled in concerning local subsistence adaptations before such comparisons are made.

The climate and soils of highland Honduras

The area around El Gigante is within a "Humid-Subtropical" ecological zone which makes up 35% of Honduras' land area (Holdridge 1962). The watershed is one of the few in Honduras that drain towards the Pacific *via* the River Lempa, flowing through lower elevation "Dry-Tropical" forest (*ibid.*). The vegetation at El Gigante's altitude (between 1,100 and 1,400 m) is dominated by pine-oak (*Pinus-Quercus*) forest. At higher elevations (*i.e.* >1,500m) sweet-gum (*Liquidambar styraciflua*) trees begin to dominate as one approaches the "Humid Low-mountain" zone (*ibid.*).

The area has a pronounced wet-dry cycle of seasonal rainfall, with a majority of the annual 1,500 to 1,700 millimeters of precipitation falling between May and October (Hastenrath 1967). The highest temperatures of the year, though not significantly different than the norm, occur during those rainy months (see Figs. 6 and 7).

The soils of the El Gigante area, and the Honduran highlands in general, are classified as *someros* (superficial or shallow), developed over volcanic material with moderate to strong relief of between 30 - 60% slopes (Castellanos *et al.* 1962). In addition, these soils drain rapidly, have a high danger of erosion and a low production potential (*ibid.*). These soil conditions result in an almost exclusive recommendation by Castellanos *et al.* to use the land mainly for forestry operations. Pastures and permanent fields are only possible in those locations where slope permits. The *Sur-occidental* (south-east) region of Honduras covers 569,240 hectares. This area was divided into four classifications based on average slope by Castellanos *et al.* (1962). Slopes under 10% grade cover about 1% of the *Sur-occidental,* compared to average slopes exceeding 40% which cover over 90% of this region. The major modern population centers in this part of the country (Marcala and La Esperanza , Dept. of La Paz) lie in those areas where slopes range between 10 and 20% (Castellanos *et al*. 1962).

Regional Geology

Regional key site surveys conducted in 1998 allowed me to examine and compare many rock shelters in the area (see Fig. 1). However, only El Gigante appeared to contain intact, deep cultural deposits. Geomorphologically the site is very similar to others visited in the region that consisted of undercut scarps of bedrock tuffs. But, El Gigante uniquely, became a sediment sink. The geological evolution of El Gigante is critical to the interpretation of its archaeological contents.

El Gigante's bedrock consists of an ignimbrite tuff, a volcanic rock composed of welded ash, pumice and pyroclastic debris. This bedrock characterizes the entire region. The rock shelter was originally formed by running water eroding and undercutting this tuff. Scouring of the welded tuff is evident from the water-worn pothole formations visible in the bedrock of the cave (see Photo 5). The process is still visible outside the cave along drainages in the bedrock of the water shed, and in other locations where water flows over bare tuff exposures. Water has long since stopped flowing through El Gigante. Sediments of the roof and walls are now eroding very slowly to the floor solely through gravitational (coluvial) and aeolian (wind) action.

Rock shelters in various stages of evolution were observed throughout the region. One such rock shelter in the early stages of geological evolution was the *Cueva de Quiala*, along the *Quebrada Licencial*. Based on the observation of these rock shelters, I propose that the original formation of El Gigante was due to the action of a paleo-meander in the channel of the Estanzuela River. Since the time of El Gigante's formation, the river has cut the valley much deeper and the Estanzuela River is now about 100 meters below the rock shelter floor. These events occurred during the formation of the dissected volcanic plateau of Central America's Central Cordillera. This geologic group of rocks, known as the *Grupo Padre Miguel*, originated in the Miocene and Pliocene epochs between about 1.5 and 23 million years ago. At that time, an unknown number of volcanoes were very active in the area (Kozuch 1991; Williams and McBirney 1969).

There was significant late Pleistocene and Holocene volcanic activity in neighboring El Salvador, including major eruptions of Ilopango and Coatepeque volcanoes (Rose *et al.* 1999). These volcanoes, however, are too distant to have been the source of the tephras here in highlands of Honduras. On this basis, certain conclusions can be reached about the age of the strata directly overlying the bedrock. For example, an unpublished radiocarbon date of 39,000 BP (Hasemann *pers. comm.*) taken from directly above the bedrock is highly suspect. The date is at the extreme limits of the radiocarbon method and may actually represent an "infinite" C14 age. The basal stratum sampled by Hasemann is overlain by strata that are the result of volcanism. These pyroclastic flow deposits are indicative of events capable of extreme destruction over long distances. However, since the nearest volcanoes known to be active in the late Pleistocene are too far away to have been sources for these flows, it is more likely that these strata derive from eruptive events associated with the very ancient *Grupo Padre Miguel*. This precludes the possibility of Paleoindian deposits in El Gigante below these white tephras, unless the colonization of the Americas is dramatically older than conventionally thought (*i.e.* >50,000 years BP). A detailed discussion including illustrations of the stratigraphy is given in Chapter 3.

The composition of the sediments that have accumulated during the Holocene were influenced predominantly by anthropogenic inputs in addition to the very slow colluvial erosion from the roof and walls of the shelter itself. The yellow ash encountered on top of the ancient tephras which distinguishes Strata III and IV is anthropogenic. A complete discussion of the archaeological site formation processes and descriptions of individual strata are given in Chapter 4.

Relevant Climate Studies

Lewis Messenger (1990) compared several regional archaeological sequences from eastern and southern Mesoamerica with relatively fine-grained sequences of climate variation. He found repeated correlation between punctuated events in cultural sequences and rainfall patterns. Messenger's method relies on the premise (admittedly an oversimplification, but necessary for the model) that the decade of the 1960's represented an analog to other cool periods such as the "Little Ice Age." This proxy had been suggested earlier by Sanchez and Kutzbach (1974). He evaluates the regional rainfall patterns from that period and projects them back in time. The exercise highlights an important factor in the climate of Mesoamerica. Central America's rainfall is influenced by two oceans, and while periods of cool temperatures lead to droughts along the Pacific coast of Guatemala, El Salvador and along the western slopes of the Andes, they simultaneously result in higher than average rainfall in the Southeast United States, west-central Mexico, northern Yucatan, the Caribbean coast of Honduras and the West-Indies. Messenger (*ibid.*) concludes that the Maya reached their peak population during a prolonged period of globally cool weather from AD 200 – 900 (the Classic period), during which lowland Guatemala, Belize and the Yucatan received slightly more than normal rainfall. He also correlates the collapse or Terminal Classic period with the intensification of a climatic regime that become more unstable and increasingly drought prone.

A similar correlation between cultural decline and climate fluctuation has been observed by Haug *et al.* (2003). They examine a sequence of varves (finely laminated lake sediment layers) from the ocean floor of the Cariaco Basin. These sediment sequences allowed a reconstruction of very fine resolution (down to individual seasons) for the period from 700 to 950 A.D. Percentages of titanium in the soil were used as an index of regional hydrological conditions. Higher rainfall can be inferred for those periods when there are increased quantities of titanium in the soil, indicating increased riverine detrital input. This study also suggested that the collapse of the Classic Maya occurred during an extended period of regionally dry conditions punctuated by intense droughts (lasting from 3 to 6 years) that occurred at approximately 810, 860, and 910 A.D. (see also Hodell *et al.* 2000).

Unfortunately, these fine-grained analyses linking climate and cultural change focus only on the past 5,000 years. Reconstructing the climate and rainfall information as far back as the Pleistocene - Holocene boundary is difficult. At this scale, global glacial and interglacial patterns are our only proxy measures. Much of this work stems from interest in the timing of glacial advances and retreats in North America.

The Cooperative Holocene Mapping Project (COHMAP) is a multi-institutional consortium that studied late Quaternary climatic changes recorded in geological data and simulated by numerical models (Anderson *et al.* 1988). COHMAP scientists conclude that changes in the orientation of the earth's axis during the last 18,000 years had a significant effect on tropical monsoon and mid-latitude climate patterns. The models they present, based on lake level, pollen, foraminifera studies, and oxygen isotope ratio analyses, confirmed that a climate wetter than the present dominated the early Holocene. This trend gradually weakens by 6000 years ago, and a drier period ensues (*ibid*).

In a more recent treatment of the topic, Hodell *et al.* (2000) review multiple environmental indicators of rainfall, including pollen and isotopic analyses, in the northern American tropics, and sub-tropics including the Caribbean. They argue that the tropics are affected by inter-annual climate variation predominantly through changes in rainfall. For most of Central America, rainfall originates in the Atlantic; it is the timing of the annual onset of the wet-season during summer that is critical to many plant communities, including domesticated ones. Hodell *et al.* (2000) note the profound importance that El Niño Southern Oscillation (ENSO) events have on the timing of these annual rains.

During the Ice Age northern Central America was much cooler and drier than it is today. Around Lake Quexil in Guatemala, the average temperature could have been 6-8 degrees Celsius lower, and the vegetation community would have consisted of savanna scrub (Leyden *et al.* 1993). In Panama, evidence from Lakes La Yeguada and El Valle indicate that glacial age forests could still be found during the early Holocene as oak-rich cloud forest, a plant community nonexistent in the region today (Piperno and Pearsall 1998; Bush and Colinvaux 1990).

The boundary between the Pleistocene and the Holocene marks a profound change in the global climate system and an abrupt transition in geological time, this happened around 10,000 years ago. The final deglaciation of the Pleistocene epoch occurred in two phases. These were separated by a brief regression known as the Younger Dryas. From 16,000 to 12,000 BP glaciers retreated, perhaps due to changes in the earth's precession and the resultant increase in solar radiation on northern latitudes (Anderson *et al.* 1988). All this melt water entering the earth's hydrologic cycle created wetter climates. For a brief period between 11,000 and 10,000 BP there was a reversion to cool dry climates, but this did not last, and by 9,500 BP deglaciation was complete.

The melted glaciers created a very wet environment during the early and mid-Holocene, as shown by lacustrine records. Perhaps the most humid interval in Central America was between 7,000 and 5,000 years BP (Bradbury *et al.* 1981). This interval, known as the Hypsithermal in North America (Newsom *pers. comm.*), had the opposite effect in temperate latitudes where rainfall was diminished (see Messenger 1990, above).

The trend in the late Holocene was the reverse. Depending on the location, indications are that the planet entered a drying period beginning around 3,000 BP (or earlier). For example, at Lake Miragoane, Haiti, oxygen isotope studies indicate an increased evaporation to precipitation ratio and lower lake levels between 3,200 and 2,400 BP. Simultaneously, (around 2,500 BP) pollen counts indicate a shift from mature mesic forest (Moraceae dominant) to a dry weedy landscape at around 2,500 BP (Hodell *et al.* 2000). Similarly, at Lake Chichancanab, Mexico, oxygen isotope values and rising gypsum content in lake sediments point to a (relative) drying trend around 3,000 BP (Hodell *et al.* 2000). This situation reversed itself briefly during the period that Messenger (1990) correlates with the Classic Maya ascendancy (c. 1700 - 1000 BP) and rainfall was slightly above average for several centuries. However, across the western hemisphere, droughts became especially acute during the period from ca. 1,300 to 1,100 BP. Hodell *et al.* (2000) have found evidence for widespread droughts, from California to Patagonia, again, coincident with the collapse of the Classic Maya (see also Messenger 1990).

It could well be that the widespread deforestation attendant with full-scale agro-economies of 1,000 B.C. triggered "desertification" of some areas, reinforcing the trend toward increasingly severe droughts across the continent (Hodell *et al.* 2000).

Nevertheless, the increase in drought frequency would have significantly decreased the predictability of resource availability and increased subsistence risks starting around 3,000 BP.

The "Maya Collapse," which was not altogether consistent across the Maya region, cannot be blamed entirely on the drought pattern described above. It is during this time that major regal-ritual centers in the Northern Puuc zone and at Chichen Itza thrived (Webster 2002). Why this should be the case is unclear. It does, however, underscore the dynamic nature of subsistence systems creating a mosaic of adaptations across the hemisphere. I emphasize these data because they demonstrate some direct linkages between cultural processes and climate. 3,000 BP is an important date in the prehistory of El Gigante because the first evidence of domesticated maize is found around this time.

Vegetation history and anthropogenic disturbance

Pollen records provide some of the most comprehensive views of past vegetation communities (Traverse 1988). In Mesoamerica there have been several recent studies of lacustrine sediments that relate to the current discussion.

The Petén Lake District lies in the northern Guatemala lowlands. Isleby *et al.* (1996) summarize a near-complete record of Holocene vegetation history in this region based on pollen core data. At the termination of the Pleistocene, warm moist conditions were present. By the early Holocene, Isleby *et al.* conclude that the area was a cool dry savanna some 6 – 8 degrees Celsius colder than today (confirming the conclusions of Leyden *et al.* 1993, above). By 8,600 BP the pollen record at Lake Petén-Itza, Guatemala, clearly shows the establishment of high forest, including species (specifically trees belonging to the Moraceae and Urticaceae) that thrive in much wetter (mesic) conditions than exist today in the Petén. This represents a global shift to a new equilibrium of the post-glacial period. However, as early as 5,610 BP, Isleby *et al.* (1996) note the beginnings of an increase in the abundance of secondary forest taxa such as *Byrsonima*, a low stature tree and typical savanna element. They infer this was produced by a drier period with possible anthropogenic forces contributing to a decline in the forest cover. That is, the relative abundance of pollen from disturbance-adapted taxa (*e.g., Ambrosia* sp., Asteraceae, and Poaceae) and second growth forest taxa increases significantly. Subsequent to this period the climate seems to have stabilized and there are few changes in the pollen profiles. By 1,880 to 950 BP, there is very strong evidence (including maize pollen) that humans were clearing large areas of forest. It is during this period when Isleby *et al.* (1996) note a similar appearance of "Maya Clay" sediments that are found in many other lake core studies. These clays indicate substantial erosion and loss of forest due to human influence. After this time (coincident with the demise of the Classic Maya) the forest begins to regenerate.

Lake Yojoa in central Honduras is about 100 kilometers northwest of the Estanzuela Valley and has been sampled for fossil pollen. Lake Yojoa lies at an elevation of 635 m above sea level and receives about 2,000 millimeters of annual rainfall. Unfortunately, the core taken and reported on by Rue (1989) is only 1.5 meters in depth and provides a vegetation record only back to about 5,000 years BP. Nonetheless, the record at Yojoa for that period mirrors that of the Petén lake cores. That is, a relatively xeric forest shows increasing evidence of disturbance (decreases in percentages of arboreal taxa) as early as 4,770 +/- 385 BP (UGa-5380). This is about 900 years later than the disturbance noted in the Petén cores. Evidence of maize pollen was found just slightly later (higher in the column) than that. Furthermore, significant vegetational changes associated directly with the intensification of agriculture (such as the appearance of field-invading weeds like *Ambrosia* and other Asteraceae) are observed in the Yojoa core by 2,950 BP. This is concurrent with the first ceramic occupation of Los Naranjos during the Jaral phase (800-400 B.C.) (Baudez and Becquelin 1976).

Rue, *et al.* (2002) report on a pollen core taken from Lake Petapilla near the archaeological site of Copan, Honduras. The core dates as far back as 3,750 B.C., and shows ubiquitous microscopic carbon fragments throughout the entire sequence. The authors interpret this as representing a "record of continued burning in the region" (*ibid.*:267). This relatively intense fire regime in the humid tropics is directly attributable to humans intentionally altering forest communities (Webster, *et al.* 2005). Although several post-maize peaks in carbon are noted, there is no reason to discount fire use in earlier periods. The assessment of this hypothesis must wait for an older core to be found.

Cobweb Swamp in the lowlands of Northern Belize has been core sampled for pollen evidence. Forest clearing is evident as early as 2,500 B.C. (Jones 1994), much earlier than at other lowland Maya sites. This clearing is presumed to be the result of maize and/or manioc farming.

Stabilization of the climate is postulated by some to have enabled the rise of agriculture in these lowland areas around 3,000 B.C. (Pohl *et al.* 1996). Indicators of major forest disturbance in the Maya Lowlands during this period include maize pollen becoming far more prevalent, large expansions of disturbance type vegetation (*e.g.*, Poaceae, Asteraceae, *Typha*, and *Cheno-Amaranthus*), marked declines in upland forest species (*e.g.*, Moraceae) and charcoal fragments becoming more common in the sediment columns.

The Modern Vegetation Community

The high elevation sub-tropical climates of highland Honduras can support the production of temperate fruits such as apples and pears. However, this region is more dominated by coffee-production, significant at the level of the national economy. The production of this cash crop makes the pine-oak forest one of the most threatened of Middle America's ecosystems (Dinerstein *et al.* 1995). A diversity of flora and fauna is being slowly replaced by extensive coffee plantations and cattle pastures. Because of the impact of these recent land-use patterns, a simple transferal of the present conditions cannot be made back in time to the prehistoric environment. The present conditions can, however, hold clues to the reconstruction of the past environment.

To understand how prehistoric behavior could have shaped the environment in a specific locale (or *visa versa*), it makes sense to start with an evaluation of the current ecological community surrounding the site. However, especially during the rapid end of the Pleistocene and through long periods of Holocene variation the present vegetational landscape is not analogous to the prehistoric situation. Nevertheless, I completed a systematic survey of trees and shrubs within the Estanzuela Valley in 2001 in order to establish a modern reference for the comparison of El Gigante's vegetation community to other areas and periods. The plant community was sampled using a belt-transect (also known as line-strip or strip-transect) method (Lindsey 1955). This method is commonly used by ecologists studying forest vegetation (Barbour *et al.* 1987). Seven, five meter by 200 meter belt transects were established perpendicular to the Estanzuela river (see Fig. 2). Species presence for all trees, shrubs and herbs was noted at five meter intervals along each transect. Final species identifications were made by Dr. George Pilz at the Zamorano Agricultural University, Tegucigalpa. The results of the survey are given in Table 1. The percent cover of each species was calculated for each transect by dividing the number of five-by-five meter quadrants in which the species was present by the total number of quadrants along that line. The table shows the mean percent cover for the seven transects along with standard deviations.

In the dry season of 2001 I also conducted informal but extensive interviews with local workers and their families about locally grown garden plants and crops. Diversity is a noted quality of most indigenous home gardens (Peters 2000). Alcorn (1984) noted 182 plant species in the house gardens of Huastec Mayan Mexican households. Home gardens inventoried in the Yucatan contained between 133 and 135 species (Rico-Gray *et al.* 1990). On the other hand, gardens inventoried by Price (1983) in Costa Rica averaged only 16 species. Local gardens near El Gigante contained at least 45 species during the dry season (see Table 2); more species may be planted at other times of the year.

The modern predominance of pine on the landscape around El Gigante may be an artifact of human action. Uncultivable land is used as pasture, and fires caused by human activity are intense and frequent in the dry season. This combination of use-and-abuse has lead to patchy climax forests dominated by fire tolerant and fast-growing species such as pine (Pilz, *pers. comm.*). Wetter climates of the mid-Holocene and the cool and arid climate of the late Pleistocene would have been characterized by different plant communities than those present today. It is possible that the prehistoric landscape of El Gigante has no modern analog at all. We can only work backward from the current vegetation community and extrapolate what resources and challenges the cooler and drier, or wetter and warmer conditions would have presented. The El Gigante vegetation surveys establish a baseline for proposing such hypotheses.

The vegetation community in the immediate area of El Gigante is dominated by three tree species (see Table 1): pine (*Pinus* sp.), oak (*Quercus* spp.), and *nance* (*Byrsonima crassifolia*). Over 22% of the surveyed area contained pine trees. One oak (*Q. segoviensis*) was present across 25% of the survey area while another oak species (*Quercus sapotifolia*) was present in almost 30% of the plots. *Nance* occurred on nearly a third of the landscape as well.

Also, notable is the high density of succulent species. Maguey plants (*Agave* sp.) were found to cover 14% of the landscape and *vaca gorda* (*Agave* sp.) was encountered in nearly one-third of the transect segments.

The area is characterized by a high density of shrubby species. This is no doubt due, in part, to the high disturbance in the area from cattle grazing and the prominence of fire. Nine species were particularly dominant. *Lengua de venado* (*Dodonaea viscosa)*, the most common species in the area, was present in 44% of the plots. Four species of Melastomataceae, known locally as *cerín*, were almost ubiquitous, occurring across 83% of the survey. *Chiribito* (*Calea zacatechichi*), a member of the Asteraceae, occurs across over one-third of the landscape. Legumes (Fabaceae) were also quite common; *Calliandra rubescens* and *C. grandiflora* were present in 13% - 17% of the plots respectively. *Anisomeris protracta*, a small purple-berried shrub in the Rubiaceae family, was found in about a quarter of the sample units.

Conclusions

Combining regional climate and vegetation change data with the results of the vegetation survey, we can begin to construct a plausible, yet very general vegetation history for the Estanzuela Valley. First, the composition of the plant community around El Gigante can be placed within a broader classification of habitats in Honduras. David Lentz constructed such a classification as a part of the larger regional study of El Cajon, Honduras (Lentz 1989), and though the area is lower in altitude, similar habitats are described.

The El Gigante landscape is classified as Pine-Oak forest. This habitat has also been described for the higher reaches of the Oaxaca Valleys, above 1,700 m (Smith 1978:19). In addition to two pine species and five oak species, Lentz (1989:65) lists four other trees common to this habitat, two of which are also found at El Gigante: *Brysonima crassifolia* and *Inga* spp. Mutually common shrubs include *Calliandra* spp*.,* *Calyptranthes, Malvaviscus, Miconia* spp*., Psidium* spp*., and Pluchea*. There are few overlaps with the herbaceous plants listed by Lentz, reasons for the difference probably include the 300 meter difference in elevation as well as differing microenvironments in the broader valley bottom pockets of the lower reaches of the Humuya and Sulaco rivers. The El Cajon region is northeast of El Gigante, firmly on the Caribbean slope of Central America. Historical land-use no doubt differed in each area as well.

Lentz (1989:65) notes that the prehistoric pine-oak zone might have been far more grassy and savanna-like than we see today. Current fire regimes have accelerated erosion and land use as pasturage has favored those species less palatable to domestic stock animals. Lentz (1989:65) asserts that this degradation has been ongoing for at least two millennia. The rapidly changing character of the landscape, accelerated by the historic introduction of cattle, helps to explain the paradox of why so few of the plant foods recovered from archaeological contexts at El Gigante currently grow in the area surrounding the site.

In addition to the pine-oak habitat, there was likely a viable riparian community on the banks and gravel bars of the Estanzuela River. Though limited in area, this narrow strip of valley bottom would have made valuable aquatic resources available during some of the year, as well as providing useful annual herbaceous plants and a more diverse list of tree species possibly including the Guanacaste tree (*Enterolobium cyclocarpum*). Today this seasonally wet zone is dominated in its lower reaches by village fields and coffee *fincas* (farmsteads). Along its upper reaches it is now dominated by stands of rose apple (*Syzygium jambos*), a non-native tree. Although degraded now, this thin ribbon along the river was certainly a valuable zone which added to the diversity of the area in prehistory.

It is unlikely that there are modern habitats comparable to the Pleistocene environment at El Gigante. There were no glaciers in Honduras, but the highlands were probably much colder and drier given the general global trend at the time of the terminal Pleistocene when much of the earth's water was locked up as ice at the poles (Hodell *et al.* 2000). Pines were undoubtedly present, although the entire Highland plateau that runs down the spine of Honduras may have supported fewer forests dominated by this single species. Instead, a sparse savannah scrub and juniper community including a mix of patchy parkland and forest refugia may have been more common (Hodell *et al.* 2000:19). Mammals, including horse, sloth, mammoth, mastodon and gompithere, were not yet extinct in the New World at this time and may have inhabited these forests and parklands.

In a dramatic contrast to the cold and dry Pleistocene, the post-glacial early Holocene climate was not only warmer but more humid (Hodell *et al.* 2000:22). Currently, pine and oak (combining the two oak species) at El Gigante occur at an approximately 1:2 ratio; during the early Holocene this ratio likely fluctuated. Wetter times would have favored oak, perhaps creating cloud forests dominated by that species (Hodell *et al.* 2000:19). This possibility has been reported for locales in early Holocene Panama (Bush and Colinvaux 1990). The Pine-Oak-Sweet Gum zone, made up of *Pinus pseudostrobus, Quercus* sp., and *Liquidambar styraciflua* (Lentz 1989:65) may have extended much lower in elevation (covering the entire Estanzuela Valley) during these wetter times. Pine-oak forest may have been "pushed" to lower elevations or, have been absent entirely in the transition to Lowland forest. Such a depression of vegetation zones between 11,000 and 10,000 years ago has been documented at Lake Patzcuaro, Michoacan, Mexico. The pine-oak zone was 800 to 1,000 meters lower in elevation and denser there (Pearsall and Piperno 1998:234). It appears that by the mid-Holocene, about 5,500 years BP, the climate may have settled into a mostly stable pattern of relatively drier and cooler conditions.

During this time, forest succession may have favored a more open and grassy pine-oak forest in central Honduras (Lentz 1989). The ramifications of these subtle shifts in the forest community at El Gigante are unclear. For example, Simms (1985:167) notes that pine nuts were an efficient resource in terms of their return per unit of labor cost and would be expected to be utilized by foragers when available. Yet, there is little evidence from our investigations to show that the inhabitants of El Gigante utilized either pine nuts (*piñon*) or acorns in their subsistence practices. On the other hand, these oaks provide forage for browsing species of mammals such as deer, which may have benefited the inhabitants of El Gigante. It is possible that the species of pine and oak at El Gigante produced pine nuts and/or acorn masts which were less amenable as food than those of the U.S. Southwest or California.

By the Formative Period the environment around El Gigante may have assumed more familiarity to today. In the absence of grazing, which so dramatically impacts the current landscape, we might have used the results of the modern surveys as analogs to the most recent prehistoric period represented archaeologically at El Gigante. In the Late Formative period anthropogenic forces began to influence the landscape more than climatic change (Lentz 1989:69). Fruiting trees such as avocado (*Persea* sp.), hog plum (*Spondias* sp.), Sapotaceae (*Manilkara* sp. and *Pouteria* sp.) and soursop (A*nnona* sp.) may have been quite common growing wild in what is now cattle range. The current dominance of *Byrsonima* sp., a "key indicator of savannah vegetation in the neotropics" (Isleby *et al.* 1996:267), is a likely artifact of this anthropogenic disturbance. This type of situation has been well documented prehistorically in the Maya region at Copan (Paine and Freter 1996).

There are, however, still examples of extensive areas isolated from some of this modern degradation and still managed in a way that might serve as an analog to prehistoric practices. Doña Francesca's remote rock shelter farmstead, first examined in the 1998 key site surveys, is one such example (see Photo 6). Doña Francesca lives in a rock shelter and she has her home garden containing herbs and small plants arranged immediately outside the vestibule of the cave. In an intermediate zone from 10 - 35 meters down slope, she has laid out her *milpa*, a terraced, mixed field of maize, beans and squash. Dispersed within this zone are some orchard crops such as bananas, citrus, coffee plants and avocado. This zone gives way to an area planted more densely and systematically with useful trees forming the outermost ring of managed land. This landscape system extends in a concentric fashion, perhaps, three-quarters of a kilometer out from the hub of the domicile.

Periods of El Niño, or Southern Oscillation, events certainly had an impact on the subsistence tactics of prehistoric people, but very little is known about the details of these oscillations before 1,500 B.C. It is interesting that an agro-economy based on maize, beans and squash comes to maturity at El Gigante well after 2,000 B.C., during a time when short-term El Niño droughts become more common (Hodell *et al.* 2000). Richerson *et al.* (2001) recently proposed that agriculture evolved in the Holocene precisely because it was a more climatically stable era than the Pleistocene. However, El Niño oscillations occur at a smaller scale than the variation described by Richerson *et al.* (2001) and this pattern should not be confused with their hypothesis. These El Niño events, pronounced in the last 3,000 years, consisted of drought and excessively cold periods that could have lasted for decades and may have forced the inhabitants of El Gigante to rely on subsistence practices more directly under their control and to become more reliant on storage. Human populations still relying on wild and cultivated (but undomesticated) resources may have been more severely affected by this climatic regime, forcing a transition to more labor-intensive subsistence strategies.

Figure 6 Annual average rainfall in Marcala, La Paz (elev. 1207 m)

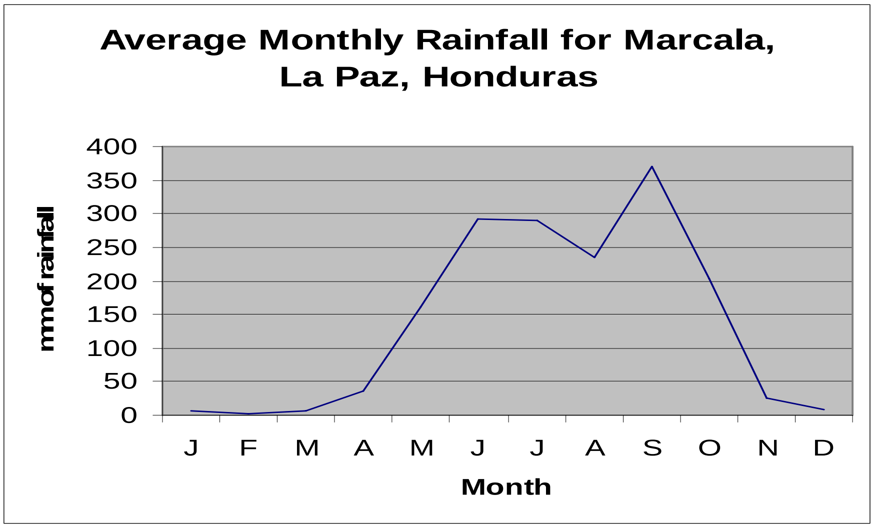
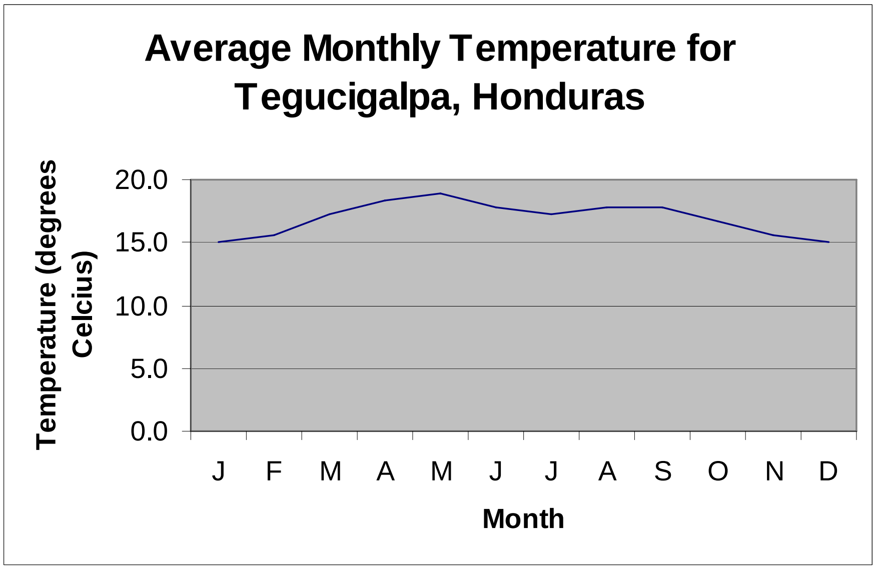


Figure 7 Monthly average temperature in Tegucigalpa, Honduras (elev. 987 m)



Source: Data derived from The Global Historical Climatology Network, version 1; 120 months between 1951 and 1963. http://www.worldclimate.com/

Photo 5 Pothole formation in El Gigante (left) and an active pothole outside the site (right)

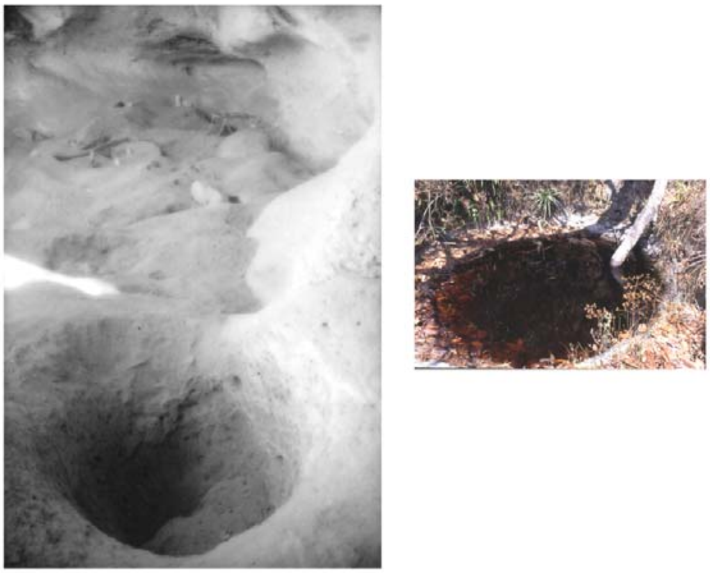


Photo 6 Landscape modification around an existing rock shelter habitation

Table 1 List of the plants found in the 2001 Estanzuela Valley Botanical Survey, mean percent cover and standard deviation.

Species	**Percent Cover**	**Standard Deviation**
Agave sp. (*maguey*)	14.0%	17.0%
Agave sp. (*vaca gorda*)	29.8%	28.0%
Anisomeris protracta (Benth.) Standl. (*palo cute*)	14.7%	.
Buddleja sp. (*hoja blanca*)	2.7%	0.0%
Byrsonima crassifolia (L.) Kunth (*nance*)	31.8%	15.0%
Calea zacatechichi Schltdl. (*chiribito*)	38.1%	24.0%
Calliandra grandiflora (L'Hér.) Benth.	17.8%	10.0%
Calliandra rubescens (Martens & Galeotti) Standl.	13.1%	20.0%
Calyptranthes hondurensis Standl. (*arrallan*)	9.0%	6.0%
Cephalanthus salicifolius Bonpl. (*botancillo*)	7.7%	.
Chromolaena glaberrima (DC.) King & Rob.	8.4%	3.0%
Clethra lanata Mart. & Gal. or *macrophylla* Mart. & Gal. (*zapotillo*)	7.0%	3.0%
Clidemia capitellata (Bonpl.) D. Don (*cerín*)	42.2%	20.0%
Clusia salvinii Donn. Sm. (*penque burro*)	5.0%	.
Dodonaea viscosa (L.) Jacq. (*lengua de venado*)	44.0%	22.0%
Ficus cotinifolia var. *hondurensis* (Standl. & L.O. Williams) C.C. Berg (*amate*)	2.5%	.
Harpalyce rupicola Donn. Sm.	2.5%	.
Hauya elegans DC.	15.0%	.
Heterocentron hondurense Gleason (*begonia*)	21.9%	19.0%
Heteropteris beecheyana Juss. (*bejuco*)	5.0%	.
Ilex guineensis (Aubl.) Kuntze	25.1%	9.0%
Inga vera Willd. (*guamo*)	4.7%	4.0%
Lippia graveolens Kunth (*oregano*)	17.5%	.
Lysiloma auritum (Schltdl.) Benth. (*quebracho*)	2.5%	.
Malvaviscus arboreus Cav. var. *arboreus (cordoncillo)*	5.0%	.
Miconia albicans (Sw.) Triana (*cerín*)	9.3%	7.0%
Miconia theaezans (Bonpl.) Cogn. (*cerín*)	28.1%	13.0%
Myrica cerifera L. (*vegetal*)	11.8%	.
Perymenium nicaraguense Blake	12.4%	7.0%
Pinus sp. (*pino*)	22.5%	13.0%
Pluchea odorata (L.) Cass. (*zucunan*)	5.1%	4.0%
Psidium guajava L. (*guayaba*)	10.2%	14.0%
Psidium guineense Sw. (*guayaba acida*)	5.0%	.

Table 1 (cont.) List of the plants found in the 2001 Estanzuela Valley Botanical Survey, mean percent cover and standard deviation.

Species	**Percent Cover**	**Standard Deviation**
Psychotria jinotegensis Nelson, Molina & Standl.	10.2%	8.0%
Psychotria sp.	5.9%	.
Quercus sapotifolia Liebm. (*encino*)	29.1%	23.1%
Quercus segoviensis Liebm. (*roble*)	24.8%	9.0%
Rubus adenotrichus Schltdl. (*mora*)	2.5%	.
Senna pallida (Vahl) Irwin & Barneby var.	20.5%	16.0%
Syzygium jambos (L.) Alston (*manzano*)	2.9%	.
Ternstroemia tepezapote Schltdl. & Cham. (*palo golpe*)	4.3%	3.0%
Tibouchina longifolia (Vahl) Baill. (*cerín*)	2.9%	.
Wimmeria acuminata L.O. Williams	25.0%	.
unidentifed (red berry 2)	5.0%	.
unidentified (unknown 2)	28.7%	36.0%
unidentified (unknown shrub 1)	2.5%	.
unidentified (yellow berry)	8.8%	.

Table 2 Species observed in surveys of the gardens and orchards of Estanzuela village.

Species	**Common Name**
Aloe vera L.	*sabila*
Ambrosia cumanensis HBK.	*altamisa*
Anacarddium sp.	*maranon*
Annona sp.	*anona*
Bixa orellana L.	*achote*
Buddleia americana L.	*hoja blanca*
Bursera simaruba L.	*Jiote*
Carica papaya L.	*papaya*
Chenopodium ambrosioides L.	*ipazote*
Citrus aurantifolia Swindle	*Limon*
Coffea sp.	*Café*
Cupresus sp.	*cipres*
Equisetum giganteum L.	*cola caballo*
Eupatorium laevigatum Lam.	*Azota caballo*
Geranium sp.	*geranio*
Heliotropium indicum L.	*cola de alacran*
Hibiscus rosa-sinensis L.	*clavel,* carnation
Hyptis verticillata Jacq.	*verbena*
Astrocaryum sp. L.	*guamo*
Lepidium virginicum L.	*mastuerzo*
Lippia alba N.E. Brown	*juanilama*
Lippia dulcis L.	*orozul*
Lippia graveolens HBK.	*oregano*
Mangifera sp.	*mango*
Mentha x piperita L.	*herbabuena*
Musa sp.	*platano o huerta*
Ocimum micranthum Willd.	*albaca*
Petiveria alliacea L.	*ipacina*
Pinus sp.	*Piñon*
Plantago major L./*P. australis* Lam.	*llanten*
Pluchea symphytifolia (Mill) Gill.	*siguapate*
Polypodium aureum L.	*calaguala*
Prunus sp.	*durazno*
Psidium guajava L.	*guayabo*
Ruta chalepensis L.	*Ruda*

Table 2 (cont.) Species observed in surveys of the gardens and orchards of Estanzuela village.

Species	**Common Name**
Sambucus mexicana Presl. ex. DC.	*Sauco*
Sida rhombifolia L.F/*S. acuta* Burm.	*escobilla*
Solanum sp.	*tomate*, tomato
Tagetes lucida Cav.	*pericon*
Taraxacum officinale L.	*diente de lion*
Vetiveria zizanioides Nash.	*valeriana (zacate)*
Zingiber oficinales Roscoe	*jengibre*, ginger root
Unknown	*siempre viva*
Unknown	*curarina*
Unknown	*cojoyitos*

TOTAL (n) = 45

CHAPTER 3: EXCAVATION AND STRATIGRAPHY

Introduction and Methods

This chapter outlines the history of excavations at El Gigante since it was first discovered and leading up to the current project. It also includes the description and justification of methods employed in the course of the research project to date. The data presented in this dissertation follows up on the original testing of the site in 1994 by George Hasemann. Dr. Hasemann directed the first seasons' exploratory key site surveys completed by the author in 1998. Pilot excavations were carried out at El Gigante in 2000, consisting of two one-by-one meter units. The major portion of the material discussed in this dissertation was excavated in 2001. All of the field work was accomplished with the support of the Instituto Hondureno de Antropologia e Historia.

In the 2000 field season two adjacent 1x1 meter test units were dug in an undisturbed portion of El Gigante (Units 1 and 2, see Fig. 5). The goals of these pilot excavations were to identify the temporal components of human occupation found in the cave and to assign them to cultural complexes or phases. This strategy was also designed to determine where intact cultural deposits were located within the cave and how well they were preserved. This provided a basis for the IHAH to begin implementation of a preservation and interpretation program at the site. Units 1 and 2 were placed as near as possible to the exposed section of Hasemann's 1994 unit, and in an area with as little apparent surface disturbance as could be recognized. The 1994 profile was first re-exposed to provide a "preview" of the stratigraphy of the planned units. This allowed us to dig non-arbitrary stratigraphic levels, maintaining strict control on provenience.

The second season of excavations was carried out between October and

December of 2001 and was more extensive, adding another 17 units, bringing the total to 19 units (see Fig. 5 and Photo 7). The overriding goal of this second and main season of excavations was to recover as much archaeological material as possible, from all of the represented periods at the site.

Because of the unique preservational environment of El Gigante, no flotation was attempted because water-soaking of the material would have destroyed the delicate, desiccated floral remains. In such circumstances, fine-mesh dry sieving is the common alternative to process bulk sediment samples for macro and microbotanical remains. Unfortunately, only three large bulk soil samples were taken for fine dry sieve processing. In retrospect, this was an error. More features and strata should have been systematically sampled. It is hoped that future investigations at El Gigante can provide these samples.

An inventory of all the sediment samples that were taken from the site is presented in Appendix C. There were three 100% sediment samples with volumes equal to or greater than 400cc. These were obtained from two archaeological features that were bisected and exposed in final wall profiles and from one particularly organically rich stratum (B1, B2 and B3). Fourteen sediment samples of smaller volume were taken from the east wall of Unit 2. In this case, a 5 x 5 x 5cm cube of material was collected from each of the exposed strata in that unit's wall. These were intended for pollen analysis (P1-14). Also, two column samples (5 cm wide and 5 cm deep, in increments of depth coinciding with stratigraphic changes but never thicker than 5cm) were removed. One of these was from the South wall of Unit 3, beginning at the surface continuing down to the termination of the excavation (C1-18). The other was intended to sample only a single section of the stratigraphy in the West wall of Unit 6. This section represented a particularly thick sequence of yellow ash layers (Sub-strata IIIe through IVa) that we considered important at first because of their possible volcanic origin (C19-29).

All of the aforementioned materials were shipped from Honduras by air freight to the laboratory of Dr. Kenneth Hirth at the Pennsylvania State University. These remain there in storage under U.S.D.A. soil permit quarantine conditions. Several of these samples have been analysed for the purposes of this thesis. The column sample from Unit 3 was used in a preliminary study of carbon content in Chapter 4. Five samples were processed for pollen fossils (P8, P9, P10, P11 and P14). Three bulk samples (B1, B2 and B3) were dry sieved, sorted and described for their botanical content by Dr. Lee Newsom, a specialist in paleoethnobotany; these results are presented in Chapter 6. Significantly, these three represent our only samples from which we can make any inferences concerning the <1/8" fraction of the botanical component of the site.

All attempts were made to excavate levels within discrete strata, with no mixing. Obviously, this ideal was met with varying results. The complexity of the stratigraphy made it difficult, but we were largely successful. Within each sedimentary zone (see below for definitions), arbitrary 5 centimeter levels were dug. All the material was processed through a dry screen of 1/8 inch hardware cloth. All possible macroscopic remains were picked by hand from 2 foot by 3 foot screened boxes set on large saw-horses. The sequence of these levels and their concordance with the stratigraphic order is the basis for archaeological interpretation (Adams 1975, Gasche and Tunca 1983). The interpretation of the concordance between all excavated levels and described stratigraphy is provided in Appendix B.

The excavation method is significant because archaeological deposits in rock shelters and caves form through a diversity of activities centered at the same location, creating, generally, a complex "palimpsest" of natural and anthropogenic sediments (Strauss 1990). Mixing and superposition of strata present a problem in these circumstances. This was noted in the 2000 test-pitting operation where pit features were identified that originated in Formative levels and extended down into the Archaic strata (*e.g.,* Fig. 13, Feature #8). Cave strata were excavated slowly to guarantee that intrusive features were accurately identified and removed *in situ*. Features were handled as distinct strata in order to separate their contents from that of surrounding matrix. Photos were taken of all identified features (see Chapter 4) and they were removed and processed in discrete levels. The units and level depths of these features are identified in the site concordance (see Appendix B). All features are described in the following chapter, this chapter seeks first to clarify the geological and stratigraphic relationships within the site.

Because of the desiccating nature of the extremely fine ash found in the cave, deposits were excellently preserved. These friable, dry ashy deposits were difficult to deal with mechanically because they were so fine. Airborne dust became a problem. Because of this in addition to the danger of contracting fungal lung infections from bat guano, all field personnel were forced to wear masks during excavations.

The units were not dug simultaneously. No "floors" were encountered or pursued horizontally. Instead, units were dug sequentially using exposed strata as a guide to excavation. For example, Unit 1 was brought to depth and terminated first, exposing what would be the south wall of Unit 2 and the stratigraphy of that profile. Levels from the second unit were then "peeled back", attempting to keep all levels within discrete strata. Unit 2, therefore (and all subsequent units in the main block), had somewhat better control of stratigraphic provenience than the first unit. Unit 1 is the only unit which was excavated without a side-wall exposed first. All other units in the main block were excavated in the sequential manner described above with at least one wall exposed to guide the excavator. The units were excavated in a configuration that allowed the last two units (18 and 19) to be excavated with three wall profiles initially exposed. These, therefore, have the best archaeological control (see Photo 8). It is from units 18 and 19 that many of the radiocarbon determinations were selected. These methods are the same as those used by Kent Flannery (1986:67-69) at Guilá Naquitz. Units were terminated after excavations encountered Stratum VII and were sterile for at least two consecutive levels (see below for the rationale for this decision).

The main block, extending off the Unit 1 and 2 pilot units, consisted of 12 square meters of excavated floor area (Units 1, 2, 3, 4, 6, 7, 9, 13, 16, 17, 18, and 19; see Fig. 5). The key consideration in the placement of these units was the attempt to transect the shelter perpendicular to its orientation. The sub-surface profile along this axis best demonstrates the physical evolution of the geologic structure (*cf.* Collins 1991; Farrand 2001, 1985; LaVille *et al* 1980; Waters 1992). However, the model of rock shelter and cave formation developed by Laville and others was based on a dominant process of freeze and thaw common in temperate Europe, where the formation of *ebullis* fragments (characteristically spalled and weathered rubble) is a major sedimentary constituent. The formation of El Gigante's sedimentary matrix was dominated by anthropogenic forces, and slow colluvial and aeolian erosion of the roof and walls.

Nevertheless, the east-west orientation of the main block of units revealed the character and partial shape of the basal bedrock from front to back and did shed light on the geomorphological formation of the shelter. This trench revealed that the rock shelter has eroded slowly enough that its physical evolution has had little effect on the cultural deposits of the last 10,000 years. In a general model of rock shelter formation, the cave is born with initialization of differential erosion or undercutting of the bedrock, this is followed in more mature stages by the recession of the drip-line as erosion continues to carve out the interior of the cave and the lip becomes more and more unstable, eventually the shelter is destroyed by successive roof collapse. There was no evidence in the El Gigante main block trench of large-scale morphological changes in the cave's configuration during the time of human occupation. On the basis of this perpendicular section I think the shelter's interior existed much as we see it today throughout the Holocene.

Three other areas of the rock shelter were sampled for this investigation. The first was located near the rear wall, in the deepest portion of the shelter where the looting of possible burials was noted (Units 5, 8, 10, and 14). Some human remains were recovered in this area but the sediments were thoroughly disturbed. This attempt to locate a burial against the rear perimeter of the cave was unsuccessful but, only the very limited sample was possible. The second target, were the large, naturally formed "pothole" (Jackson 1997) depressions in the bedrock in the northern portion of the cave (Units 11 and 12). These water-worn bowls were a meter or more across, and over a meter deep. They were characterized by smoothly eroded walls and must have originated in the very early stages of the rock shelter's formation. Most were at least partially filled with sediment and debris. They appeared to be likely places for human activity including as storage bins or burials. Unfortunately, both of these areas turned out to have been highly disturbed, and neither contained evidence of intact prehistoric human deposits. Extensive reworking and mixing of these sediments by looting and modern activity had left trash incorporated throughout.

The third location was selected to follow-up on previous investigators' suspicions of very early human settlement (Hasemann, *pers. comm.*). It enlarged our sample of what I suspected (after 2000 pilot testing and results) to be non-cultural strata. We did this by continuing the excavation of a 1 x 1.5 meter unit (Unit 15) where previous investigator had terminated theirs (Hensley-Sherman and Jung's, unpublished 1993 excavation). We dug beginning at about 1.5 m below the surface and continued to bedrock. This did not produce any additional cultural material.

As mentioned, the intent of the excavations was first, to recognize all of the represented archaeological horizons and second, to document them by way of recovering as much intact subsurface material as possible from each. To achieve a balanced sample of the material remains of past human behavior that occurred in different parts of the cave-space, multiple areas were sampled. This strategy targeted *in situ* deposits and systematically expanding those areas where they were found. The main central floor was trenched perpendicular to the cave mouth, two of the nine pothole formations were selected and sampled, and the area of the disturbed rear periphery was tested as an extension of the perpendicular transect begun in the main block.

Each unit was designated a number, as was each level and sub-level. All artifacts were bagged separately by class ("lithic," "ceramic," "floral," "other") in the field and labeled with provenience information. Raw counts were made of the material and recorded on excavation forms. In combination with detailed field notes, all unit profiles were drawn, described, and photographed after they were completely exposed. The finished walls of the blocks were lined with clear plastic and the units back-filled to discourage further looting.

Stratigraphy

A clear stratigraphic sequence was identified in the main block and is represented in Figures 8-16 and Photos 10-17. Also included in the Figures for this chapter are stratigraphic profiles of the other excavation locations, the west block units (Figures 17 and 18), the pothole units (Fig. 19) and the deep extension of the 1993 unit (Fig. 20).

In the main block, the upper 60 cm of deposits represented a Formative period occupation (Strata I and II). These deposits overlay a pre-ceramic component represented by at least 45 cm of mostly undisturbed, stratified sediments (Strata III, IV and V). These Pre-ceramic levels were intact despite intrusive pits of the Formative occupation and recent looting of burials. Below 105 cm was a sequence of volcanic deposits that predated human occupation (Strata VI through IX). For the most part, the sediments were easily distinguishable despite their undulating and dipping character. Most contacts between the strata were distinct disconformities, not gradual gradations from one to the next. Some difficulty was encountered in separating localized deposits from more extensive ones. As a general rule however, the strata were thick enough (from 5-10 cm) to be distinguished and excavated discretely. When necessary, strata were divided into “Sub-strata”, described individually below (Ia, Ib, Ic, *etc.*) and further if necessary, into sub-sub-strata, again hierarchically (*e.g.*, Ia1, Ia2, Ia2.1, Ia2.2, *etc.*). The later are referred to as “Layers”.

Stratum I contained 4 sub-strata (Ia, Ib, Ic, and Id). The upper portions (Ia and Ib in particular) were seriously disturbed in places by looting and modern activity. All of these sub-strata consisted of densely packed, mostly unburned organic material, including *petates* (woven mats), matted grass, wood, leaves and reeds, floral material and bone, and relatively sparse amounts of lithics and ceramics.

Sub-strata Ia and Ib consisted of compact and coarse botanical material, variable in color and of anthropogenic origin. Ia included the exposed surface material and is suspected to be of highly mixed deposits, with modern trash visible in some profiles. Ia and Ib were 10 and 15 cm in thickness and extended across all the main block units. Stratum Ib, in particular, represented disturbance and fill material at the edge of the main block closest to the cave’s mouth and includes the large pit depression, Feature #2 (see below for complete description of features). This fill and mixed material made up the bulk of Units 9 and 13. Units 7, 16, and 17 were less affected by modern activity and formed the westernmost extent of the intrusion of sub-stratum Ib into older sediments.

Sub-stratum Ic made up the bulk of Feature 1 (see Fig. 12); this intrusion extended from the west edge of the main block into the west edges of Units 6, 2, and 1 to a depth of 50 cm. Feature 1 is composed of a very coarse carbon with some ash and contained 30 - 40 cm of solid packed charcoal. This feature was interpreted as a large fire pit, perhaps used for *maguey* roasting.

Sub-stratum Id was a fine gray ash interspersed with a lighter whitish ash and sparse carbon. There was some amount of yellow ash with Munsell values ranging from 7.5YR 7/1 (light gray) to 10YR 3/1 (very dark gray). This sub-stratum was thick, reaching a maximum of 25 cm in Unit 1. However, it seemed to extend away from our excavations, and only appeared along the south wall of Unit 1.

Stratum II began at approximately 30 cm in depth below the surface, though it was much deeper in some areas. It is distinguished from Stratum I by its more compact character and consisted of four sub-strata (IIa, IIb, IIc, and IId). The organic constituents of this stratum were significantly less common than those in Stratum I, and Stratum II was much thinner. Stratum II was composed mainly of interspersed fine ashes, charcoal, and limited bone fragments. Sub-stratum IIa was a large multi-component pit feature (#8), located in the NW corner of the main block (Units 6 and 19, see Fig. 13). Sub-stratum IIb was a small pit feature (#6), possibly a post hole bisected by Units 19 and 17. These features are discussed in more detail below.

The layers IIc1, IIc2 and IIc3 were successive thin lenses (about 5 cm each) that retained similar *petate* and matted grass, coarse charcoal, wood, leaves, ceramic and lithic material to Stratum I. They were notably more compact than previous layers, with interspersed light gray colored ash (7.5YR 7/1). These layers were limited in extent to Units 2, 3, and 18, and were truncated on the east and west by intrusions from above.

Sub-strata IId was a thicker deposit, underlying IIc and similarly limited in extent to the central west portion of the main block. It was a similar coarse ash mixed with cultural debris and botanical materials. It was light gray in color (7.5YR 7/1).

Stratum III varied in depth but was encountered as deep as 70 cm below the surface. This stratum was much more homogenous than the upper two strata and consisted of bright yellow, fine anthropogenic wood ash. These yellow sediments were interbedded with gravelly gray ash and very fine sediment, apparently eroded from the walls and roof of the cave. This stratum was subdivided into 6 sub-strata that were distinguishable as separate depositional events. Strata in this zone were less extensive than in previous zones. Localized deposits grouped together were sub-divided to a greater degree in this stratum. The discontinuities between strata were more numerous, and at this depth, individual sub-strata become more difficult to trace across multiple units.

Sub-strata IIIa and IIIb were features (#6 and #7, see Fig. 11) found within a meter of one another in Units 17 and 19. They are described in more detail with the rest of the features.

Layer IIIc1 was a thin (5 cm) layer composed of very fine sand and small sub-angular gravel. Carbon and organic material (both burned and unburned) were present but were very small and fragmented. This layer was predominantly a dark grayish brown (2.5Y 4/2) but the color was variable in patches. Layer IIIc2 was similar, though it was composed of very fine, pale brown (10YR 6/3) ash, with sparse charcoal. Layers IIIc1 and IIIc2 were limited to the contiguous Units 2, 6, 18, 19.

Layers IIIc3 and IIIc4 were slightly more extensive lenses of light gray (7.5YR 7/1) ash with interspersed yellow laminae. These relatively fine and compact ashes contained some carbon and limited quantities of bone fragments, extended across the central portion of the main block in Units 1, 2, 3, 6, 18, and 19. The layers were disturbed at the edges by large intrusions from the east and west (Features #1 and #2).

Below these, lay another thin (5 - 10 cm) layer, IIId3.1. This lens of sediment contained quantities of gravel, burnt and unburned organics, plus fragmented bone and sparse charcoal. Its color varied from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2); the lighter sections seemed to be thicker. Sub-stratum IIId (and its sub-member layers) included two features (#3 and #4) and was limited to the southern central portion of the main block (Units 1, 3, and 18).

Sub-stratum IIIe was an extensive undisturbed Archaic deposit located in the central portions of the main block. It was moderately thick (5 to 10 cm) deposit consisting of a very fine ash mixed with sparse gravel and some lithic (cultural) material. It was a mixed gray to yellow color, with heavier gravel load in the light gray lenses (2.5Y 7/2 and 10YR 7/2). Lithics and bone were present in this sub-stratum, as well as some grass, leaves and other organic material.

Layer IIIf2 also extended across the intact central portion of the main block at a depth of half a meter, varying in thickness from around 5 cm in Unit 1 to more than 20 cm in Unit 2. The sediments of this layer were comprised of a fine soil (not ash) containing coarse charcoal and a moderate amount of angular gravel. Its Munsell color, is very dark gray (7.5YR 3/1) and differed from many of the more typical gray/yellow strata and sub-strata of III. Similarly, layer IIIf3, was a sub-lens of the former, but differentiated by its dark gray color (10YR 4/1) and limited to one small pocket in the south walls of Units 1 and 3.

Stratum IV was very similar in character to Stratum III, though slightly darker brown in color. This stratum contained bone, charcoal and lithics in denser quantities than the strata above. Stratum IV had two additional sub-strata, IVa and IVb. Stratum IV is differentiated from Sub-stratum IVa in profile by an unconformity roughly halfway between the two and by a slight color distinction that was light gray (2.5YR 7/2, 7.5YR 7/1) in hue. Overall, these lay at a depth of approximately one meter and were between 5 and 15 cm in thickness. Sub-stratum IVb was slightly more extensive and deeper; it remained undisturbed beneath the large and intrusive Feature 1 on the west, and extended into the west side of Unit 7. This sub-stratum also distinguished itself by the high density of bone fragments and lithics contained in the ash matrix. Sub-strata IVb ranged in color from light gray (2.5Y 7/2) to gray (10YR 5/1).

Stratum V represented the last of the cultural material-bearing sediments and was divided into 2 sub-strata (Va and Vb). Both Va and Vb were relatively thin (5-10 cm) consisting of abundant angular gravel, ash, coarse charcoal, organic material, flaked lithics and large mammal bone. Sub-stratum Va was dark gray (10YR 4/1), whereas the underlying Sub-stratum Vb was increasingly gravelly and pumicy with a pinkish gray color (7.5YR 7/2). These two strata extended to an approximate depth of 75 cm below the surface from the west edge of the main block of excavations, underlying Feature 1 and most almost all previous strata of the main block.

Stratum VI represented the basement, or original floor of naturally accumulated sediments upon which subsequent anthropogenic sediments were deposited. There was a somewhat discontinuous boundary between Stratum V and VI, and little percolation or mixing of cultural material occurred into or below this stratum. This was due in part to the very indurated nature of the fibrous and pumaceous tephra. Intruded into this matrix were some bits of fine carbon. However, the overall color remained a light gray (2.5Y 7/1). This stratum extended across the entire main block and could be matched with confidence to strata identified in Hasemann's original test trench located just south.

Therefore, it is assumed to underlie most deposits in the entire cave. Overall this stratum was rather robust in thickness, up to 20 cm in some locations, but also thinned to less than 10 cm in others. Its undulating character, both top and bottom, was another indication that this and the remaining strata below were of a completely different nature (and age) than the preceding ones. For this reason, this stratum was selected as a marker stratum, used in combination with artifact recovery to evaluate the termination of a majority of the units.

Strata VII, VIII and **IX** are the remaining, non-cultural strata of the cave's stratigraphic sequence. Together with VI, they alternate between the white, indurated and pumicy tephras (Strata VI and VIII) of volcanic origin, and very carbonaceous loose black soils (Strata VII and IX) sandwiched between them. Sub-stratum VIIa was a loose and gravelly soil so heavily laden with very fine carbon particles that its Munsell color was black (10YR 2/1). These sediments were the most soil-like, (decayed organic matter and fine sediment) rather than the accumulated ash and rubbish of the upper layers. In the dark soil, one could occasionally distinguish the fragmented edge of a leaf. It is apparent from these radically different sediments that the cave's interior was very different during the time when these strata were exposed. Perhaps it was more similar to some of the wet and vegetated caves visited in the regional survey.

Stratum VIII was divided into five sub-strata on the basis of changing color and texture. Sub-strata VIIIa through VIIIe were very thick (nearly 50 cm). Sub-stratum VIIIa was an indurated gray (10YR 5/1) tephra, gravelly and porous. Sub-stratum VIIIb was a very pale brown (10YR 8/2) pumaceous tephra, with a distinct peachy tone. Sub-stratum VIIIc was extremely fibrous, perhaps due to post-depositional mineral precipitation within the interstices of the porous tephra. It also exhibited white tephra clasts in a yellow matrix, perhaps gravels from a stratum below, scoured from the surface upon deposition. Overall, its color was a very pale brown (10YR 8/4). Sub-stratum VIIId was another light gray (10YR 7/1) indurated tephra. Sub-stratum VIIIe was the first deposit of this sequence, also a compact and crumbly tephra with small gravel and pinkish white (5YR 8/2) pumice inclusions. Interestingly, it contained a heavier density of whole rodent bone than the others.

Stratum IX was indistinguishable from stratum VII in color, texture and inclusions. It was also a black (10YR 2/1) soil, colored dark by fine carbonized plant remains and it was up to 20 cm thick. This thickness may represent a relatively longer period of deposition than the similar sediments of VII, also sandwiched between volcanic tephras (strata VIII and VI). Stratum IX lies on the bedrock.

Table 3 summarizes some of the details concerning individual strata described above, including Munsell colors, thickness, and depth. In addition, Table 3 relates the stratigraphy to chronological determinations and culturally significant associations (*e.g.* the pre-ceramic boundary). The radiocarbon dating determinations and these associations are the topics of the following chapter.

Site Concordance

The term "Level" is used to describe the excavated provenience assigned during excavation. This is distinguished from "Stratum", "Sub-stratum" or, "Layer", which refer to the sedimentary divisions observed in the profile. Every excavated level was assigned to a stratum (or numerically identified sub-stratum or layer) after the excavation was complete. With Unit and Level information, readers may refer to the concordance tables in Appendix B and in combination with the stratigraphic profiles in Figures 8-20 calculate the position of any artifact in three dimensions, including its stratigraphic association. In this system, the level designations, especially if compared between two different units, can be misleading in terms of chronology. Each excavated level was assigned to a concordant stratum, which is the chronologically significant label. This classification of the "archaeostratigraphic" units follows that outlined by Gasche and Tunca (1983).

Stratigraphic control must be absolutely certain as all subsequent interpretations of the cultural history of the site are grounded in this sequence. Any future work on the material recovered from this site must depend on the framework put forth here by the original excavator. The site concordance links the excavated provienience (Unit and Level information) to the systematic stratigraphic sequence of the site, determining its relative temporal placement with respect to the rest of the assemblage. The concordance was constructed after fieldwork was completed and all profiles could be matched, excavator descriptions coordinated, and a consistent terminology arrived at for site-wide classification.

Table 3 Summary of archaeo-, litho-, and chrono- stratigraphic classification.

Epoch	Period	Phase	C14 Date*	Stratum	Comment	Depth (below surface)	Thickness	Munsell
HOLOCENE	Historic			Ia	Surface mixture (Classic and Postclassic Hiatus)		10 - 15cm	
	Formative	Late Estanzuela	1950	Ib				
				Ic	Feature #1	10 - 50cm	30 - 40cm	
				Id			25cm	light gray (7.5YR 7/1) to very dark gray (10YR 3/1)
				IIa	Feature #8	30cm		
				IIb				
				IIc			5cm	light grey (7.5YR/7/1)
			2525	IIc3	Maize (AMS)		5cm	light grey (7.5YR/7/1)
			3780	IId	Date indicates some prehistoric mixing			light grey (7.5YR/7/1)
			2280	III	Maize (AMS)	70cm		
				IIIa	Feature #6			
				IIIb	Feature #7			
				IIIc	Earliest possible evidence for ceramics			
		Early Estanzuela	3100	IIIc1			5cm	dark grayish brown (2.5Y 4/2)
		Transitional Zone (Late Archaic Hiatus)						
	Archaic	Late Marcala		IIIc2				pale brown (10YR 6/3)
				IIIc3				light gray (7.5YR 7/1)
				IIIc4				light gray (7.5YR 7/1)
				IIId3.1			5 - 10cm	very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2)
			6630	IIId3.3	Feature #3			
				IIIe			5 - 10cm	light gray lenses (2.5Y 7/2 and 10YR 7/2)
			6660	IIIf2		50cm	5 - 20cm	very dark gray (7.5YR 3/1)
				IIIf3				dark gray color (10YR 4/1)
				IV		100cm	5 - 15cm	(light gray (2.5YR 7/2)
				IVa			5 - 15cm	light gray (7.5YR 7/1)
		Early Marcala		IVb				light gray (2.5Y 7/2) to gray (10YR 5/1)
		Transitional Zone (Early Archaic Hiatus)						
PLEISTOCENE	Paleoindian	Esperanza	9590	IVc	Feature #5			
				V				
			9600	Va			5 - 10cm	dark gray (10YR 4/1)
			9210	Vb		75cm	5 - 10cm	pinkish gray color (7.5YR 7/2)
			9240	VI	Quid (AMS), mixed from above		<10 - 20cm	light gray (2.5Y 7/1)
				VII	Black inter-volcanic sediments			black (10YR 2/1)
			9290	VIIIa	Cordage (AMS), mixed from above	150cm	10cm	gray (10YR 5/1)
				VIIIb			10cm	very pale brown (10YR 8/2)
				VIIIc			10cm	very pale brown (10YR 8/4)
				VIIId			10cm	light gray (10YR 7/1)
				VIIIe			10cm	pinkish white (5YR 8/2)
			39,820	IX	Black inter-volcanic sediments	195cm	20cm	black (10YR 2/1)
PLIOCENE			1.5 million	Bedrock	Grupo Padre Miguel			
MIOCENE			23 million					
OLIGOCENE			35 million					

* - C14 dates are calibrated (bp) averages.

Figure 8 Stratigraphic section, south profiles of Units 1, 3, 7, 9, 13.

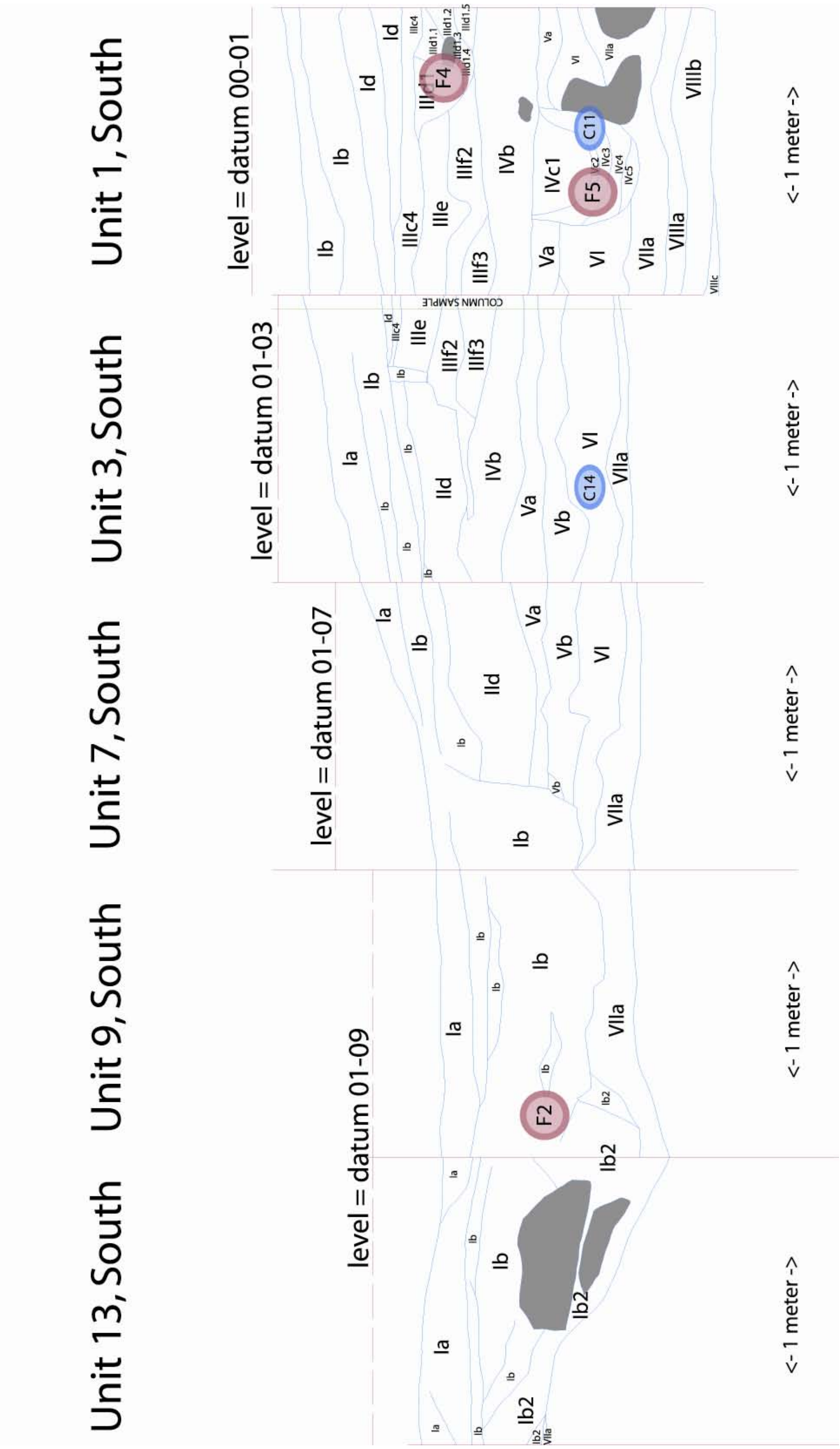


Figure 9 Stratigraphic section, south profile of Units 4, 2, 18, 16, and north profiles of Units 9 and 13.

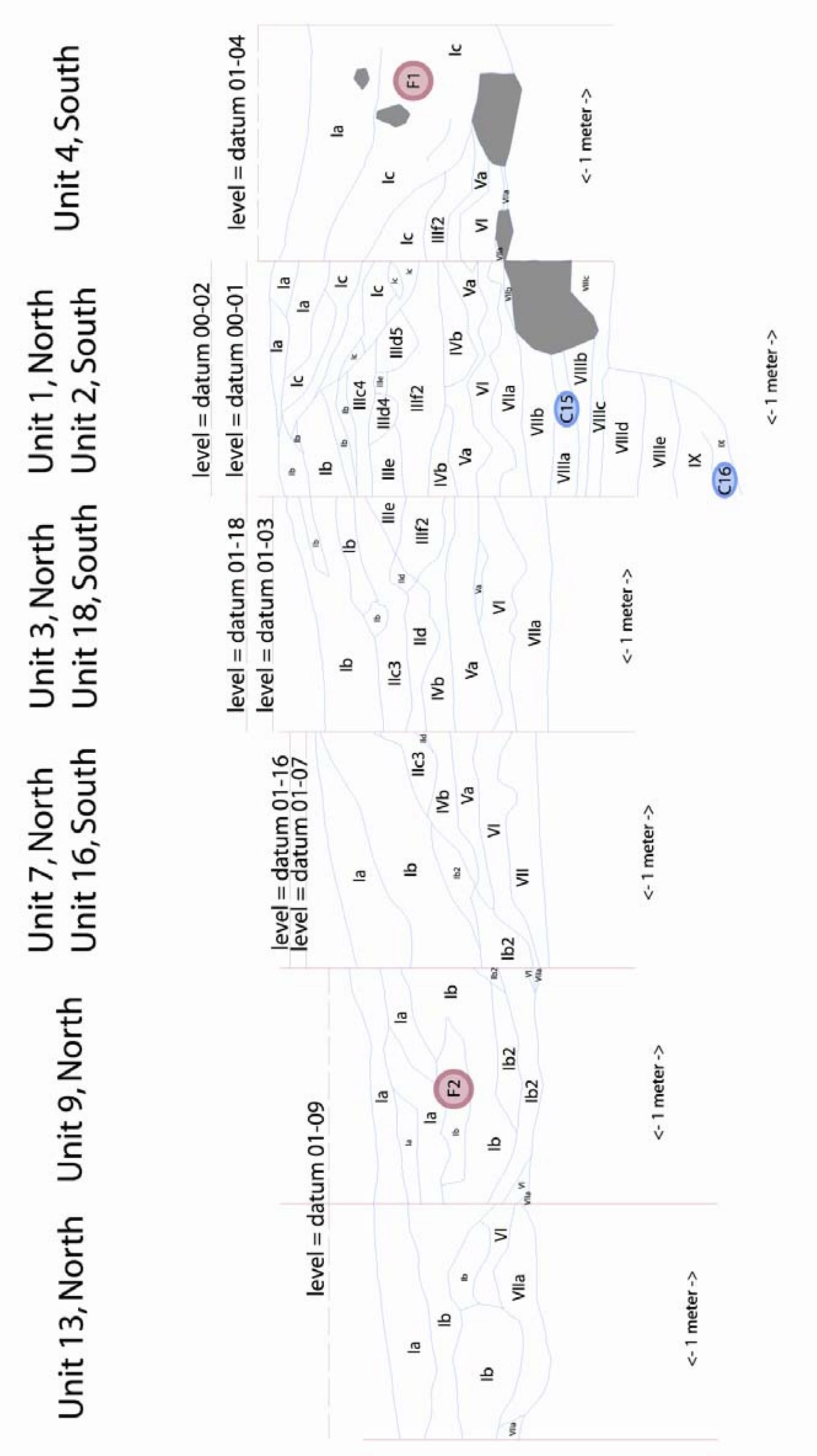


Figure 10 Stratigraphic section, north profile of Unit 4 and south profiles of Units 6, 19, 17.

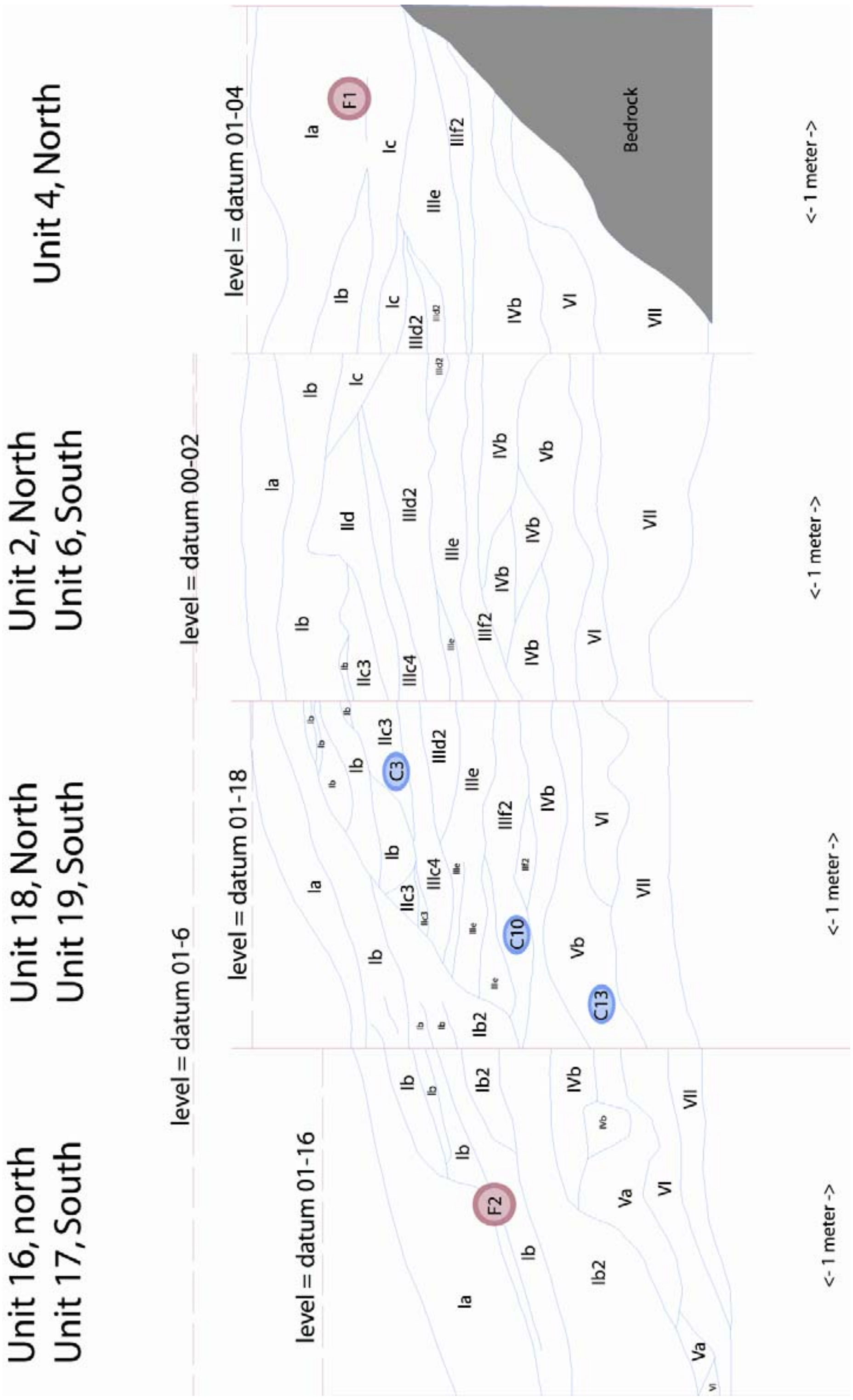


Figure 11 Stratigraphic section, north profiles of Units 6, 19 and 17

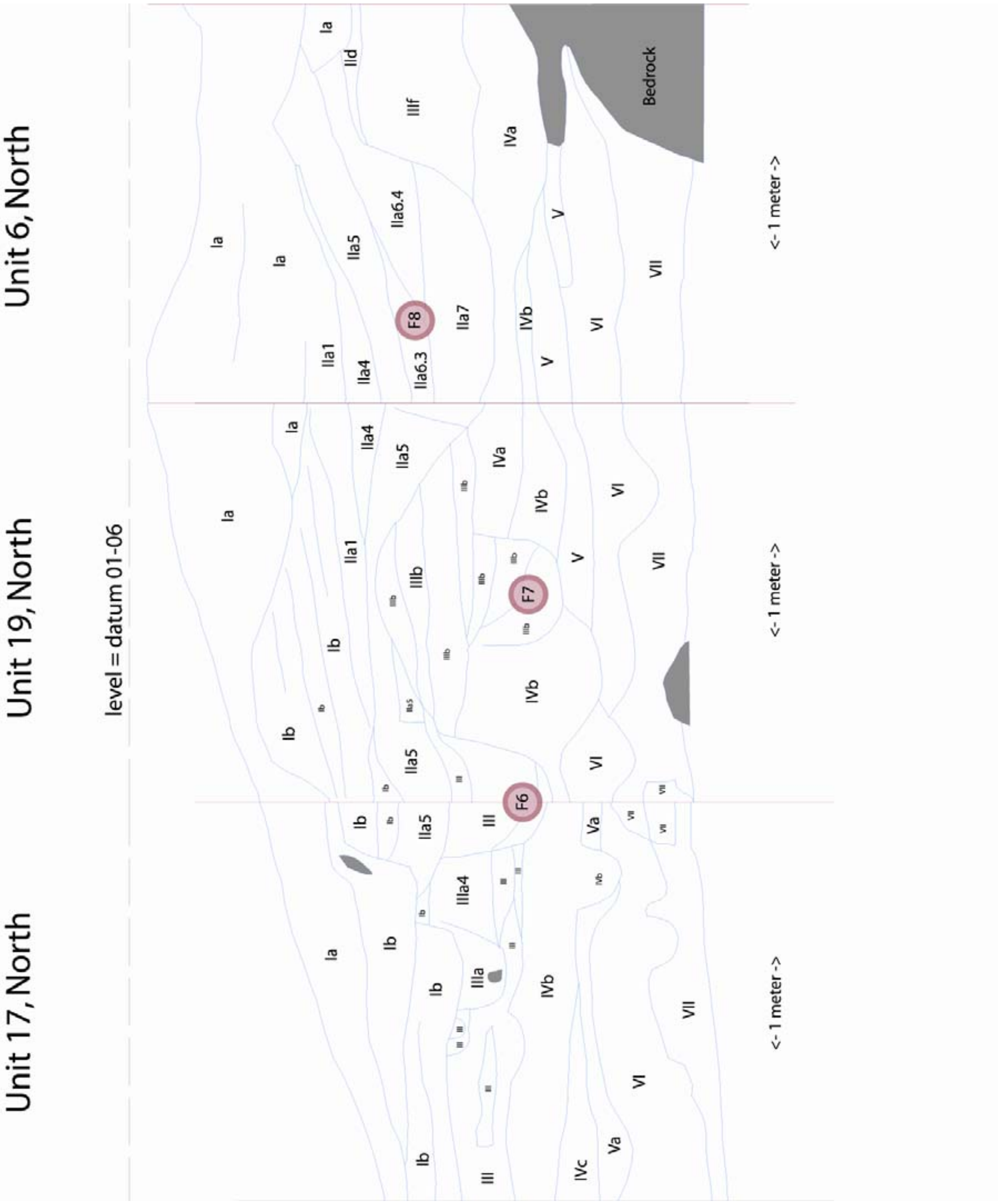


Figure 12 Stratigraphic section, west profile of Units 1, 2, 6.

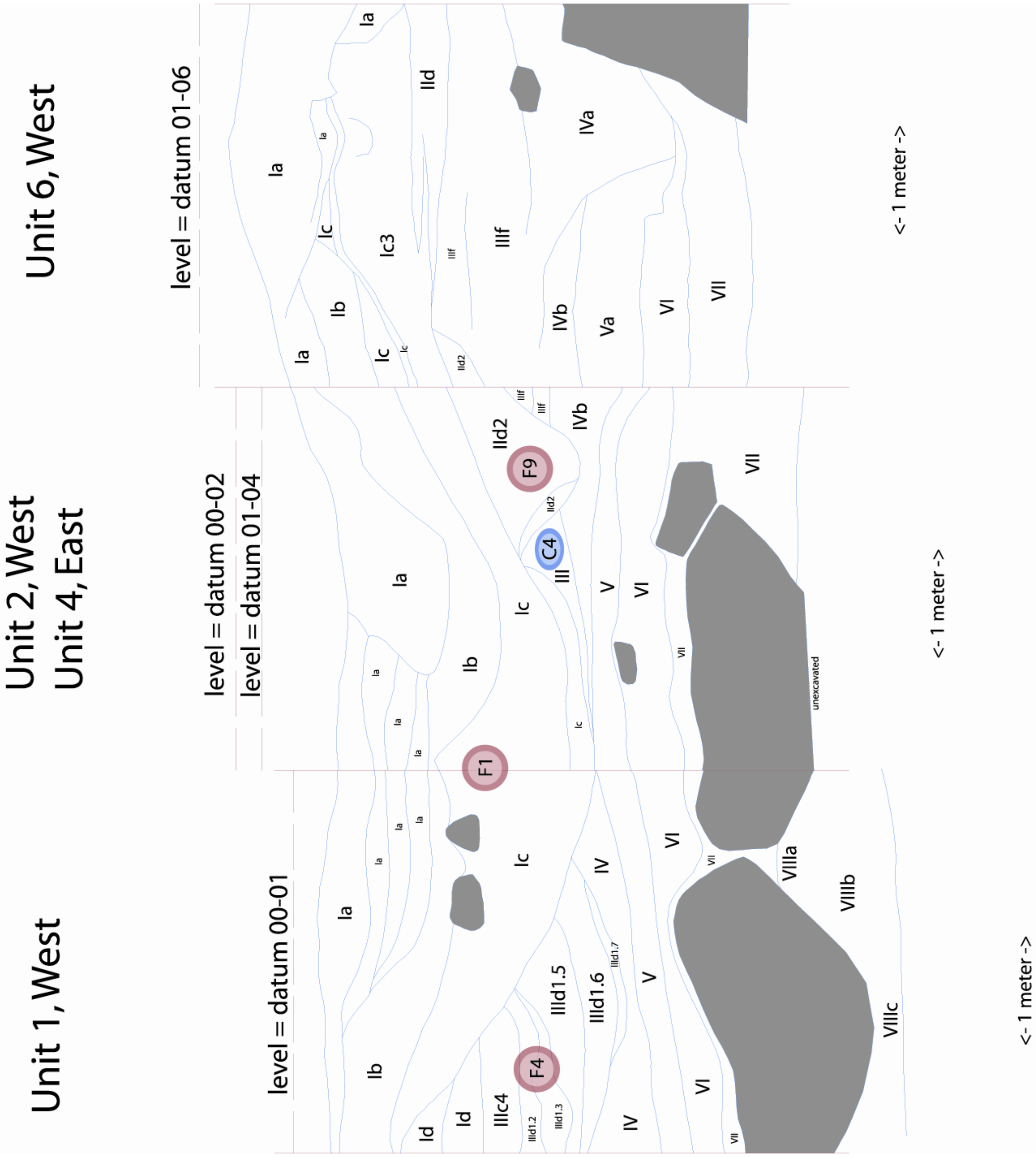


Figure 13 Stratigraphic section, east profile of Units 1, 2, 6.

Figure 14 Stratigraphic section, west profiles of Units 17, 16 and 7

Figure 15 Stratigraphic section, east profiles of Units 17, 16 and 7.

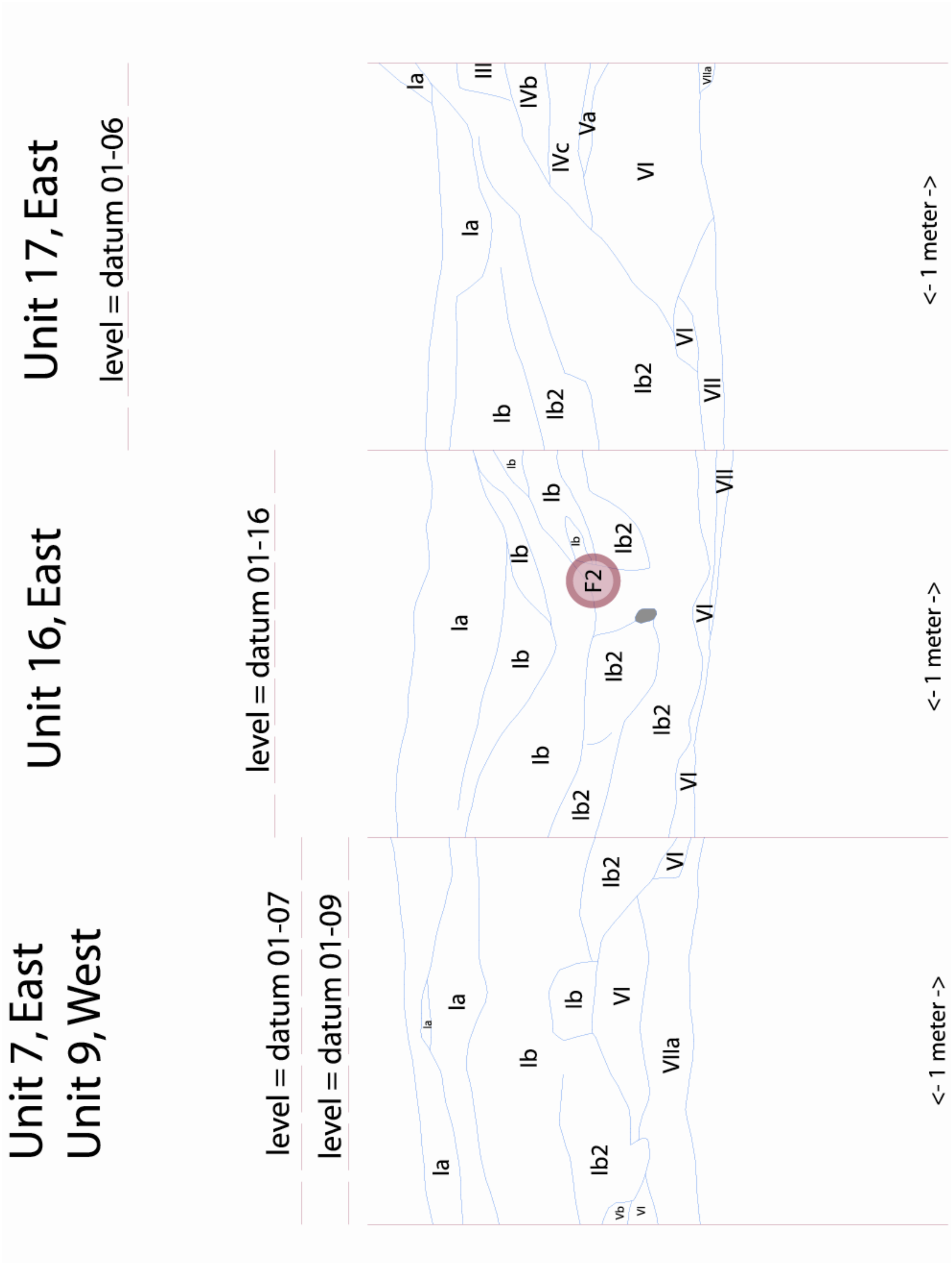


Figure 16 Stratigraphic section, east profiles of Units 9 and 13.

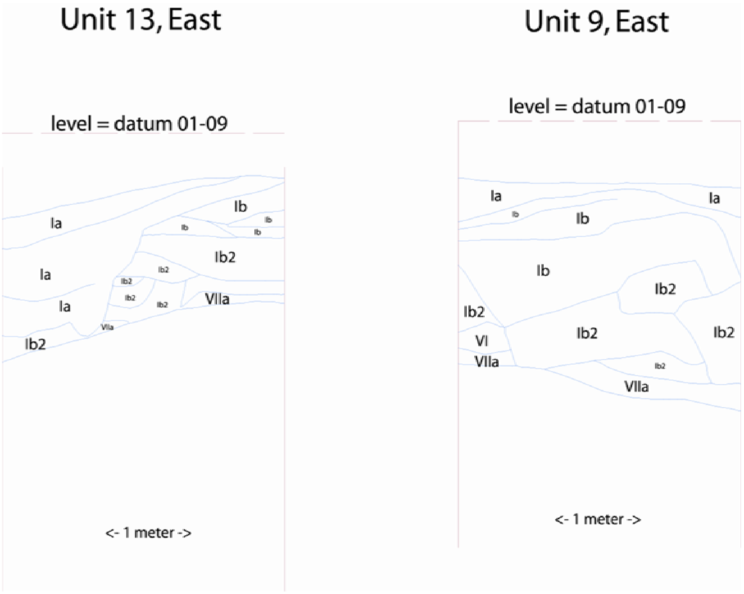


Figure 17 Stratigraphic section, West Block profiles (Units 8,14,5).

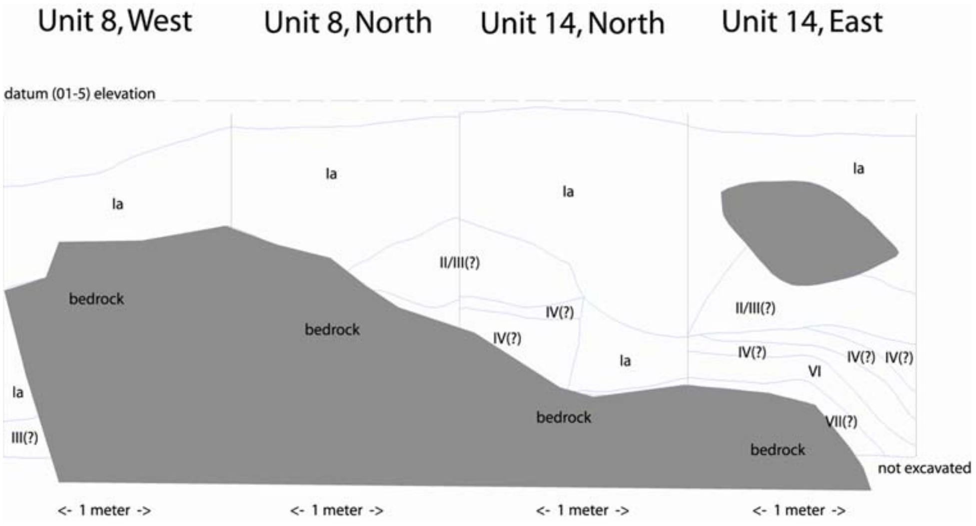


Figure 18 Stratigraphic section, West Block profiles (Unit 10).

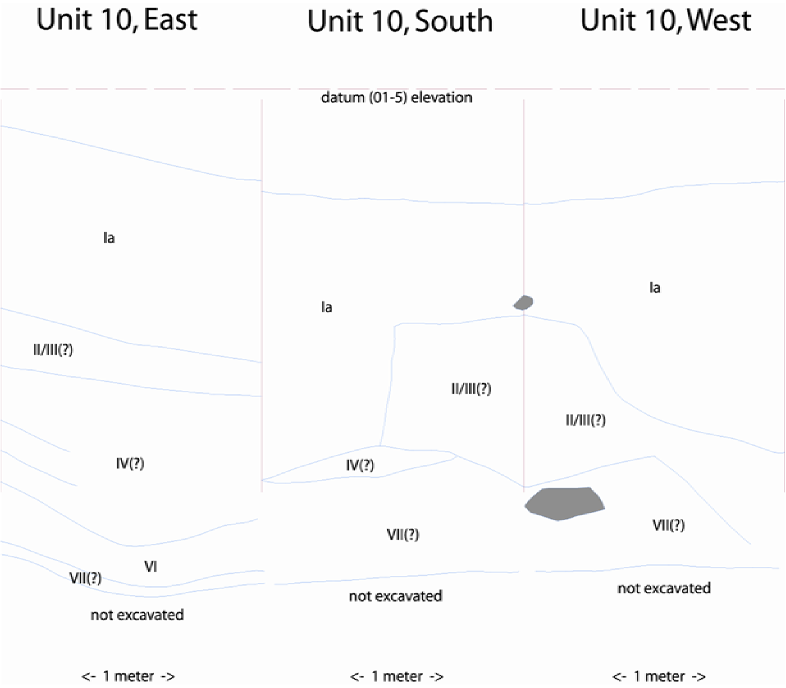


Figure 19 Stratigraphic section, “Pothole” profiles (Units 11 and 12).

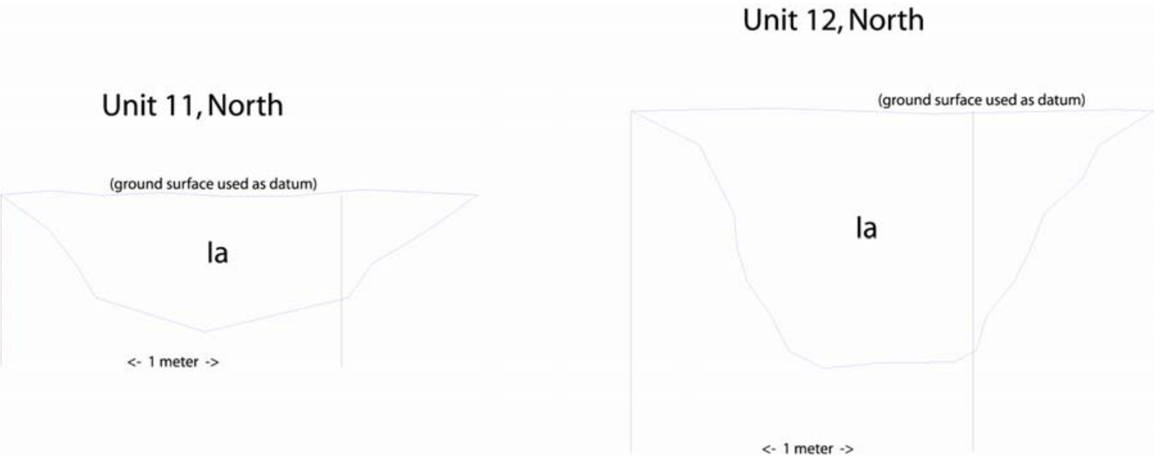


Figure 20 Stratigraphic section, extention of “Hasemann Unit” (Unit 15), excavation began at 1m below ground surface.

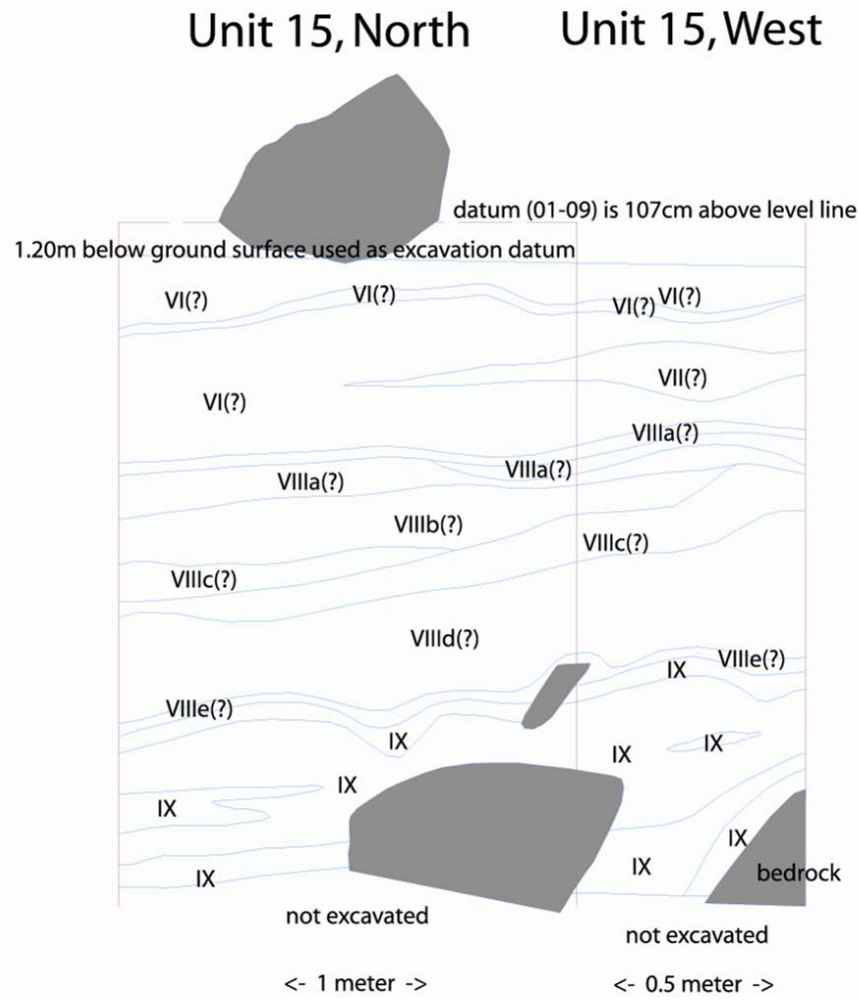


Photo 7 Excavation overview, trench orientation is approx. east-west

Photo 8 Excavation of 17 (unit on right), three sides of 18 exposed

Photo 9 Nephtali at the screening and sorting station

Photo 10 Unit 1, west wall, Features 1 and 4

Photo 11 Units 6, 19 and 17, north wall, Features 6, 7 and 8 (compare to Figure 9)

Photo 12 Units 17, 16 and 7, east wall, feature 2 (compare with Figure 13)

Photo 13 Units 7, 3 and 1, south wall (compare with Figure 6)

Photo 14 Units 1 and 2, east wall, feature 3 (compare with Figure 11)

Photo 15 Unit 1, south wall, feature 4 and 5

Photo 16 Unit 15 tephras

Photo 17 Unit 2 and 1, east wall, strata VI-IX

Photo 18 Unit 1 and 2, west wall, feature 1, feature 9 (compare with Fig. 10)

CHAPTER 4: THE EXCAVATION RESULTS

Radiocarbon Dating and the Cultural Sequence

Dr. Hasemann submitted at least five samples for radiocarbon analysis from the 1993 and 1994 test pitting excavations; the laboratory results for two of these and his personal communication regarding three others are known (see Table 4: Samples 16, 17, and 18). Because of the distinctive nature of the stratigraphy, these first assays were used to cross-date and affirm the presence of several contiguous strata in our more recent excavations. These dates and strata guided this project's original classification and sampling strategy. Two of the original radiocarbon samples bracketed the upper layers of the Formative occupation, (our Strata I and possibly II) between 0 and 120 AD (Hasemann *pers. comm.*, not included in Table 4). Dates 17 and 18 obtained from much deeper sediments (we believe Strata V) returned uncalibrated dates 9,450 +/-70 BC and 9,970 BC (these are published in Hasemann 1996, but with no precise provenience information). Another uncalibrated date (Sample 16) of 39,820 +/-1,100 BP was returned from sediments overlying the bedrock (we infer Stratum IX). This is the deepest part of the rock shelter. Hasemann reported recovering a worked bone awl and a possible fragment of human cranium from these levels (Hasemann *pers. comm.*). Based on my own examinations, however, I believe that this early date does not reflect human activity in the cave and instead, that these remains were intrusive or misidentified

Given the missing excavation records, I was not able to determine the exact location of Hasemann's dates within the cave. Hasemann's dates were used only as a pre-excavation guide and not relied upon in this dissertation's analyses.

Fifteen additional samples were submitted by the author (see Table 4 and Fig. 8-

10 and 12-14 for stratigraphic locations). Sampling for these dates was guided by several goals, but unfortunately limited by budget. AMS dates were selected first, they were reserved for items of particular merit, including corn cobs and Paleoindian artifacts. The remaining funds were divided to provide as many conventional radiocarbon dates as possible. These were directed toward placing certain features in time, and at providing a check on the interpretation of the stratigraphic relationships (chronological order) of excavated strata. Many samples packaged in aluminum foil in the field remain unalayzed that can be used in the future for dating and refinement of the sequence.

The results clustered into three groups (see Fig. 21). These are henceforth referred to as the Estanzuela, Marcala, and Esperanza phases (in part after MacNeish 1986, from youngest to oldest). Figure 22 compares the archaeological occupation phases at El Gigante with those from other sites of the region and those discussed in the thesis.

The following dates listed are all calibrated, two-*sigma* results, reported as calendar years "BC" or "AD". That is, one can be 95% certain that the actual age of the carbon sample submitted lies between the range(s) given. They were calibrated using INTCAL 98 (Stuiver, *et al.* 1998). Unless otherwise stated, uncalibrated radiocarbon dates are reported as "BP" or, radiocarbon years before present. Calibrated dates as are given as AD or BC calendar dates throughout the dissertation.

The **Estanzuela phase** (2,430 BC - AD 230) falls between the Mid- or Late-Formative to the very early Formative or very late Archaic periods of traditional Mesoamerican culture periods. The Estanzuela phase can be further split into two distinct occupations that range from AD 230 to 400 BC (Late Estanzuela, Samples 1-4) and from 800 BC to 2,430 BC (Early Estanzuela, Samples 5-7). Sample 1 was taken directly from charcoal recovered from Sub-stratum Ib from the profile of the east wall of Unit 1. Sample 2 was picked from screened material and charcoal excavated from unit 18 Level 7, and also assigned to Sub-stratum Ib (see Fig. 13). Samples 3 and 4 are AMS dates directly from two early maize cob fragments. These were recovered from Layers IIc3 and Stratum III (see Fig. 10 and 12 respectively). However, the younger age of the samples suggests that the cobs are not from these contexts but mixed down. Samples 5, 6 and 7 confirm that Sub-strata IIc, d, and possibly the upper portions of Stratum III are 1,000 years older. Sample #5 was taken directly from the east wall of Unit 2. Samples 6 and 7 were recovered from excavated materials from Unit 18, Level 18 and Level 21, respectively (see Fig. 13 and 14). It remains possible, given the large discrepancy between Sample 7 and the following set, that the level was incorrectly assigned to Stratum III and that these early Estanzuela dates refer only to Stratum II.

The second group of dates (Samples 8-10) range from 4,850 to 6,410 BC, the early to mid-Archaic period. This time span has been named the **Marcala phase**. The range falls within what MacNeish (1986), in a review of the Mesoamerican Pre-ceramic, termed “Archaic sub-stage 1” (see also MacNeish and Nelken-Turner 1983). These dates were all derived from Sub-strata of Stratum III. Sample 8 came directly from Feature #3 in the east wall of Unit 2, designated Layer IIId3.3. Sample 9 was also recovered from the intact east wall of Unit 1, Layer IIIf2. The material for sample 10 was picked from the screen during the excavation of Unit 19 Level 31 and assigned to Layer IIIf2 as well. However, this date is 1,000 years younger than the date from Sample 8 (see Fig. 13 and 10) which indicates either a very long period with little deposition or, another case of slightly mixed materials.

The first occupation of El Gigante is evident between 8,300 BC and 9,220 BC (radiocarbon Samples 11-15), placing it in what MacNeish termed “Lithic sub-stage 3" (MacNeish 1986). The possibility of Paleoindian occupation was suggested earlier for this area of Honduras by Bullen and Plowden (1963) and also by MacNeish (1986; MacNeish and Nelken-Turner 1983). In accordance with their terminology, I have named this occupation the **Esperanza phase**. This earliest material is found in the lower portions of Strata IV through V. Sample 11 is from Feature 5, Unit 1, south wall, Layer IVc3 (see Fig. 8). The charcoal material for sample #12 was recovered from the east wall of Unit 1, Sub-stratum Va (see Fig. 13). Sample 13 came from charcoal picked from the screen while excavating Unit 19 level 37, Sub-stratum Vb (see Fig. 10). In addition, some cultural material belonging to this phase has been incorporated into Stratum VI and as deep as Stratum VIII.

It should be emphasized that dates pertaining to this deepest cultural material were taken directly from items that were incontrovertibly of human origin, and were not based solely on associated carbon. AMS radiocarbon assays were performed on a maguey quid (Sample 14 from Unit 3 Level 28, Stratum VI) and on a piece of cordage (Sample 15, Unit 1 Level 23b, Sub-stratum VIIIa), both returning calibrated ages of around 10,500 years before the present (see Fig. 8 and 9).

The reader will note that Sub-stratum Va slightly post-dates Sub-stratum Vb by 400 years. There are three instances of a radiocarbon date being slightly out of order with respect to the stratum it was assigned (see also Table 4, Samples 4, 12, and 6). With so few dates available, it is impossible to completely disentangle the chronological discrepancies. However, in general I am satisfied with the somewhat coarse grained chronology and convinced that the mixing that has occurred is minor. Nevertheless, no direct dates are given for the first appearance of anything based solely on association with charcoal or other material from an equivalent stratum.

The black, highly organic-laden sediments sandwiched between tephras below these cultural levels contain paleoecological information seldom preserved in the New World Tropics. Because the single radiocarbon date (c. 39,000 BP, #16) available for this lowest soil (stratum IX, see Fig. 9) was essentially infinite (i.e. at the limit of radiocarbon dating), it must be viewed with a great deal of suspicion and it is my guess that the true age is much older. I would place the time of these tephras formation well in the Pleistocene or even Pliocene. The character of Strata VI and VIII (their pumicy texture, angular gravel and lapilli) suggest they are the result of pyroclastic flow. Pyroclastic flows are fast moving, extremely hot mixtures of gas and ash. These deposits are capable of extreme destruction over long distances, however, no volcanoes in the vicinity of El Gigante have been active since those distant epochs (Williams and McBirney 1969, Rose *et al.* 1999).

Disturbances and Gaps in the Archaeological Record

The post-holes and storage or trash pits from the Formative and Archaic periods complicated the chronological placement of artifacts and ecofacts. The constant reworking of the sediments by the inhabitants of El Gigante mixed materials through strata. Many Formative-era pits extended into Archaic strata and some Archaic features extended down into pre-cultural depths. Other sources of mixing included bioturbation by rats or mice, as well as insects burrowing in the soil. Major disturbances such as those of larger burrowing rodents were not noted.

In addition, modern looting has taken its toll on the site as discussed earlier. Looting is especially evident in the west block (Units 5, 8, 10, 14) and pothole (Units 11, 12) units. These excavations showed that the sediments against the back wall of the shelter had been recently turned over. Cigarette butts, pits and skins of historically introduced plants such as mango and banana, and other modern trash were found throughout even the deepest levels there. In the Main Block of units upon which all the artifact analysis is based, the deepest modern intrusion noted was to Sub-stratum IIa. It must be noted, however, that tests involving the direct dating of macrofossils (*e.g.* Long and Fritz 2001) show that movement of material does occur through what appear to be coherent and well excavated strata.

The three gaps in the chronological record are most obvious in Figure 21. This sequence has been constructed from a mere fifteen radiocarbon samples; even twice as many dates would be insufficient to feel truly comfortable with the chronology. However, I believe the discrete grouping of the dates is not due to a lack of dates, nor to random chance. Instead, they reveal three periods during which either no sediment was deposited and humans were not present, or in which the actions of humans disturbed and perhaps even removed sediment and debris that may have subsequently been mixed into deposits dating to a later time. The later possibility is a serious concern, as mixing of this sort would confound our analysis. However, the dates that do appear out of order in Table 4 do not differ by an order of magnitude that would suggest such extensive reworking. Each hiatus must be evaluated separately and each might shed light on site formation processes and cultural behavior at the site.

First, the entire Classic, Post-Classic, and Historic periods are essentially absent from the current analysis. They are represented only by the faintest traces of diagnostic material from Sub-stratum Ia and on the surface. The archaeological record seems to end 1,720 years ago. This is because no dates were submitted from the highly mixed and disturbed sediments of superficial strata. Classic period ceramics were identified from surface remains examined by others (see Chapter 1). The uppermost (youngest) Formative era dates were taken from what were deemed as the latest, but intact, deposits. The Classic and Post-Classic periods surely witnessed periodic use of the cave. However, perhaps because of their ephemeral nature, or perhaps due to modern looting and casual historic use of the cave, these more recent deposits have not been preserved in the archaeological record at this site. Habitation may have become less common, or the cave may have been reserved for funerary and ceremonial functions, leaving little material remains behind (other than the burials, which were specific targets of looters).

Second, there is a large gap (2,420 years on the basis of the limited series of dates) between the Early Estanzuela and Marcala phases. It is plausible, but unlikely that the area was not occupied and the cave not utilized during this time. In the Formative period the cave might have turned from camp to house, and routine housekeeping (*e.g.* sweeping and removal of rubbish) would have affected site formation and the deposition of cultural material. These activities in the Formative period could have disturbed and removed earlier deposits perhaps those deposits that may have been left during the temporal gap under discussion. In addition, the digging of storage and rubbish pits and fire hearths (see Feature discussion below) had the effect of mixing some materials between earlier and later occupations, evidence of these kinds of activities are more common in the Formative (see Feature Descriptions, below) and could also have caused an apparent hiatus of occupation. I believe this mixing is of relatively limited extent. Given the excavation methodology these intrusions were noted and accounted for in most cases. The possibility of older material becoming mixed with younger material most likely occurred in the transition zone between occupations. However, because each occupation zone is relatively deep, consists of multiple strata, and was classified conservatively with this in mind, I believe the samples on the whole are not adversely affected by mixing.

The third gap in the sequence cannot be explained in terms of a region-wide period of intensification such as the Archaic-Formative transition. There are no dates within a 1,620 year range between the Marcala and the Esperanza phases. It is a gap which roughly coincides with "Sub-stage IV" of MacNeish's Lithic (or Paleoindian) stage of the Pre-ceramic era (1986). Perhaps in this case, a lengthy occupation hiatus (between the Paleoindian and Archaic occupations) is a plausible explanation. Populations in the New World at the end of the Pleistocene were undoubtedly very sparse on the landscape and the absence of highly mobile bands of hunters and gatherers from this area for such a period is possible.

Feature Descriptions

In situ archaeological features give significant clues to specific activities. For example, grass-lined storage pits were found at Guilá Naquitz (Flannery 1986), and used to argue that the inhabitants were residing at the rock shelter for extended periods of time.

Storage features imply a behavioral strategy of harvesting and conscious effort directed at prolonging the availability of a resource (Testart 1982). In the key site surveys of 1998, the cases of modern and historic rock shelter habitation that I documented led me to expect certain feature types including storage facilities to be found at El Gigante. I observed, in use, things like post-holes that formed interior "rooms", wattle and daub walls that enclosed the mouths of shelters, and earthen ovens (see Photos 25 and 26). However, none of these feature types were found archaeologically at El Gigante, suggesting, perhaps, that the shelter never served such a specialized or intensive domestic function.

In sum, sixteen archaeological features were identified during the excavations of El Gigante. The majority of these seem to have been generic refuse pits and/or small hearths. Each of these is described below. Individual descriptions of the feature contents are given based on information recorded in the field on excavation level forms. The faunal remains were not identified by a specialist. A very general quantitative inventory, limited to two Units (1 and 2), is presented in Chapter 5. The following plant identifications have not been carried out by an expert. Those that have are presented in Chapter 6. Note that Appendix A is provided which cross references common, scientific and (Honduran) Spanish names for the plants that are mentioned in the descriptions of the features.

Feature 1: Feature 1 is a major feature, a large circular charcoal pit, estimated at over two meters in diameter. This pit extended into the main block from the west wall, appearing in Units 1, 2, 4, and 6 (see Fig. 12 and Photo 18). Given the ubiquitous charcoal remains and presence of fire cracked rock in this feature, I believe it may have been an agave (*Agave* sp. [*maguey*, Spanish]) roasting pit. The undisturbed lower portion of this pit extended to a depth of 85 cm and was designated as Sub-stratum Ic, placing it in the late Estanzuela phase (mid to late- Formative). The central portion was dug to bedrock and filled with large fragments of carbonized wood within which concentrations of fire cracked rock were found.

Feature 2: This feature was a large irregular shaped intrusion of non-specific function filled with Formative period refuse including fragmentary ceramics. This pit contained some of the best-preserved and presumably most recent prehistoric artifacts found during the excavations, including a hide bag, remnants of cordage, and painted textile cloth in a matrix of mixed gray ash, oak (*Quercus* sp.) leaves and grass (unidentified species) (see Photo 35 and 36, Fig. 15 and Photo 12). The full extent and shape of this pit was not possible to ascertain because the excavation did not reach its north, south or eastern limits. The pit extended across most of the eastern half of the main block, partially disturbing the upper portions of Units 3, 18, and 19 to depths up to 50 cm. The bulk of material from Units 7, 9, 13, 16, and 17 was recovered from this multi-use feature. The feature includes Sub-stratum Ib and Layer Ib2. It postdates Feature 1 and is indicative of Formative period disturbances and habitation activities. It appears possible that materials such as old bedding, hearth ash, and refuse were pushed toward the mouth of the shelter away from living and working areas. Ultimately, much of this material may have been pushed down the slope and out of the shelter altogether.

Feature 3: This circular round-bottomed pit (25 cm diameter and 40 cm depth) was bisected by Unit 2. It appears in the unit’s east wall (see Fig. 13 and Photo 21). It contained two distinguishable in-filling episodes. A radiocarbon sample submitted from the bottom portion of the feature yielded a date of 6,630 +/- 60 radiocarbon years BP (uncorrected) (Table 4, Sample 8); firmly placing the feature in the Archaic, or Marcala phase of the rock shelter occupation. This feature was very well isolated during the excavation of Unit 18 (see Photo 24). The top half (the second in-filling), was designated as Layer IIId3.3 and consisted of a yellowish gray loose ashy soil. Four pieces of flaked stone (one of obsidian), 10 *Manilkara* sp. and/or *Sideroxylon* sp. seed coats, a hog plum (S*pondius* sp. [*ciruela*, Spanish]) pit and some unidentified rind fragments were found in this matrix. In addition, 24 large mammal bone fragments were recovered as well as some armadillo scales and a few small mammal bones (note that the size classes discussed are arbitrary and used only for the preliminary sorting and description of the material as discussed in the next chapter). The pit's lower half (from which the Archaic date was taken) was quite different in character than the upper portion. Designated as Layer IIId3.4, the initial in-filling of the pit was dominated by organic material including oak leaves, grass stems and leaves, and food remains. Botanical fragments cataloged totaled 70 pieces, including avocado pits (*Persea americana*), maguey quids, *Manilkara* sp. and/or *Sideroxylon* sp. seed coats, hog plum seed pits and possible bromeliad (unidentified species) or other epiphytic plant fragments observed growing on many trees in the valley today. Seven lithic flakes (six of which were obsidian), 43 medium and large mammal bone fragments, and two pieces of cordage were also recovered from this portion of the feature. Based on the remains found in this pit, it appears to have been first filled with refuse and then later used as a fire pit. A one and one-half liter (1500 cc), 100% bulk sample was collected from the bottom half of this Archaic age feature. A description of the methods used to sort the sample and its contents are given in the small seed component section in Chapter 6.

Feature 4: This pit is located in the southwest corner of Unit 1 and seems to have been a hearth used multiple times; it was designated as Layers IIId1.1 - IIId1.7 (see Fig. 8 and 12 and Photo 20). Stratigraphic association places these strata in the Archaic, contemporary to or, slightly younger than Feature 3. This feature was not identified during excavation, (it occurred in the first excavation unit dug in the shelter when precise stratigraphic differentiation was difficult (see excavation methods, above). The thin (2-5 cm) layers were not excavated discretely and therefore are not distinguishable in this analysis. Overall the light brown, dark brown and gray mottled ash contained significant amounts of charcoal and flaked lithics (15 of 19 were obsidian). One small one-handed *mano* along with more than 100 bone fragments were recovered. Feature 4 was larger and shallower than Feature 3, with a diameter of 75 cm and a depth of 35 cm. Also, like Feature 3, it seems to have been used multiple times, showing at least seven distinct depositional episodes. Little organic material remained, although some burned pine needles (*Pinus* sp.) and tufts of grass were noted in the matrix. Because of the paucity of organic remains and ubiquity of faunal material found in this pit, as well as the size and multi-use character of the feature, it may indicate that a group of individuals repeatedly resided at the cave, perhaps on specialized hunting expeditions.

Feature 5: This feature was recognized after the conclusion of the excavations where it appeared in the exposed profile. A carbon sample (Sample 11) from Feature 5 returned a date of 9590 +/- 60 BP (uncorrected). The round-bottomed pit was similar in form to Feature 3. It measured 35 cm in diameter and 35 cm in depth. Like Feature 4, it was composed of several distinct deposits, in this case at least five, that were designated as Layers IVc1 - IVc5 (see Fig. 8 and Photo 22). Few artifacts were recovered from this feature other than flaked lithics and bone. Very little organic material was recovered either. The sediments were composed of a gray ash. It is inferred to be another reused refuse-hearth pit.

Feature 6: This hearth feature (see Fig. 11 and Photo 11) exhibited a similar morphology to the previous round-bottomed pits described above. During the excavation of the northwest corner of Unit 17, a pocket of mixed gray and light brown slightly sandy ashy soil was encountered at a depth of about 39cm below the surface. Assuming a circular shape, it would measure approximately 50 cm in diameter and 25 cm in depth. The pit was bisected by Unit 17 and thus was exposed and isolated in Unit 19 for very well-controlled excavation. Fifteen flakes were recovered from the pit (seven of obsidian) and 32 pieces of mammal bone, including small mammal fragments. There were also a large number of hog plum pit and corn cob (*Zea mays*) remains in addition to other unidentified organic constituents recovered from this feature. On the basis of its stratigraphic position, this pit is inferred to date to early in the Formative period during the early Estanzuela phase.

Feature 7: This feature was also a round-bottomed pit and was apparently used multiple times. Three stages of deposition were recognized in profile (see Fig. 11 and Photo 11), but designated simply as Sub-stratum IIIb. Feature 7 is thought to be roughly contemporary with Feature 6 and was composed of similar texture and color sediments. These sediments were grayish to tan with sparse charcoal and a high organic content. A diverse array of plant remains were recovered from this zone, including hog plum pits, avocado rind, other unidentified rinds that may include squashes (*Cucurbita* spp.), and corn cobs. This feature is situated at a depth of 90 cm below the surface and may be from one of the earliest Formative occupations. It is overlain by undisturbed strata that appear to be waste-strewn floors. The intrusion of Features 1 and 2 to the west did not disturb this feature. Feature 7 measures 20 cm in diameter and 25 cm in depth.

Feature 8: This feature post-dates that of Features 6 and 7. It is a broad bowl-shaped pit, one meter in diameter and 33 cm in depth. The multiple Layers (IIa4 - IIa7) composing this feature may again be indicative of a larger and longer occupational use of the site in this period. This feature contained a large quantity and variety of floral remains, suggesting that farming was being extensively practiced in the late Formative period. The feature's upper layers consisted of a loose light gray ash with some denser yellow pockets of ash with some carbon dispersed throughout (see Fig. 11 and Photo 11). Ceramics and maize cobs were ubiquitous in this zone. However, bone was limited to fragments of small mammals and, given the volume of excavated material, lithic flakes were sparse. In the lower portion of the pit sediments were brown to dark brown. Artifacts were similar to those in the upper portion and the floral assemblage dominated. However, the density of maize cobs decreased and the *Manilkara* sp. and/or *Sideroxylon* sp. specimens as well as hog plum pits were found in remarkably high concentrations. Large-mammal bones were also more common lower in this feature. Lithic flake recovery remained low (less than fifty flakes). Two small ground stone *manos* were recovered from the base of this pit feature at a depth of 85 cm; sediments at this depth were unconsolidated soil and fine carbon. A carbon sample associated with the base of this pit was collected during excavation but remains undated.

Feature 9: A small funnel-shaped pit was exposed directly below the termination of Stratum I and the base of Feature 1. This 45 cm diameter and 25 cm deep pit may have been the base of a larger feature, but was truncated by the intrusion of Feature 1. Feature 9 was encountered in Unit 2 at a depth of 45 cm below the surface, it extended slightly into Unit 6 on the north and slightly into Unit 4 on the west (see Fig. 12 and Photo 18). Artifactual components included a mix of organic remains in a matrix of grayish brown very fine soil and ash, removed from Unit 2 as Level 11 (stratigraphic Layer IId2). Forty-five stone flakes (16 obsidian) were recorded as well as 5 ceramic shards and a small number of remains, including 2 corn cobs, an avocado pit and some avocado rind fragments as well as a hog plum pit and a single masticated wad of agave fiber. Animal bones were recovered in moderate density. A maize cob dated directly from underlying material placed this feature at 2,280 +/-40 BP (uncorrected) (Table 4, Sample #4) indicating it was formed in the mid- to late Formative period (late Estanzuela phase). A half-liter (500cc), 100% bulk sample was collected from this feature, a description of the methods used to sort the sample and its contents are given in the small seed component section of Chapter 6.

Feature 10: This shallow hearth or fire pit (which is a common feature type) was found in the floor of Unit 1 after the excavation of Level 15, it was removed as Level 16b (see Photo 19). It consisted of a 12 cm diameter circular patch of dark brown loose ashy soil containing fine organics and charcoal; this was bordered by a distinctive ring of different, darker and more carbonaceous soil. The deposit was shallow, 8 cm in depth, and bowl-shaped. The top of this feature was located at 89 cm below the surface in Sub-stratum IVb, and dated to the early Marcala (Archaic) phase. A bone awl, five pieces of flaked lithic debitage and some ciruela remains were recovered from this feature. Of the bone recovered, almost half (5 of 12) of the large mammal specimens were burned.

Feature 11: In plan view, Feature 11 (Unit 18 Level 32a) was similar to Feature 10: it was composed of a 15 cm diameter dark ring around the border of a lighter circle (Photo 23). It was 5 cm deep and located at a depth of 67 cm below the surface. This feature was not dated directly, it is considered to be from Layer IIIf2. The materials recovered from the feature include maguey remains, grass, and a limited number of flaked lithics (4 pieces). Large-mammal bone fragments were uncommonly dense in this feature, and armadillo (Dasypodidae (?)) scales and crab (unidentified, freshwater(?) species) shell fragments were recovered as well.

Feature 12: This was the third of the small pit features with carbonized borders found in the lower zones of Stratum III. This 10 cm diameter, 6 cm deep pit was found in Sub-stratum IIIe at a depth of 53 cm below the surface in Unit 18 Level 28. At the base of this small pocket we recovered a tightly packed, partially burned "nest" of fine epiphytic moss. This could have been used as tinder for fire, or perhaps as discarded packing/lining for the pit. The item is intriguing and several other possible interpretations are possible. The only other materials recovered from this feature were avocado rinds and fragments of small mammal bones.

Feature 13: This feature resembled Features 10-12 and, like Feature 12 was found in Sub-stratum IIIe. Feature 13 consisted of a shallow fire pit with a carbonaceous black border. This feature was excavated in Unit 3, Level 14 at a depth of 38 cm below the surface: it was 19 cm in diameter and 6 cm in depth. Like Feature 12 this feature also had some unburned grass (perhaps tinder material) at its base. The mostly white ash matrix contained few artifacts, these included 5 flaked lithics, 5 bone fragments and limited botanical materials.

Feature 14: The excavation of Unit 19 uncovered three shallow-bottomed pits in close proximity to one another. These were excavated concurrently and are described together here. All measured between 38 and 45 cm in diameter and were between 8 to 10 cm in depth. These relatively homogenous deposits consisted of grayish brown to light brown loose ash and soil with an estimated 25 to 30% carbon inclusions. These pits represent intrusions from Layer IIIf2 into the underlying sediments of Stratum IV. One of these pits (at Level 33) contained maize cobs which was unexpected in these early strata. These cobs remain undated by direct AMS methods, but have a fully domesticated morphology suggesting they were mixed down in the deposit.

Feature 15: In the southwest quadrant of Unit 18, Level 31 (Layer IIIf2) a dense accumulation of fire cracked rock was encountered 69 cm below surface (see Photo 23), forming a single 7 cm deep layer. These stones included 3 pieces of ground stone among the rhyolitic and bedrock tuff cobbles. The density of material in this feature was high: 375 fragments of mammal bone (mostly large mammal), 146 pieces of flaked lithic debitage, and many *ciruela* pits were recovered. Feature 15 appears to have been a hearth. Its form differs markedly from that of Features 10-13. The dense clustering of fire altered rock, unique from the sites' other features, point to a hearth function, its specific use can not be inferred at this time, however.

Feature 16: This bowl-shaped fire pit was found in Unit 3 Level 28, 73 cm below the surface in Stratum VI. It was composed of a slightly sandy, loose gray ash mixed with significant charcoal and organic inclusions. Feature 16 measured 25 cm in diameter and 9 cm in depth. Its artifactual components were unremarkable, and included 5 flakes, 22 floral remains (*ciruela* and *maguey* remains as well as some unidentified plant parts), and 2 faunal remains. This feature resembles the generic refuse-hearths described above and may be one of the earliest examples; no date was directly derived from the feature.

Feature Summary

In summary, the predominance of multiple-use hearth and refuse pit features throughout the Marcala phase of the El Gigante occupation indicates that perhaps Archaic people were beginning to use the shelter as a regular extended base camp during regularly scheduled collections of wild foods in the area. The increasing occurrence of these types of features may indicate increasing logistic planning from this central place. An increasingly common but, still non-sedentary mode of "collecting" may have developed within a larger cycle of more mobile "foraging"-based systems (Binford 1980). If wild foods that were available and abundant only at certain times of year could be stored, surpluses could be relied on for lengthier periods. However, at El Gigante, the bulk of the botanical items recovered would not have been ideal for such a strategy. Storage is aimed at extending the availability of resources through time, perhaps as an intentional risk-buffering strategy. This strategy is central to many hypotheses regarding subsistence adaptation and social complexity (e.g. Smith 1995, Flannery 1986, Testart 1982). Storage economies are prerequisite to the adoption of seed grain agriculture defined by Smith (1995) and Piperno and Pearsall (1998). Thus, “collectors” (who store food in central locations) might be predisposed to the adoption of agricultural practices, while foragers (who move to areas of naturally-available food) would be less so (Binford 1980). In this regard, it appears that the hunter-gatherers at El Gigante used mobility as a major tactic in their subsistence strategy, and fall further towards the forager end of the spectrum. This may help to explain why the adoption of agricultural lifeways occurred at such a late date at El Gigante. However, more regular and longer occupations suggested by some of the features in the Estanzuela period may indicate some movement towards a collection mode of foraging. This also may have promoted storage technologies that we are unaware of.

There is no indication that any of the food items recovered, for example, avocado, hog plum, agave and *Manilkara* sp. and/or *Sideroxylon* sp., were harvested and stored in bulk for any significant length of time. The drying of these fruits *en masse*, would not necessarily have left any kind of archaeological trace, however. The process may have been as simple as laying them out on the dry cave floor to dessicate. Likewise there is no indication in the early part of the record to indicate systemativ use of any large containers for storing food. Baskets and grass lined pits may have served the purpose quite adequately, though. At any rate, it is my opinion that most of the resources that make up such a large portion of the refuse (though not necessarily a large portion of the diet) would have lasted longer on the tree. That is, assuming they were safe from other animal competitors, selective harvesting for immediate needs, while gathering information and managing for increased future potential harvests, may have been an attractive alternative to storage for El Gigante's inhabitants. Stands of *maguey* and patches of fruit trees can be harvested throughout the late spring and summer (see Chapter 6) and patches would have been easy to locate, exploit and monitor from a base such as El Gigante. Visiting different patches on a daily or weekly basis could be neatly worked into forays that also targeted game or other opportunistic resources encountered along the way.

There is little evidence in the way of archaeological features at El Gigante for material investments in storage facilities. A more effective strategy for prolonging resource availability in the Archaic at El Gigante would have been to cultivate available stands of useful species, and augment them through planned plantings, weeding and active propagation. These activities would have been low-cost and have had a high pay-off resulting in an extended period of diverse resource availability, and short-term (seasonal) stability. Unfortunately, these simple and effective methods leave no archaeological traces (Peters 2000, see Chapter 7).

Sedimentary Analyses

Ash Comparison

One distinctive aspect of the El Gigante stratigraphic sequence were several thick, relatively homogenous layers of ash (particularly Strata III and IV), at times these exhibited very thin, alternating yellow and white laminae. During our excavations an overnight security team was hired to guard our equipment and the site. In the four months of field work, a large pile of campfire ash from locally-available wood built up adjacent to the site. This ash pile, sheltered behind the drip line of the cliff, was perhaps 20 cm deep, fairly compact and was the same color as the material we were digging through in the rock shelter.

At one time having suspected a volcanic origin for some strata in the site I refered to methods outlined for Quaternary tephras by Kittleman (1979) and in Steen-McIntyre (1985). A sample of this wood ash was taken from the camp fire and compared to a sample from El Gigante (Unit 6, west wall, Sub-stratum IIIe/f). The pH of both samples was measured using Colorplast 5-10 EM reagents litmus paper. Although the archaeological material was slightly more alkaline (8.5 - 9.0) it was very close to the modern fire sample (8.0). Visually, the two samples were distinguishable only in that the archaeological sample had coarser sand size grains in the matrix of ash. Under a microscope at 400x, this trend was also observed. However, the physical appearance of sub-angular, low sphericity particles seemed very similar between the two samples. The mineral crystals observed were the same dark brown color under normal light and bluish green under polarized light.

These brief and simple tests seem to confirm that the thick strata (III and IV and some of their sub-members) are composed of wood ash. I believe that these deposits were the result of camp fires over multiple and extended periods within the cave. Based on their thickness and extent within the cave, these ashes also indicate an intensive human use of the shelter during the time of their deposition. These activities are hypothesized to have been particularly intense during the mid- and late-Archaic (corresponding to the inferred dates of Strata III and IV).

Soil Carbon Content

Fire was important to early hunter-gatherers. It had many uses, ranging from cooking and heating, to landscape level transformations that were achieved by its repeated use for clearing vegetation, *etc.* (Smith 1995; Sauer 1952). Analysis was undertaken of sediments from the stratigraphic column taken from the south wall of Unit 3 to try and address the issue of fire use. Equal volumes of sediment were taken from each of the strata within a column sample from the south wall of Unit 3. The sediment samples were sieved through a series of standard geological brass sieves. The material in the largest fraction (#10, or >2.0 millimeter) was itemized and weighed. Of the 18 strata sampled (Stratum VIIa -Ia), four had percent carbon contents (by weight) above 2% (see Fig. 23). This reaffirms assessments of the anthropogenic origin of the ash in Strata III and IV. The most significant quantities of carbon were from Sub-strata IIIf3, Stratum IV and Sub-stratum IVb, in which carbon composed 8.7%, 5.7%, and 3.4%, respectively. It is possible that burning wood intensified in the shelter through the mid/late Archaic. This conclusion invites questions regarding the impact of this behavior on the environment.

Fire Cracked Rock

A third avenue of evidence for the intensity of fires in the cave (and, by extension, occupation intensity at El Gigante) came from the examination of the fire cracked rock (FCR) found in the excavations. Prehistoric cooking practices often utilized river cobbles as heating stones, and prehistoric hearths were often lined with rock if multiple use events were intended. Many rocks became heated in the process and were left as refuse in fireplace and hearth contexts. The results of this heat on the rock is observable to the naked eye: the altered cobbles appear discolored, coarser grained and more friable and angular than unaltered river cobbles.

We systematically recorded the quantity of FCR during the excavation of Units 1, 2, 18 and 19. Plotting the average number of pieces of FCR per level by stratum (see Fig. 24), reveals a noticeable increase in the amount of FCR present in Sub-stratum IIIf. The FCR data and the soil carbon data correlate nicely, showing peaks in fire usage in the Marcala phase and again in the Esperanza phase. Averages increased again in the most recent periods of Formative occupation, indicating an intensification of the activities through time.

Large earth ovens which capitalize on the heat retention of rocks are used to process *maguey* for consumption. This ethnographically-documented practice produces enormous amounts of FCR over time (Castetter *et al.* 1938, Dering 1999). Feature 1 (see Photo 18) may represent such an accumulation of massive amounts of fuel and rock for roasting agave hearts. An increase in the amount of agave roasting may serve as an explanation for the later FCR trends at El Gigante. Coincident with the spikes in FCR during the Formative was a notable increase in the quantity of archaeological *maguey* remains in the botanical assemblage (see Chapter 6). Both quids (masticated wads of agave fiber) and other largely burned parts of the maguey plant increased in abundance through the sequence. In the early Paleoindian and Archaic strata, quids and other *maguey* remains were uncommon (<20 collected); in Stratum III, 42 quids and 73 other pieces of *maguey* were present; in Stratum II, this number increased to 260 quids and 232 other pieces; In Sub-stratum Ib, 1363 quids and 1345 other *maguey* pieces were recovered.

Conclusions

The archaeological context of the material found at the site of El Gigante is deep, stratified and dry. Large areas of sub-surface stratigraphy were found to be intact despite the presence of superficial looting. Deeper levels were preserved very well. Once exposed the strata are distinguishable in profile and can be removed with great control during the excavation. Features including trash and burn pits, rock-lined hearths and refuse dumps were noted in the excavation. Many of these features intruded into thick yellow accumulations of ash that are believed to be the remains of multiple and extended periods of mid-Archaic camp fires. The combination of textural and qualitative sedimentary analysis, focusing on the character of the ash matrix, soil carbon content, and FCR, point to a possible period of more intense fires in the shelter during the mid- and terminal Archaic. This observation may have implications for resource use at the landscape level, including the use of fire as a landscape modification tool. However, the exploration of that topic lies beyond the scope of this dissertation. Below these archaeological strata lie a series of pre-human volcanic sediments.

Table 4 Radiocarbon determinations

#	Lab ID	Comment	Stratum		C14 age	+/-		cal(2sig)BC		13C/12C
1	Beta-156242	upper level	I	b	1970	70		160	220 AD	-25.0
2	Beta-171702	EG01 18.7	I	b	1930	60		50	230 AD	-25
3	Beta-171701	EG01 18.20 (maize)	II	c3	2010	40		100	70 AD	-8.9
4	Beta-159055	EG00 2-14a (maize)	III		2280	40		400	350	-8.5
							and	310	210	
5	Beta-156243	Lower level	II	c3	3040	220		1760	800	-25.0
6	Beta-171703	EG01 18.18	II	d	3780	60		2430	2030	-25
7	Beta-171704	EG01 18.21	III	c1	3100	40		1440	1280	-25
8	Beta-156247	Feature "F3"	III	d3.3	6630	60		5650	5480	-25.0
9	Beta-156244	Lower level	III	f2	7140	200		6410	5640	-25.0
10	Beta-171705	EG01 19.31	III	f2	6180	90		5320	4850	-25
11	Beta-156245	Feature "F5"	IV	c3	9590	60		9220	8750	-26.0
12	Beta-156246		V	a	9600	60		9220	8760	-25.0
13	Beta-171706	EG01 19.37	V	b	9210	60		8590	8280	-25
14	Beta-171700	EG01 3.28 (quid)	VI		9240	40		8580	8300	-10.2
15	Beta-171699	EG00 1.23b (cordage)	VIII	a	9290	40		8620	8430	-10.6
							and	8360	8340	
16	?	Hasemann's "zone XVII"*	IX		39820	1100				?
17	ISGS 2965 2	Unknown provenience**			9450	70		8934	8868	-24.3
							and	8857	8790	
							and	8705	8688	
							and	8675	8343	
							and	8292	8273	
18	ISGS 2966 3	Unknown provenience**			9970	70		9904	9044	-25.3

* samples submitted by Hasemann 1998, personal communication.
** earlier samples, Hensley-Sherman 1994?

Figure 21 Radiocarbon age ranges

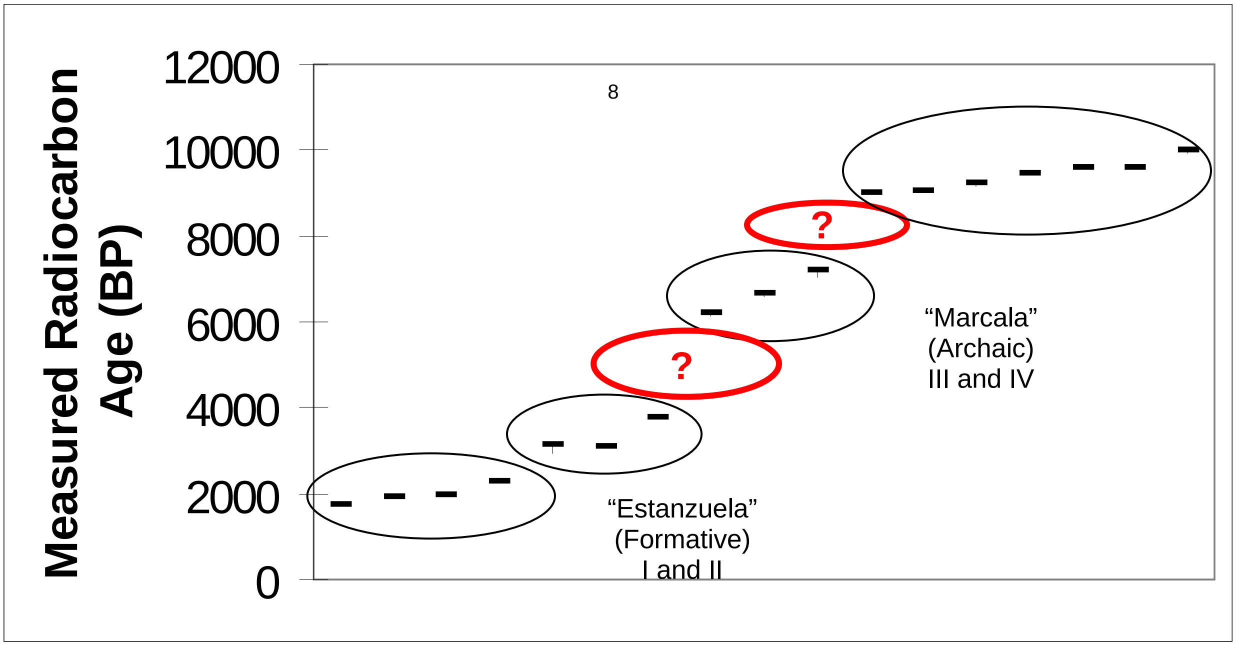


Figure 22 Comparison of El Gigante archaeological phases to sites discussed in the text

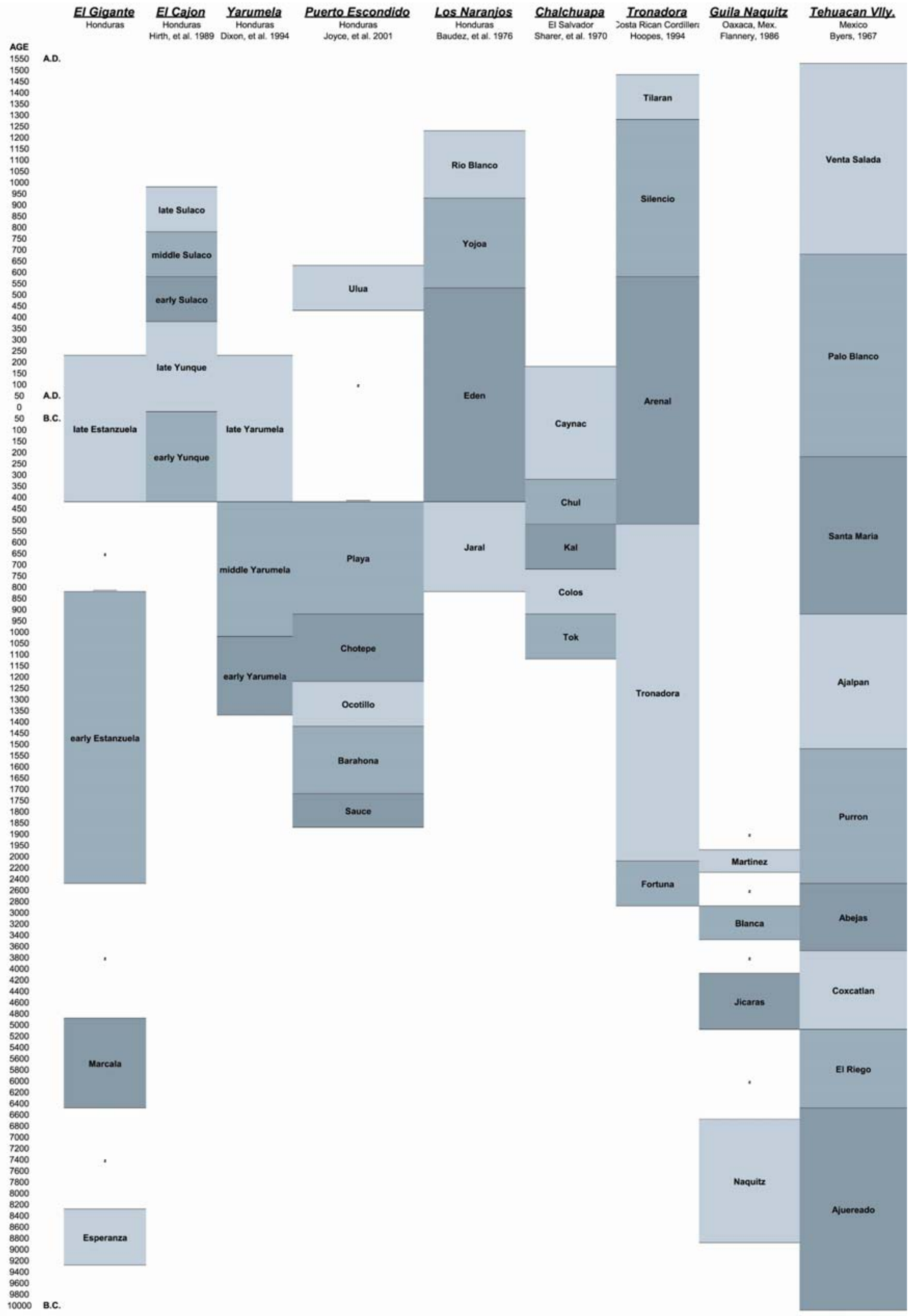


Figure 23 Percent carbon content (by weight) of >1mm fraction, by stratum from column sample, Unit 3.

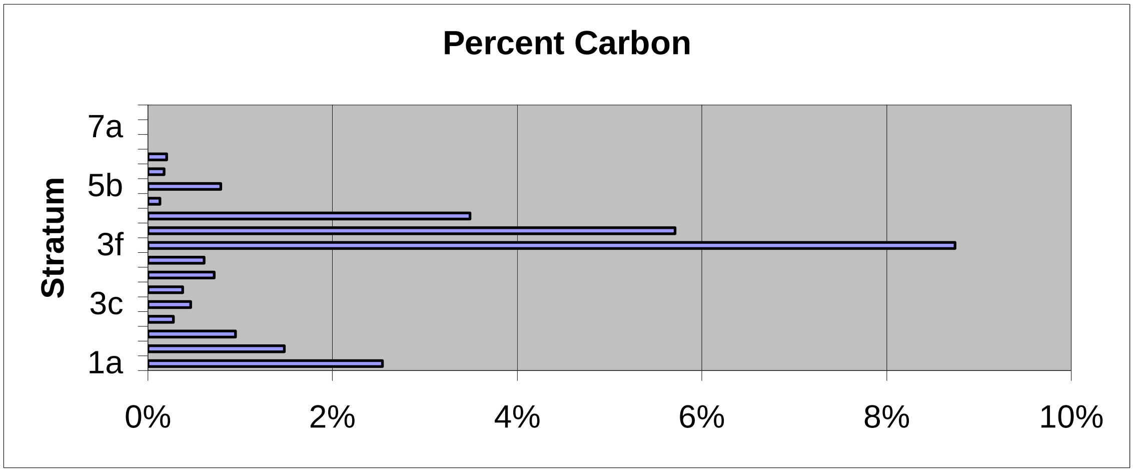


Figure 24 Average Number of Fire Cracked Rock fragments by stratum (Units 1, 2, 18, 19).

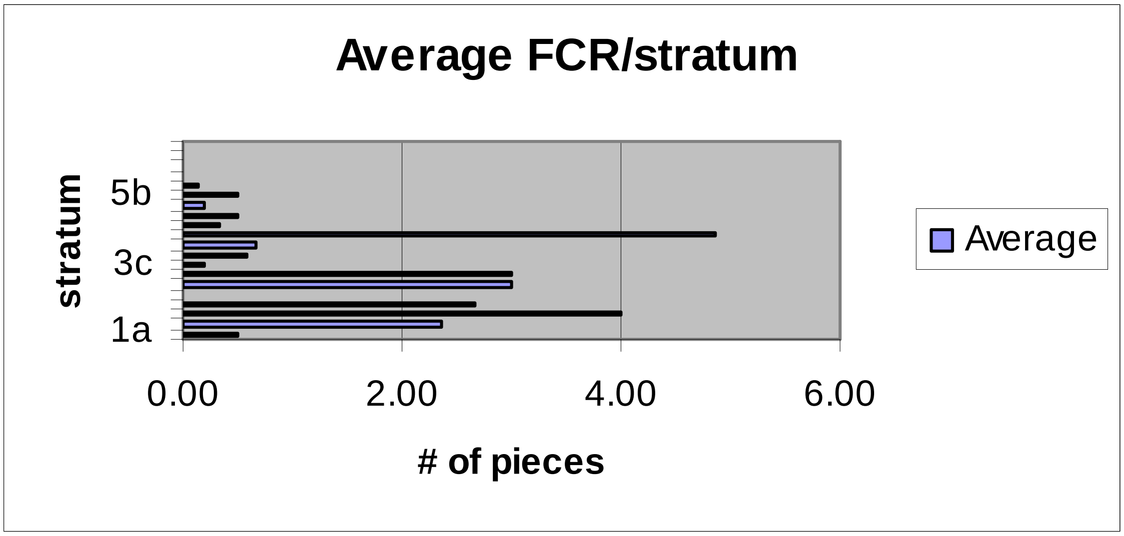


Photo 19 Feature 10

Photo 20 Feature 4

Photo 21 Feature 3

Photo 22 Feature 5

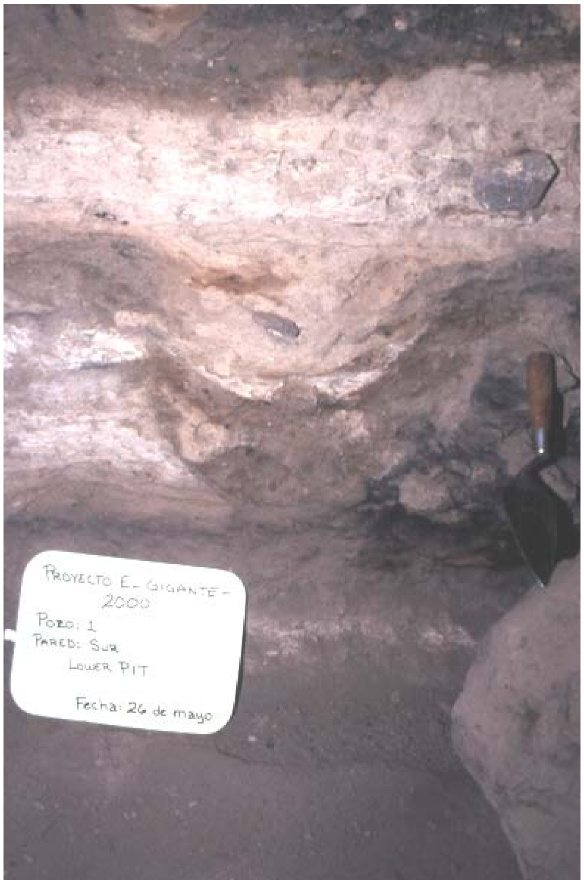


Photo 23 Feature 11 (upper rings) and 15 (lower FCR cluster)

Photo 24 Feature 3

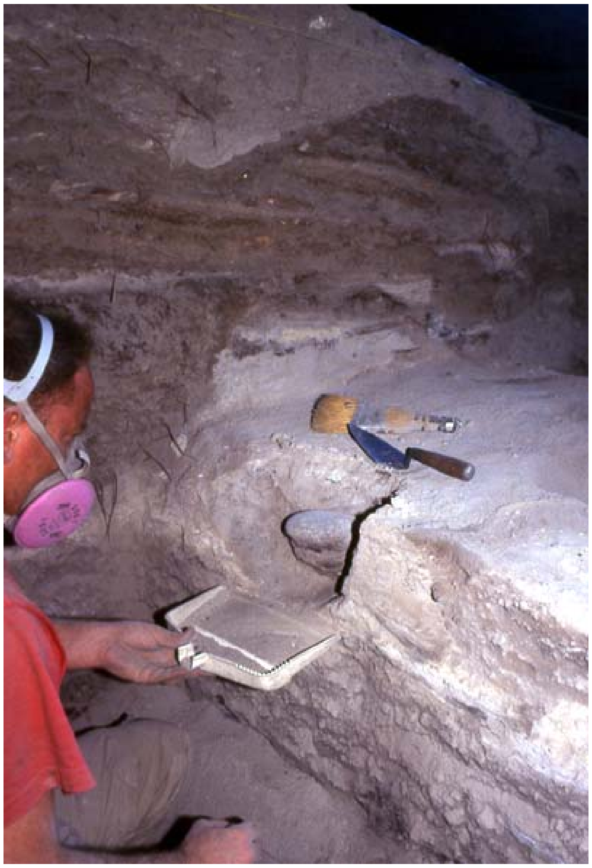


Photo 25 Wattle and daub wall constructed in a rock shelter, Cueva del Chon

Photo 26 Posts and drainage channels in the floor of an inhabited rock shelter.

CHAPTER 5: MATERIAL CULTURE AND FAUNAL REMAINS

This chapter summarizes and discusses the artifactual material recovered from *in situ* contexts of the main block of excavations. Material recovered from other locations was considered too disturbed to confidently relate to the cultural sequence. The main block consists of twelve 1-meter-square units (Units 1, 2, 3, 4, 6, 7, 9, 13, 16, 17, 18, and 19) dug across center of the cave floor area (Fig. 5). A total of 417 levels were dug in these units. Each excavated level was assigned to the geological stratum from which it was sampled (I through IX, see Chapter 3 for methods).

The material discussed in this chapter includes ceramics, lithics (flaked and ground stone), faunal material, human bone, worked bone and shell, textiles and, lastly, the rock shelter's intriguing pictographs. Recovery averages and other statistics are presented for the excavated levels. A diachronic perspective is achieved by comparing these averages between strata. Separately excavated levels from the same stratum or sub-stratum are considered comparable contexts within the site in this analysis; they are discrete deposits with some functional continuity and basis for chronological contemporaneity (Emery 2004:23). The floral remains are not discussed in this chapter but are described separately in Chapter 6.

Ceramics

Ceramics were ubiquitous in the upper levels of the excavation (Fig. 25). There were averages of between 4 to 9 sherds per level in Sub-strata Ia – Ic; these date to the Mid-Formative (Late Estanzuela phase). This average dropped substantially in Sub-strata

IIa - IIIc. Ceramics were consistently recovered in this Early Formative (Early Estanzuela phase) period, but at densities of less than 2 sherds per level. Some isolated sherds were found in Middle Archaic (Marcala phase) contexts, but are thought likely to have been mixed prehistorically into sediments dating to this time. These errant pieces serve as a barometer of the extent of mixing between pre-ceramic and ceramic period occupations. The mixing is limited in both scope and extent throughout the strata.

Much of the ceramic assemblage from the near-surface levels was of mixed provenience because it was included in the patchily distributed overburden of looters' fill that lies across the surface of the rock shelter. Levels excavated from below Sub-stratum Ib were uninfluenced by this looting activity. The exact date of the first appearance of ceramics is difficult to establish because of the limited number of radiocarbon dates available. The lower level of Layer IIc3 dates to 800-1760 (cal) B.C. (#5 in Table 4) and represents a broad estimate of when ceramics may have come into common use at El Gigante. This estimate places the earliest Estanzuela phase ceramics at El Gigante contemporaneous with Jaral (800-400 BC) and Eden (400 BC - 550 AD) phases at the site of Los Naranjos on Lake Yojoa in Central Honduras (Baudez and Becquelin 1976), and also with Early Period (300 BC - 300 AD) ceramics in the Reventazón River region of Costa Rica (Kennedy 1976). Interestingly, stylistic traits from both these assemblages mirror those at El Gigante, including the use of incised and punctate decoration as well as a large percentage of Red on Buff wares (see below). There is no indication of a particularly precocious ceramic tradition at El Gigante, as at other Central American localities. For example, in northwestern Costa Rica the Tronadora Complex is dated as early as 2,000 B.C. (Hoopes 1994).

The total collection of ceramic sherds consisted of 1,048 fragments. Two units were selected for more detailed inventory, including a definition of type and form for a 262 sherd sample. This analysis was undertaken by Dr. Kenneth Hirth and the author.

By far the dominant ceramic type is a slipped, unburnished black/brown (10YR 4/2, dark grayish brown) ware, representing approximately 33% of the sampled assemblage. Matte Brown and Burnished Cafe types each represent about 10% of the assemblage. More rare, is the Obscuro Burnished type (7% of the assemblage) which is a darker-brown color (7.5YR 2.5/2, very dark brown) with black interior.

Only a single sherd was recognized as belonging to a previously defined type, that is Usulatan or Negative Resist ware considered diagnostic of the Late Formative Period. Other minor components of the assemblage include Red wares (10YR 3/3, dusky red), Red on Natural (2.5YR 3/4, dusky red; 2.5Y 7/4 pale yellow or 7.5YR 5/4-5/6 brown-strong brown), Dichrome Red wares (with either black interior or exterior), a single Classic Period Polychrome sherd, Incised and Appliquéd pieces, Orange on Cream, Differentially Burnished, Brushed Exterior/Burnished Interior, and Thick Black.

Many different forms of ceramic vessels were present (Fig. 26). Most frequent were bowl bodies (30%) and jar bodies (29%). Interestingly, another relatively common form was a fired clay ball (Photo 27). These balls varied from 1.26 to 1.63 cm in diameter, with an average of 1.4 cm. Their function remains uncertain. Suggested uses include use as blowgun pellets (though they seem too lightweight), or as rattle elements in ceramic/gourd containers. Minor components of the assemblage also include globular jars or bowls with circular restricted mouths (in Spanish, *tecomates)*, plates, vessel supports, and jar handles.

Very few rim sherds were recovered that could be used to measure rim diameter. The four measurable bowl rims measured were 7, 14, 16, and 18 cm in diameter. Two *tecomate* lip fragments measured 7 cm and 8 cm at the mouth diameter, though such a measurement tells us little about the overall size of the vessel. Another single jar mouth was determined to be 14 cm in diameter. With such a small sample, little can be extrapolated from these statistics; however, larger vessels were more commonly recovered.

The El Gigante ceramic assemblage had a distinctly utilitarian, or household character. However, some of the fine-decorated examples may have been related to Formative Period burials, heavily disturbed by looting (see chapter 3 regarding looting and burial location and below for more on the human remains). No whole vessels were recovered *in situ* from any human internments or other archaeological context.

Future analysis of the entire ceramic collection could test hypotheses concerning changing site function or trade relationships. Stylistic analysis of the collection could assist in geographic mapping of incoming wares, pointing to socio-cultural influence or contact with other areas within or outside the Maya sphere. Functional changes in the rock shelter's use through time could possibly be addressed by examining the changing frequencies of ceramic form. Lastly, a technological approach might reveal sources of clay or pigments that could assist in defining the extent of local production (or lack thereof).

Flaked lithic artifacts

An analysis of the means by which people procured and processed their food can be made by examining the flaked lithic artifacts. This helps to understand changing Archaic Period subsistence practices. Flaked stone debitage is produced in the manufacture of stone tools (including scrapers, drills, burins, blades, and bifacial projectile points) that were used for various activities including hunting and butchering. Several hypotheses were posed on the basis of an intitial examination of debitage recovered from El Gigante in 1993 (Dixon 1994). These are confirmed by the current analysis. For example, the distribution of raw material types suggest that many tools produced during the Archaic and Paleoindian periods did not require a fine cutting edge. The variety of chert and basalt used indicate that probably more than one reduction strategy was being employed. Dixon also concludes, on the basis of the limited retouch and use wear indications on the chert artifacts, that the assemblage represents the expedient use and discard of locally available material. However, he also finds that 10 - 30 % of the chert is heat treated, indicating a more complex reduction technology even within a single raw material class. Lastly, Dixon notes, and our investigations confirm, a general lack of large chopping tools (*e.g.,* axes).

We recovered few formal tools in these excavations, however, a limited technological analysis (*sensu* Sheets 1975) of the debitage reflects how and what types of tools were made. A total of 10,750 pieces of chipped or flaked stone were recovered in the main block of excavations. There is a clear fall-off in the average number of flakes per level by stratum. The counts range from a high of near 90 per level in Archaic age strata to less than 20 per level in Formative contexts (Fig. 27). This might indicate a decline in the importance of sharp cutting edge tools, generally associated with the procurement and processing of meat, within the subsistence economy.

The raw materials that make up the flaked stone assemblage are composed of obsidian, rhyolite, andesite, basalt, and chert. Coarser-grained volcanic rock serves for chopping and mashing, but obsidian is by far the superior material for tasks such as butchering which require a sharp slicing edge. Sources of obsidian were important material and symbolic regional resources (Saunders 2001). Obsidian was widely traded throughout Mesoamerica (Parry 2001; Spence *et al.* 1984; Sanders and Santley 1983), including the southern peripheries of the Mesoamerican culture area (Aoyama 1999; Sheets *et al.* 1990; Sheets 1989). I believe that several obsidian sources were available to the inhabitants of El Gigante. The La Esperanza obsidian source is located only twenty kilometers to the north of El Gigante (Sorenson and Hirth 1984) and the San Luis mines are 100 km away from the shelter (Aoyama 1999). These sources were integral in the production of standardized prismatic blades, hallmarks of later periods in Mesoamerican prehistory (Parry 1994; Clark and Bryant 1997). Prismatic blades produced from polyhedral cores do not occur at El Gigante. However, these obsidian sources were probably known and exploited as early as the Paleoindian period. Future use of geophysical sourcing, such as Neutron Activation Analysis, or X-ray diffraction, could explore the extent to which lithic raw material conditioned settlement adaptations and/or requirements for mobility (*cf.* Daniel 2001; Jones *et al.* 2003). Some of these regional sources in Southern Mesoamerica and the Northern Intermediate Area, have already been characterized to facilitate this type of analysis (Sheets *et al.* 1990).

The lithic assemblage was divided into two samples: a washed portion used to clean the flakes for accurate identification and classification, and an unwashed portion that was reserved for future residue or other analyses. In the unwashed sample (Units 1, 2, 18, and 19) attributes recorded include the debitage counts per level by raw material type, the number of flakes, and an itemization of formal tools and any utilized or retouched flakes. The washed, sample (Units 4, 6, 7, 9, 16, and 17) allowed a closer evaluation of cortical flake frequencies, as well as an independent check on statistics regarding raw material type and ubiquity of tools from the other portion of the assemblage.

To gauge the overall availability and use of obsidian relative to other raw material types over time, I compared the ratio of the sum of all other raw material types to obsidian. In the entire unwashed sample there was, on average, 1 flake of obsidian for every 2.12 flakes of other material in each level. The average ratios for individual strata ranged from a maximum of 1:3.42 in Sub-stratum IIIc to a minimum of 1:1.50 in Stratum VI, with no apparent trends over time (Fig. 28). A tabulation made of the washed sample confirmed this average, with obsidian artifacts making up about one-third of the total lithic assemblage across all strata.

According to the organizational model of Carr (1994) there are logical steps in the production of stone tools and certain steps must precede others. To form an idea of how the entire technology was organized, I evaluated the debitage in terms of these steps using the frequency of cortical flakes (those produced in the first stages of lithic tool production). Changes in the frequency of early-stage debris produced at this location aid in understanding the production and maintenance of stone tools. For example, a low frequency of cortical flakes indicates that cores were prepared away from the site. For obsidian this probably was accomplished at the quarry sites of La Esperanza or San Luis. This may point to differing degrees of mobility and access to raw materials through time. Parry and Kelley (1987) have proposed a shift from prepared to expediently prepared core technology as might be reflected in an analysis of cortical frequencies, may reflect a corresponding shift in increasing sedentism. It is my qualitative impression that much of the debitage left at El Gigante is a result of an expedient technology. There were few indications of any standardized bifacial or polyhedral core preparation at El Gigante. Bifacial thinning flakes were noted during excavation but, far more irregular, utilized flakes, and flake-blades were recovered. The debitage characterizing El Gigante's Archaic may appear haphazard and opportunistic, and therefore more expedient in quality, but it is premature to infer a higher level of sedentism from this fact alone. Expediency may be a reflection of many other factors, including for example, raw material availability. An expedient multi-purpose core may, in fact, have been more suited to a generalized mobile subsistence strategy. This would be especially true in ecological/geological contexts where larger game is relatively rare and specialized hunting apparatus is not required. There is no need for a forager to invest significant effort in a technically sophisticated core, when it is possible to acquire new raw material several times a year in the course of annual movements. This may have been the case at El Gigante.

As mentioned above and recognized by Dixon (1994), the presence of multiple raw material types implies that multiple production strategies were at work, presumably geared toward different functions. Therefore, to asses the meaning of cortical flake frequencies we must separate out different material types in the analysis. The results of the tabulation of cortical flakes by material type and their comparison to the sum of later stage debitage of the same type are presented in Table 5 and Figure 29.

There was considerable variation in cortical flake frequency between strata for all raw material categories (obsidian, basalt and chert; note that the “other” category contained too few individual samples to allow further analysis). In the earliest zones of Esperanza phase occupation (Strata V, VI and Sub-stratum VIIa) few cortical flakes were recovered. With the exception of the chert in the earliest stratum, cortical flakes comprise less than 20% of the sample until around Sub-stratum IVa where they become more common. Interestingly, in the Marcala phase the cortical frequencies for the material types seem to parallel one another. Although chert frequencies remain low through Stratum III, basalt and obsidian are at times upwards of 50% of the debitage. The later Estanzuela phases of occupation (Strata I and II as well as sub-members), are somewhat inconsistent. While basalt and chert fluctuate between less than 10% and to more than 20% in early and later Estanzuela periods, obsidian seems to be relatively stable with approximately 30% of the debitage consisting of cortical flakes.

The consistently low percent of cortical debitage in the very earliest Paleoindian period (Esperanza) suggests that occupants worked prepared cores in the cave, procuring and pre-processing raw materials elsewhere. This supports an idea suggested by Kelly and Todd (1988) that an economic strategy based on mobility, perhaps above all else, characterized the first peoples of the Americas. Given the unknown expectation of when another quarry would be encountered, they hypothesize that raw materials were exploited with a specialized technique of core preparation. Therefore, a camp away from quarry sites would be dominated by lithic debris lacking large quantities of cortical flakes and indicating the maintenance but, not the initial preparation of tools.

Assuming that there was consistent access to the source locations by El Gigante's inhabitants, this pattern of production may have changed in the Archaic. Higher proportions of cortical flakes in some deposits of the Marcala period indicate that more processing and core preparation was done on-site, away from raw material sources. This pattern holds true for all the material types. Presumably, much of the basalt and chert was found in local, stream bed cobble deposits on banks and bars of the many waterways of the area. During this time raw materials appear to have been brought "home" for processing. It suggests a slightly more sedentary lifestyle, or at least prolonged stays at the shelter. The erratic values, including two low results through Stratum III, temper this assessment.

Changes through the Formative period may have been influenced by the solidification of longer distance exchange and more-permanent "foreign relations" or "visiting trade institutions" (Heider 1969) developing across Mesoamerica. There is little to be gleaned from the cortical flake ratios of Strata I and II. Furthermore, these strata suffer from small sample sizes which could distort the patterns shown. Indeed, the definition of the precise technological organization of lithic tool production requires much more analysis in all cases. However, I think there is a strong argument to be made for the juxtaposition of the early and consistently low values, with the later and intermediate periods which show more erratic but generally higher ratios of cortical flakes in their assemblages.

Projectile Points

Three complete and four partial projectile points were recovered at El Gigante (Photo 28 and 29). All of these bifaces were found in Sub-strata IVb and Stratum V, belonging to the Esperanza phase (8,300 BC to 9,220 BC). Of the seven specimens, four are made from obsidian and three of variously colored chert. All of the points seem to belong to a single morphological type. Another specimen (not examined by the author) recovered by previous investigators was described as a "fishtail derivative" (Dixon 1994). However, the points recovered in the current excavation are not fluted; they have expanding, bifurcate, notched stems, are 4-5 cm in length, and are all about 3.5 cm at their broadest point (at the tip of the barbs). Some specimens have what appear to be opportunistic vertical thinning flakes taken from one side of the stem base, not to be confused with a true flute. A flute-like, vertically oriented basal channel on a projectile point can also occur as a remnant flake scar from the original ventral side of a flake blank. This, “pseudo-fluting” (Bird 1969) is not evident on the El Gigante points either. The basal thinning of the El Gigante specimens does not suggest the same technological forethought, preparation or specialization on par with the manufacture of a truly fluted point. Until further analysis of the debitage and other tool types is made, it is premature to begin talking about the evolution of these from other Paleoindian points or *visa versa*.

Most of the points have been extensively retouched, displaying tips with almost-obtuse angles. While in use, these points might have been much longer; they may have been discarded after repeated reworking and sharpening rendered them less than effective. There is remarkable consistency in the chronological placement of the points which are all from contexts (Strata IV and V) dated by radiocarbon to between 8,750 - 9,220 calibrated B.C. (2-*sigma*). It is possible that the points found at El Gigante were attached to the tips of atlatl darts. MacNeish (1976) proposes the emergence of the atlatl technology at around 9,000 BC, but there is no other evidence to argue strongly for its use at El Gigante.

Bullen and Plowden (1963) reported finding possible Paleoindian era lithics on the surface of rock shelter sites on the Highland Plateau to the north of our study area. The points they describe, however, differ markedly from those recovered in the current excavations of El Gigante. They describe one example as "lanceolate . . . leaf-shaped . . . fluted-stemmed" (1963:384;2a). They disavow any similarity of their Esperanza material to the El Jobo complex from the Taima Taima, Venezuela site. The El Jobo projectiles (characterized by willow-leaf shapes) are associated directly with mastodon remains and dated to between 13,000 and 11,000 years ago (Cruxent 1956, Pearson 2004). Bullen and Plowden do note that other similar types have been found in South America. They mention later (1963:385) that the El Inga complex of Ecuador may have a significant relationship to their collection. A potential obsidian quarry site at 2700 meters above sea level, the El Inga site contained several projectile point types including fluted Clovis-like and fishtail points as well as Ayampitin (tear-drop and laurel leaf shape), and other lanceolate and unfluted forms (Bell 1960; Dillehay 2000; Pearson 2004). Because of the paucity of data at the time, Bullen and Plowden hesitate to label their surface finds Paleoindian and call them instead the only preceramic archaic assemblages available at the time from Honduras (Bullen and Plowden 1963:384).

The El Gigante points *are not fluted*, yet are Paleoindian in age. The El Gigante finds represent perhaps only the fourth instance of diagnostic early Paleoamerican projectile points found in a buried context between the Rio Grande and Columbia

(Pearson and Cooke 2002). The other three are from the Cueva de los Vampiros, Panama (*ibid.*), the Los Tapiales site in Guatemala (Gruhn 1977) and the Los Grifos cave in Mexico (Santamaria 1981). All models of diffusion or migration based on fishtail and Clovis projectile point type distributions assume that "the fluting technique was a northern innovation that appeared and spread with Clovis populations" (Pearson 2004:93). One estimate of the range of dates of the Clovis Complex in North America is from 11,050 to 10,800 radiocarbon years before the present (Waters and Stafford 2007). The El Gigante Paleoindian projectile points probably postdate Clovis by as much as a thousand years (occurring in strata associated with dates of between 9,600 and 9,210 radiocarbon years before the present). But, while El Gigante projectile point bases have a slighty fish-tail shape, their stems are expanding, not waisted, as is characterisitic of fish tail points described in the literature in Panama (*e.g.,* Ranere and Cooke 1996:57;3.2) or Costa Rica (Snarkis 1977:18;2). I do not think they belong to the formal fishtail type but, instead deserve their own designation. Unfortunately, as such, they can not easily be used to evaluate hypothetical models of fishtail point type origin that propose evolutionary relationships with Clovis cultures (*cf.* Pearson 2004).

The El Gigante projectile points differ technologically from fluted types of lanceolate or fish tail forms described for Central and South America (Dillehay 2000, Pearson 2004). They do not conform to an out-dated and simplistic model of “Clovis-first” Paleoindian occupation of the New World (Greyson and Meltzer 2002:314; Whitley and Dorn 1993). On the basis of projectile point type alone, a more complex model that posits multiple emigrations and/or a rapid splintering of groups and their associated technological signatures is indicated. Morphologically, the specimens from El Gigante most closely resemble the points found at Monte Alegre, near Santarem, Brazil (Roosevelt *et al.* 1996) but, on this sole basis I would not claim any relationship between the two beyond a potentially convergent stylistic one. The consistency of projectile point forms at El Gigante is striking and indicates the consistent use of a tool type often associated with hunting larger game. They may represent subsistence tactics less technologically specialized (*i.e.*, lacking the highly sophisticated fluting element presumably designed for bringing down mega-faunal game) than other Central American traditions (*e.g.* Guardiria, Costa Rica; Pearson 2002) and more like the generalized subsitence adaptations inferred from South American sites such as Monte Verde (Dillehay 1989) or Monte Alegre (Roosevelt *et al.* 1996).

Caution must be the rule when using projectile point styles or types to compare geographically separate areas. In the vast majority of projectile point classifications, the labels are cultural types, not universal forms. The use of the typology to convey descriptive characters can be misleading. Hester (1986) has noted this problem by way of an example in which a Texas typology was transferred to central Mexico and to the Tehuacan Valley material by MacNeish, *et al.* (1967). Hester asserts that the use of the Texas typology erroneously implies diffusions and origins, functions and/or, dates, which are otherwise unsubstantiated. Future research on the projectile points at El Gigante must be viewed from both the local and site specific perspective as well as within the framework of the increasing sample of Paleoindian projectile points distributed across both continents.

Ground Stone Artifacts

Generally, ground stone artifacts are indications of an economy oriented towards the processing of plant foods (Wright 1994). I expected that with the onset of agricultural practices, ground stone artifacts such as mortars (Spanish, *manos*) and grinding slabs or large pestles, (Spanish, *metates*), would become more common in the archaeological record. The data show the opposite to be true (Fig. 30). Although few or no ground stone artifacts were found in the earliest Esperanza phase levels, ground stone artifact frequency peaks in the late Archaic. The Marcala phase, Sub-stratum IIIf has an average of just over 0.22 pieces of ground stone per excavated level (pcs./level). This represents about one specimen recovered, per 5 excavated levels in these Archaic strata. This density declines steadily in later periods to less than 0.1 pcs./level in the Formative period, Estanzuela phase.

One explanation for this counterintuitive result may be post-depositional mixing. Because ground stone artifacts are among the largest, heaviest items in the sedimentary column they may be subject to downward dislocation. That is, they may "settle down" in the fine ashy sediments, becoming deposited into strata below their original level. Another explanation for the pattern of diminishing ground stone could be that the activities within the cave could have changed between the Archaic and the Formative. In the earlier periods, the cave served as domicile; by Estanzuela-times, people might have lived in small hamlets in the valley bottom. During this period, grinding activities would have been conducted elsewhere. There was some evidence of alternative grinding locales from our 1998 reconnaissaince surveys of the valley. One site was recorded directly below the cave that consisted of a cluster of bedrock mortars. These grinding holes were located in the exposed bedrock of the riverbanks.

Morris (1990) describes a general trend in ground stone morphology occurring in the prehistoric Southwest United States that parallels the increased use of maize. Pre-maize ground stone is usually found in the form of one-handed *manos* used with small simple slab *metates*. The size of the *mano* , usually a manageable river cobble, is what shapes a trough on the *metate*. This changes toward the more common implementation of two-handed *manos* that are used with larger (in surface area) flat *metates*. The ground stone sequence at El Gigante does not exhibit any shift in morphological type that would indicate any specialized technology for processing grains. All the stone (*mano*) specimens found in upper levels in the excavations are one-handed modified river cobbles or fragments thereof. Ground stone (*metate*) specimens recovered from lower levels are often too fragmentary to evaluate in terms of their change in morphology over time. It seems that these tools were designed for the processing of relatively limited quantities of grain or other materials such as fiber. These ground stone implements may have had more general application than is evident in technologies representative of maize-centric economies.

Absolute counts of ground stone fragments in the sedimentary column may mislead our interpretations because of some of the confounding factors mentioned above. Instead, because ground stone technologies generally focus on processing plant foods and flaked stone on meat and animal processing, a statistic relating the two might indicate an intensification in one part of the subsistence regime. In the earliest cultural strata, the average number of flakes per piece of ground stone ranges from 354.5 (IVa) to 848 (IVb); by the latest phases this ratio has dropped to between 126.5 (IIa) and 334 (IId). The statistic is somewhat erratic through time (Fig. 31) and drawing a clear trend toward plant food processing is difficult.

Faunal Remains

Kitty Emery (2004) has noted that there is a need for more comparative zooarchaeological data sets. The following preliminary description of the animal bone recovered from El Gigante seeks to fulfill this goal. Emory also notes that the diversity of animal species that are likely to be encountered in a tropical assemblage carries coincident difficulties in identification (*ibid.*:15). I attempt here to present the methods of the standardized post-excavation procedures used to gain some insight into the meat portion of prehistoric subsistence. My first goal is to establish a plausible species list for the site. This is achieved by referencing other faunal samples from Honduras as well as with the identification of specific skeletal elements from El Gigante that allow for some broad identifications. Variation in the densities of bone from contextually similar samples throughout the Paleoindian, Archaic and Formative are intended to derive a very rough, initial measure of access to faunal resources through time (Emery 2004:23-25). Because of the preliminary nature of the post-excavation treatment to date, quantification is approached with caution, and more effort has been placed on summarizing basic frequencies (*ibid.*:33).

The dry conditions in the rock shelter were favorable to the preservation of bone. A total of 43,079 fragments of bone were collected. A sample of 9,531 (22% of the entire collection), from Units 1 and 2, were counted and cataloged in more detail. They were sorted into the following categories: unidentified mammal, armadillo (scutes), turtle (carapice), crab (carapice or claw fragments), bird, or snail (shell). None of these faunal remains have been examined by an expert or identified beyond these broad categories. The mammal category was further divided into large, medium, and small size sub-categories. A fragment of bone that could be reasonably attributed to a mammal about the size of a deer, was said to be "Large." "Medium" was defined as approximately dog-sized while "Small" was considered rabbit or smaller. Many of the bones in the small mammal category include the mandibles and long bones of mice and/or rats, as well as the remains of lizards and other small reptiles identified by mandible fragments with teeth. On the basis of a comparison with species lists presented from other sites in Northern Honduras (Henderson and Joyce 2004:227; Hirth and Cosken 1989:31), it is possible that the large mammals include not only deer (*Odocoileus* sp.), but also tapir (*Tapiris bairdi*). Medium sized mammals of the assemblage could include dog (*Canis* sp.), peccary (*Tayassu* sp.), felids, including jaguar (*Felis onca*), or, howler monkey (*Alouatta* sp.). Similarly, other small mammals that are likely to occur in the assemblage but are yet to be identified, include agouti (*Dasyprocta punctata*), paca (*Agouti paca*), armadillo (*Dasypus novemcintus*), porcupine (*Coendou* sp.), oppossum (*Didelphis marsupialis*) and rabbit (*Sylvilagus* sp.), bats (Chiroptera) (both intrusive and otherwise) may be included. The reptilian bones may include iguana (Iguanidae). Bird remains may include turkey (*Meleagris* sp.), as well as the remains of resident owls (Strigidae or Tytonidae) and might include some migrant fowl such as geese or ducks. Snail shell fragments are possibly jute (*Pachychilus* sp.). Pleuroceridae snails of both *Pachychilus* sp. and *Pomacea* sp. have been described in archaeological and ethnographic accounts of the lowland Maya in Belize as dietary supplements as well (Healy 1990). These snails are an excellent food source, calorically comparable to rabbit or turtle meat (*ibid.*:180).

The turtle carapice remains may be *Testudinata* sp.

It is especially difficult to assume that the small animals of the assemblage are the result of human use. Much of the small mammal bone may be incidental to the deposit, either brought in by owls, bats or other predators. In some cases they may be the remains of the predators themselves. I believe that much of the small bone was, in fact, brought in by other animals as indicated by the continued presence of small animal bone of similar character well into strata pre-dating occupation of the rock shelter by humans. Small game, including lizards and rodents, may have been included in the human diet at different times. However, resolving the specific proportion of each category's contribution to the overall diet is beyond the scope of this dissertation.

The average bone fragment counts (pieces per level) compared between strata are illustrated in Figure 32 and show a gradual decline in the overall amount of bone in the archaeological record. The maximum average of 293.3 in Sub-stratum IVb is notable, as well as the trend toward a much more modest average of 50 fragments per level in Strata III, II, and I.

Declining Large Game through the Archaic

The trends evident from the tabulation of large mammal bone in relation to smaller classes of bone across strata (Fig. 33) are dramatic. This analysis would be much stronger with the addition of estimates of minimum numbers of individuals (MNI), but this quantification is beyond the scope of this dissertation. Assessing factors influencing archaic patterns of animal exploitation is a common archaeological goal. Bayham (1979) devised a statistic that he called the Abundance Index (AI) to describe the changes in relative frequencies of different fauna. More recently, Ugan (2005) tested the main underlying assumption in inferences generated from simple AI's. That is, "declines in [AI] large bodied animals relative to small ones imply declining foraging returns" (Ugan 2005:75). This inference follows logically only if it can be shown that the relative energetic efficiency of hunting large game outweighs that of subsisting on smaller game. Ugan concludes that with the exception of some large fish species and invertebrate groups, body size does correlate with higher energetic return rates (*ibid*: 84).

During the Paleoindian occupation (Stratum Va) there are about three large mammal bone fragments for each smaller-class fragment. The Archaic phases (Strata IV and IVb) are similarly characterized by a high number of large mammal bone fragments in relation to other classes of game (about 4:1). Sub-strata IIIc/d/e/f, which represent transitional phases of occupation between Archaic (Marcala phase) and Early Formative (Estanzuela phase) contexts, display a transitional ratio of about 2:1. This ratio declines to below one-half of a piece of large mammal bone per other type (0.5:1) in the upper zones of the Estanzuela phase (Sub-strata Ia, Ib, IIcd). These declining AI's at El Gigante are the first indication of declining returns to large mammal hunting.

Bayham (1979) has argued that this sort of pattern in the context of Archaic dietary change, is born of necessity not choice. Using a model based on optimal foraging theory which posits a correlation of an item’s rank in the diet set with its size, Bayham shows a consistent pattern across three Archaic sites in North America of the increasing utilization of small animals, inferring that the preferred fauna were declining in abundance through the Archaic (Bayham 1979:233).

In their analysis of zooarchaeological material from Puerto Escondido, in the lower Ulua river valley of northern Honduras, a decline in white-tailed deer and other large mammals is noted from the Formative through the Postclassic (Henderson and Joyce 2004:231). These declines coincide with increases in the diversity of other fauna in the assemblage. This change is thought to be the result of increased forest clearing for farming in the region (*ibid.*:235). I think a similar general pattern is observable in the El Gigante material over a longer span of time. However, it is premature to asses the specific cause of the diminishing returns on large mammal hunting at El Gigante.

If preferred fauna were in decline, the inhabitants of El Gigante could have either expended more effort per kill to extract and maintain their calorie budget, or they could have switched to different resources. Before I discuss the evidence for diversification further, I will try to evaluate changes in effort put into the processing of large game.

To do this, I weighed individually provenienced and sorted faunal fragments, establishing an average weight for the large mammal bone fragments in each stratum's assemblage. Again, this analysis would be greatly improved with the addition of MNI statistics, to better asses the extent of processing versus post-depositional alteration. The average weight of a large mammal bone fragment may give an indication of the degree to which bones were broken down to procure their marrow (Madrigal and Holt 2002:756; Pearsall 2000:510). Only the portion of the assemblage cataloged “large mammal fragment” was used in the assessment of game processing.

If higher levels of processing resulted in more fragmentation of bone, then it appears that processing of large mammal carcasses was *less* intense during the Formative period (early and late Estanzuela phases). The average weight of fragments attributed to the later periods at El Gigante range from 1.32– 1.4 gm/piece for Sub-strata IIc/d and Ib.

The Archaic levels are consistently more fragmentary with an average of 0.66 – 1.01 gm/piece in Strata III and Sub-stratum IVb (Fig. 34). These results must be viewed with caution, however, as many processes, both behavioral and taphonomic, confound this simple statistic. For example, fragmentation may be a function of how old the bones are or, of a post-depositional disturbance such as trampling, neither of which is easily controlled for. However, the condition of the soft ash floor is such that it is difficult to imagine crushing any bone on it by inadvertent trampling

So, there is initial evidence to suggest that hunting large game became less prevalent through time, and a weak suggestion that El Gigante residents made less caloric use of the game they did hunt in the later periods. This seems counterintuitive, however, the pattern could support the idea that large mammal hunting in the Formative became a socially regulated, perhaps prestige activity more than a functional aspect of subsistence. A similar argument is used by Gary Webster (1986) to explain the pattern of deer exploitation in the later phases of the occupation of the Basin of Mexico.

A climate-based scenario has been suggested for patterns of large game exploitation observed in the North American Great Plains. Michael Sheehan (2002) reviewed faunal data across three broad time periods, the Paleoindian, Early Archaic and Middle Archaic. He found a high correlation between altithermal conditions that would have affected bison herds negatively and reduced numbers of large mammal fauna found at archaeological sites across the region. In this period from 5500 - 2500 B.C., people of the plains made much greater use of non-mammalian fauna such as fish, amphibians, birds and reptiles (Sheehan 2002:135).

This pattern of diversification in the face of declining large mammal fauna can be demonstrated at El Gigante. Table 6 presents the number of identified specimens (NISP) by stratum for each faunal category in the analysis. The NISP "is a simple count of bone fragments per taxon calculated as a ratio of bone fragments to total bone fragments and represented as a relative frequency" (Emery 2004:26). Bird, crab, turtle and snail remains (all unidentified species) are non-existent in Strata IV and V, while they make up more than a quarter of the total in Sub-stratum Ib and Ic.

In the Paleoindian period, large mammal bone fragments make up 58% and 72% (Strata IV and V, repectively) of the assemblage. There is a significant decline by the Formative, where Large mammal bone NISP's are reduced to less than 20%. The most abundant and available large game in this region was probably deer. Climate may have affected deer populations; the more mesic forests and possible restriction of the Pine-Oak zone during the Archaic (see Chapter 2) could have limited some of their preferred habitat. Another possible explanation for the declining abundance of large game through time in the El Gigante assemblage is hunting pressure or the rise of farming and social regulation (as posited above by others in different regions). In the absence of direct paleoenvironmental data and more specific identifications for the El Gigante assemblage, these hypotheses remain untested until more detailed analyses can be completed.

Pleistocene Fauna

The Central American isthmus has a dynamic biogeographical history. As the link between North and South America, it served as an animal and plant highway through which a great number of species moved between continents (Webb 1991, 1997). This variety of species and their distribution during the Pleistocene no doubt affected the migration of human groups across and within the continents (Webb and Rindos 1997;

Webb 1992). The earliest archaeological remains at El Gigante are associated with an extinct Pleistocene animal, identified as belonging to the Bovidae family. This association is one crucial criteria for the acceptance of a Paleoindian type site (Haynes 1969).

There are several paleontological sites in Honduras from which we can list species that may have been available to humans on the Pleistocene frontier. These include the sites at Yeroconte, Olancho, Gracias and Humuya. In nearby El Salvador, Corinto, Arroyo de Sismico, and Hormiguero, can be added to this list (Webb 1997). Together, these sites place now extinct Chlamytheriidae (giant armadillo), Glyptodontidae ("tanklike" endentates), Mylodontidae (middle-sized ground sloths), Megatheriidae (elephant sized ground sloths), Hydrochoeridae (capybaras), Gomphotheriidae (mastodonts), Elephantidae (mammoths), Equidae (horses), Camelidae (llamas) and Bovidae (bison) in the region (Webb 1997:106; see also Lucas and Alvarado 1991; for El Salvador see Webb and Perrigo 1984; and for Costa Rica see Mora 1988; Lucas *et al.* 1997). The El Gigante assemblage has undergone only very limited sorting and identification and at this time there is evidence for the presence of only one of the above animals.

One of two large teeth recovered has been identified preliminarily by Dr. Russell Graham of the Dept. of Geosciences, the Pennsylvania State University, as a member of the Bovidae, more specifically as *Euceratherium* sp. (Photo 30). A photo of the specimen from Unit 3, Level 27 was compared favorably to an extinct brush ox (*Euceratherium collinum*) made available at the Smithsonian Institution, Washington D.C., thanks to M. Zeder. Dr. Graham also noted in his personnal communication that the tooth was similar to Euceratherium specimens from Musk Ox Cave in New Mexico that he was familiar with. The second tooth, found separately from the first in Unit 19, level 44 has not been as closely examined. Both teeth came from secure contexts of Strata VI and Sub-stratum VIIa, respectively. These teeth would be notable mostly on paleoecological grounds as a new vertebrate paleontological record, if not for the archaeological remains found in apparent association (notably flaked lithics, cordage and masticated quids of maguey). Other Bovidae including those of *Bison* sp. have been found in paleontological sites as far south as El Salvador (Stirton and Gealey 1943, 1949) and in Nicaragua, where Bovid and human footprints have been preserved together in lakeshore volcanic sediments (Webb 1997:108). However, at El Gigante there is no direct evidence that these extinct ungulates were hunted, and it is possible that the associated archaeological remains have been mixed down into pre-occupation strata. If this is the case, a direct date on the teeth could resolve the matter. Recall chapter 3's conclusions regarding the significantly older probable dates of the pre occupation strata versus the first proven human occupation (a date for the teeth of over 30,000 years is quite possible, and would eliminate in my mind the possibility of their human association). It is critical that these two tooth specimens be examined, identified to the species level and directly dated.

Human Skeletal Remains

Human remains were relatively sparse in the excavations. Most human bone was found on the surface of the rock shelter, presumably disturbed from the looting of burials around the peripheries of the site. These included smaller bones such as phalanges, ribs and teeth for the most part. No intact burials were uncovered in our excavations, though many isolated and *in situ* human bones were recorded during the dig. In the future, detailed osteological analysis could be very useful. Perhaps there is a sufficient sample of human bone across the archaeological periods to provide for a sample appropriate for isotopic studies.

Two skulls purportedly taken from El Gigante are now located in a high school biology classroom in Marcala. One of these exhibits clear signs of cranial molding of the forehead (Photo 31). However, given the questionable provenience, little can be made of the connection to the Maya and the elite emulation this might point to. Doris Stone (1963) mentions cave rituals in her ethnography of the Lenca, who inhabited this part of Honduras. She documents an annual pilgrimage and "secret communion" to a cave and church at La Misíon (Stone 1963:215). This may indicate that the Lenca and the recent prehistoric inhabitants of El Gigante participated in a sphere of shared culture with the Maya, for whom such "cave cult" rituals were a common and fundamental element of religious practice (Stone 1995). Early Formative burials have been found in caves at Copan (*e.g.* "Gordon's Cave #3" (Brady 1995). Burials have also been noted in caves elsewhere in Honduras at the site of Talgua, the "Cave of the Glowing Skulls" (Brady *et al.* 1997, Dixon *et al.* 1998).

Worked bone and shell

I identified four bone awls from Marcala phase contexts or earlier, they were found in lower levels of Layer IIIf2, and in Strata IV, Sub-stratum IVb, and Va (Photo 32). The function of these tools is unknown. When one of the local Honduran crew saw one of the artifacts, he declared immediately that it was a "*tapizcador*" that they used every season to aid in the shucking of corn. The next day he produced an very similar modern example that he kept at home for just that purpose. Despite the similarity in form to moder tapizacadors these artifacts could have a range of utilitarian uses such as hide-working or basket weaving that also require awls or, punches. No others were found in the entire assemblage.

Two bone beads and two shell beads (Photo 33) were also found. The bone beads came from intermediate Estanzuela phase levels. They are simple tubular beads, perhaps bird bone, with neat cut marks around the ends to shape them. The shell beads are also from Formative period deposits. One was found with looter fill in the West block of units, while the other was found in Sub-stratum IId. Both of these beads are made from marine shell (the authors determination), but have not been identified to species. Their marine origin indicates some travel or exchange between this mountain region and the coast. This could have involved visiting trade institutions (Heider 1969) and/or higher levels of socio-cultural exchange, not evident in earlier material.

Textiles

Preservation was so good that cordage specimens were recovered even in the oldest Esperanza phase contexts. One of the items used in an AMS radiocarbon date was a sample piece of cordage from Unit 1 Level 23b Stratum VII which dated to 9290 +/-40 radiocarbon years BP (Photo 34).

Twinned cordage was found in varying diameters from <0.5 mm to 1.0 cm or greater, and lengths from <2 cm to 20 cm (Photo 35-38).

Selected samples of cordage and textile were sent to Prof. Nettie Adams at the University of Kentucky at Lexington for examination. For example, she described the Paleoindian piece of cordage from Unit 1 Level 23b as two elements plied together, consisting of a stringy plant material, such as flax or hemp but, most probably agave. The elements are loosely twisted, initially in the S direction then together in the Z direction. Prof Adams notes that there may be a missing element to the piece, leaving it looking "untwisted." This may have been a decorative element, as she notes is common in some Nubian grave examples she is familiar with. The wool or hair is found, when the cotton or flax elements have rotten away. Interestingly, she notes that another piece of cordage sent to her from Unit 1 Level 5 (a Formative context) is also composed of two loosely woven pieces, but begins in the Z and continues in the S direction (Photo 35). These pieces may be end pieces, never used to tie or hang something that would impart tightness to the cordage. Another piece of cordage examined by Prof. Adams exhibits signs of heavy use, including knotting and wear (Photo 36). This piece from Unit 2 Level 6b (Formative) is again different in structure from the other two pieces described. It probably also was made of agave. However, while plied of two elements like the others, they are not twisted initially and instead consist of fibers used together, "rather like silk floss"; the two elements are then plied in the Z direction.

Prof. Adams also examined a single piece of basketry made of a woody plant fiber (Photo 37). The fragment is composed of 13 rows of weft-face plain weave. There are 2.5 warps per centimeter and between rows 5 and 6 there is a row of "soumak" weave. This pattern, relieving the sameness of the plain weave is done by passing the weft over two warps, and then going back and wrapping around one of those warps before passing over two again. The piece is very finely worked and in addition has a piece of cordage through one edge. This cordage is the same material as the rest and also made of two elements plied together initially in the S direction and then in the Z direction.

Textiles, a category which included woven fragments and included pieces of *petate* (mat), basketry, nets, and painted cloth (Photo 36) were confined largely to the Formative period. A single piece (Unit 1, Level 2) examined by Prof. Adams was apparently made of cotton, but would need to be confirmed by microscopic analysis (Photo 38). Both systems of warp and weft are evident, twisted in the Z direction. The weave is a weft-face plain weave with 8 warps per centimeter and 16 wefts per centimeter. Part of the selvedge remains along one side. Though there are only two remaining wefts it is sufficient to show that there was a selvedge, it is the simplest type with no paired warps or reinforcing wefts. Prof. Adams noted a slight bluish cast to the piece and suggested a dye analysis be done. In general Prof. Adams commented that the condition of the textiles seemed very good, and in excellent condition with little shedding or other deterioration commonly seen in archaeological remains. Photos 39 and 40 demonstrate this preservation, in which a hide bag with attached cordage and a fragmentary piece of painted maguey or sisal cloth are shown (both are from Feature #2, Formative period).

Much of the assemblage consisted of knotted or twisted bundles of grass and palm fibers (unknown species). These masses of material could have been unprocessed raw material, or might have had a utilitarian purpose such as insulation, cushions, packing material, ties, *etc*. At present, palms are rare across the uncultivated landscape but can be locally common within and around the Estanzuela village.

Pictographs

Rock art is relatively ubiquitous on the walls of El Gigante and unfortunately, subject to increasing vandalism. There are two clusters of pictographs at opposite ends of the rock shelter, north and south (see Fig. 5 for locations). The broad south end offers a larger canvas. Curiously, there is no decoration evident on the back (west) wall of the cave. There are 10 images on the northern wall of the shelter: seven *cisnes* (swan or goose-like bird forms with long curved necks), two amorphous figures, and one iconic human hand. In all, 23 individual elements are grouped on the southern end (eight *cisnes,* three amorphous blotches of color, and twelve human hands done in positive and in negative, in pairs and single). Of the twelve legible hand prints, seven are right hands, five are left; only two instances seem set out or oriented to indicate a matching pair. One of the hand prints is apparently a child's. Lastly, seven of the twelve are negative, that is, not prints but stencils of the hand. The mineral and/or vegetable dyes used range from blue and greenish blue, to black, to red, to white (Photo 41 and 42).

There was no artifactual evidence found, for example a pigment stained groundstone artifact that would provide more information regarding the practice of rock painting here. Perhaps future identification of some of the many unknown plant remains will reveal a source of some of the pigments. The dating of the rock art is tenuous at best. Examples of rock art in the region are numerous, though they have received limited study. Those described from the central highland Honduran sites of Santa Rosa Tenampua, Yarales, Las Pintadas, and Santa Elena Azacualpa, have been interpreted with respect to their symbolic connection and influence from Teotihuancan during the Classic period (Reyes-Mazzoni 1976, 1977). Petroglyphs have been found associated with archaeological phases at the site of Guardiria (Turrialba), Costa Rica dating to A.D. 900-1600 (Snarskis *et al.* 1975) and in the Reventazón River Valley in the region (Acuna 1985). However, there is little to compare iconographically or, stylistically between these sites and El Gigante. Future research into the pigmenting material, or further excavations at the site, may allow for a method of directly or indirectly dating the art work. At this time there is little to establish a context for their creation or relation to other rock art of Central America.

The pictographs may take on more meaning when some association with other traditions can be made. The symbol of the human hand, for example, is a consistent theme in rock art from around the world including Australia, the U.S. Southwest, and Europe. This hand printing may represent the convergence of a universal function in the past, or they could have been left for different purposes in different cases. Perhaps at some sites they indicate an ancestral form of communication, signaling, or territorial marking. Others have commented on the possible function of iconography in precolumbian cultures in terms of the original ecological setting in which they were made (Peterson 1983). The bird-like *cisne* drawings (if they are indeed avian representations) may correspond to migratory bird species yet to be identified in the faunal remains from the excavations. These faunal remains may provide more insight into the history and function of the bird glyphs.

Table 5 Percentage of debitage with cortex by stratum and by raw material.

Stratum	Obsidian Cortex	n(total)*	Basalt Cortex	n(total)	Chert Cortex	n(total)
Ia	25%	264	14%	176	26%	299
Ib	23%	282	47%	171	32%	236
Ib2	27%	90	10%	33	26%	111
Ic, Ic3	48%	46	3%	82	7%	31
IIa1-7, IIc3	28%	92	0%	16	29%	99
Iid	34%	63	75%	14	0%	63
III	11%	30	21%	69	0%	23
IIIa, IIIa2, IId2.1	12%	38	6%	18	0%	12
IIIe	67%	30	40%	28	39%	25
IIIf	30%	91	61%	37	18%	58
IVa	8%	430	18%	73	11%	262
IVb	6%	630	12%	284	9%	520
Va	6%	373	23%	32	13%	206
VI	4%	50	33%	4	17%	28
VIIa	0%	7	0%	3	57%	11

* n(total) = the total number of flakes of that material type in the sample from that stratum).

Table 6 Number of identified specimens count (NISP) by stratum.

stratum	n=	large mammal	medium mammal	small mammal	unidentif.	bird	crab	armadillo	snail	turtle
Ia	1434	13.8%	4.0%	66.9%	0.2%	2.0%	11.4%	1.3%	0.3%	0.0%
Ib and Ic	572	18.4%	6.6%	48.1%	0.3%	16.1%	6.5%	2.1%	1.2%	0.7%
IId	69	23.2%	2.9%	66.7%	0.0%	4.3%	1.4%	1.4%	0.0%	0.0%
III	1611	59.3%	11.0%	17.8%	3.0%	1.1%	2.9%	5.0%	0.0%	0.0%
IV	2919	58.1%	17.2%	5.2%	12.3%	0.9%	4.8%	1.4%	0.0%	0.0%
V	326	72.7%	4.6%	9.8%	2.1%	2.8%	2.5%	5.5%	0.0%	0.0%
VI	580	4.5%	5.7%	89.5%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
VII	1073	0.7%	3.6%	91.8%	0.4%	3.5%	0.0%	0.0%	0.0%	0.0%
VIII	1146	0.7%	3.6%	92.3%	0.1%	3.0%	0.3%	0.0%	0.0%	0.0%
IX	81	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 25 Average and median number of ceramic sherds recovered per level by stratum.

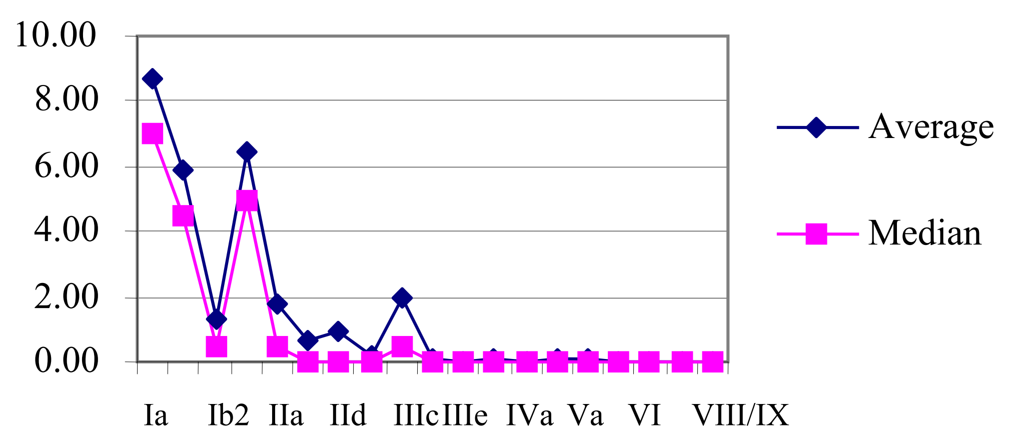


Figure 26 Profile sketches of the ceramic assemblage

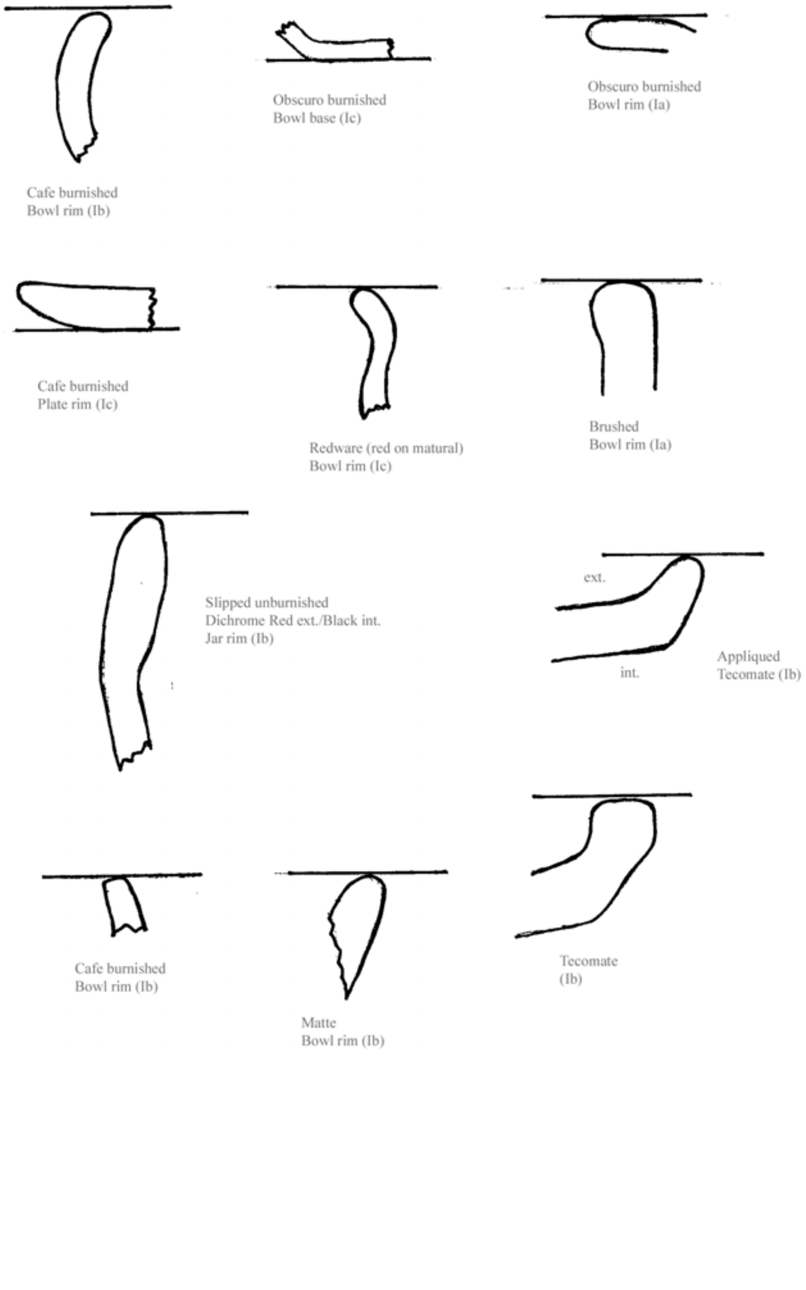
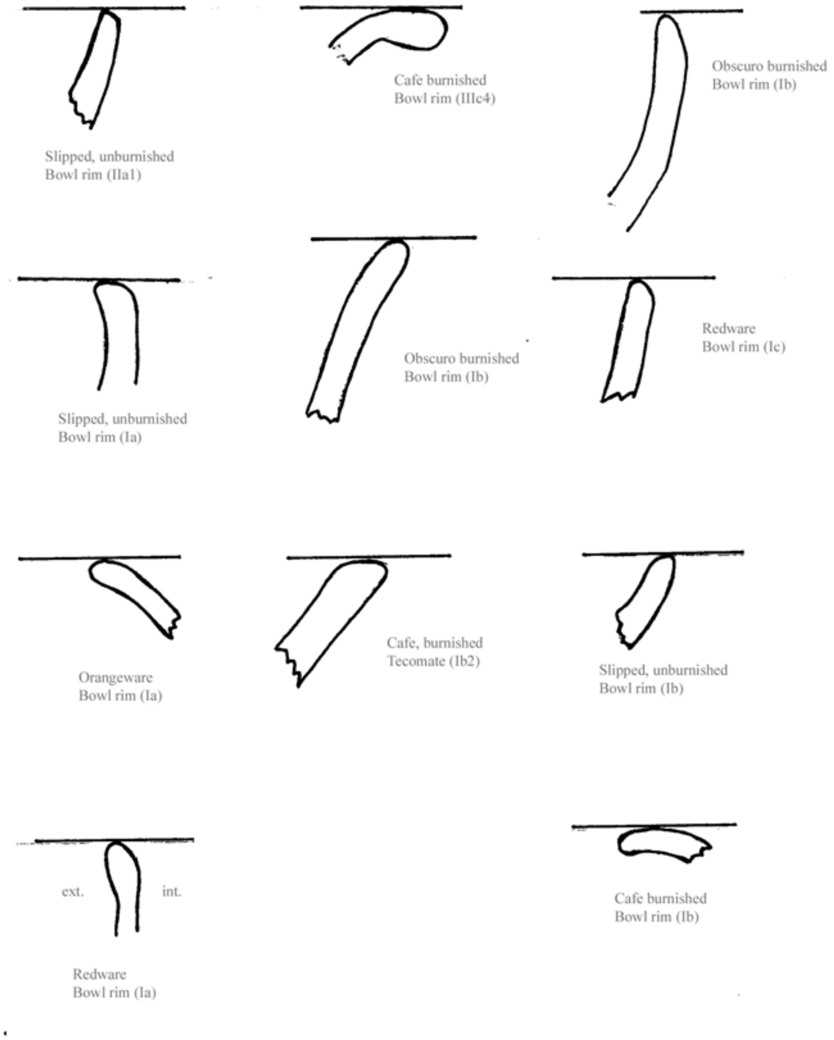


Figure 26 (continued)



Slipped, unburnished
Bowl rim (IIa1)

Cafe burnished
Bowl rim (IIIc4)

Obscuro burnished
Bowl rim (Ib)

Slipped, unburnished
Bowl rim (Ia)

Obscuro burnished
Bowl rim (Ib)

Redware
Bowl rim (Ic)

Orangeware
Bowl rim (Ia)

Cafe, burnished
Tecomate (Ib2)

Slipped, unburnished
Bowl rim (Ib)

Redware
Bowl rim (Ia)

Cafe burnished
Bowl rim (Ib)

Figure 27 Average and median number of flaked lithic pieces per level by stratum.

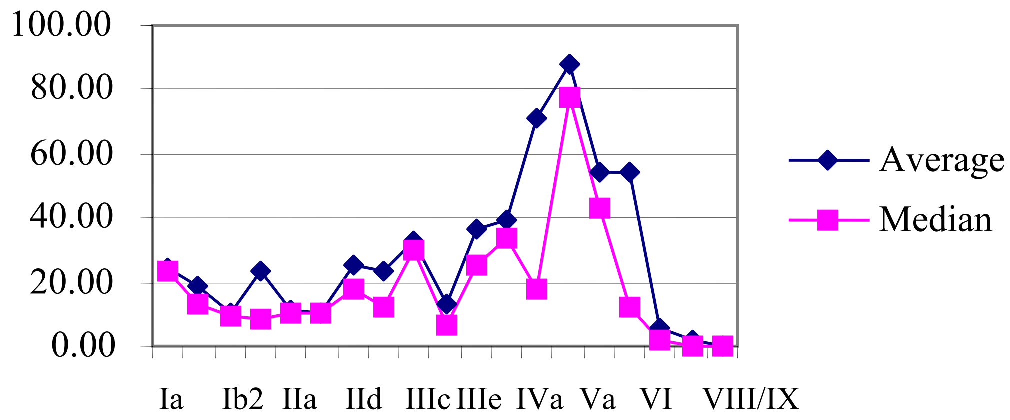


Figure 28 Number of pieces of non-obsidian (andesite, rhyolite, chert, *etc.*) for every piece of obsidian in the assemblage.

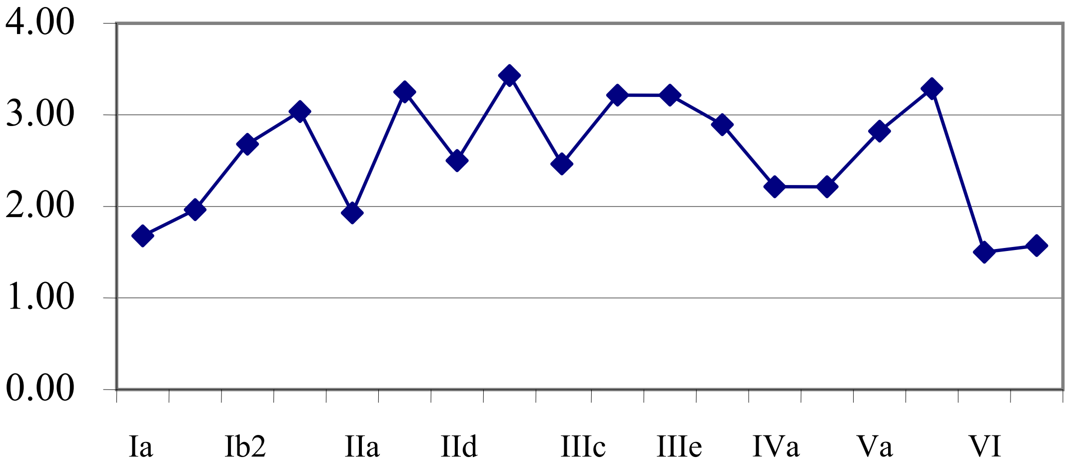


Figure 29 Percent of debitage with evidence of cortex, by raw material.

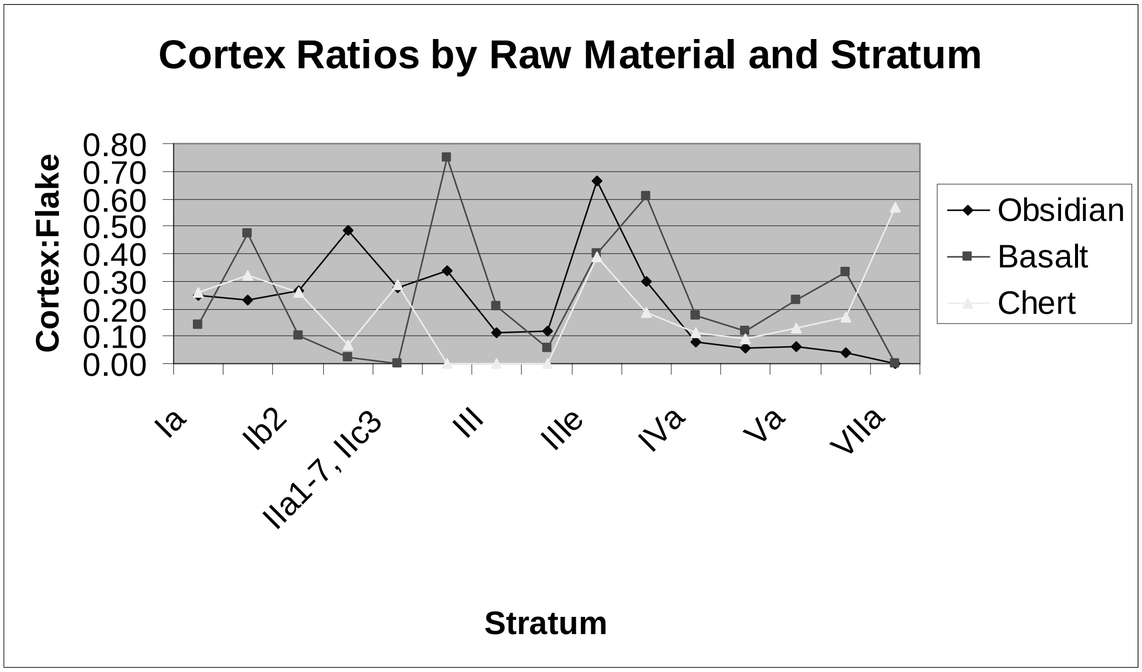


Figure 30 Average and median number of ground stone artifacts per level by stratum.

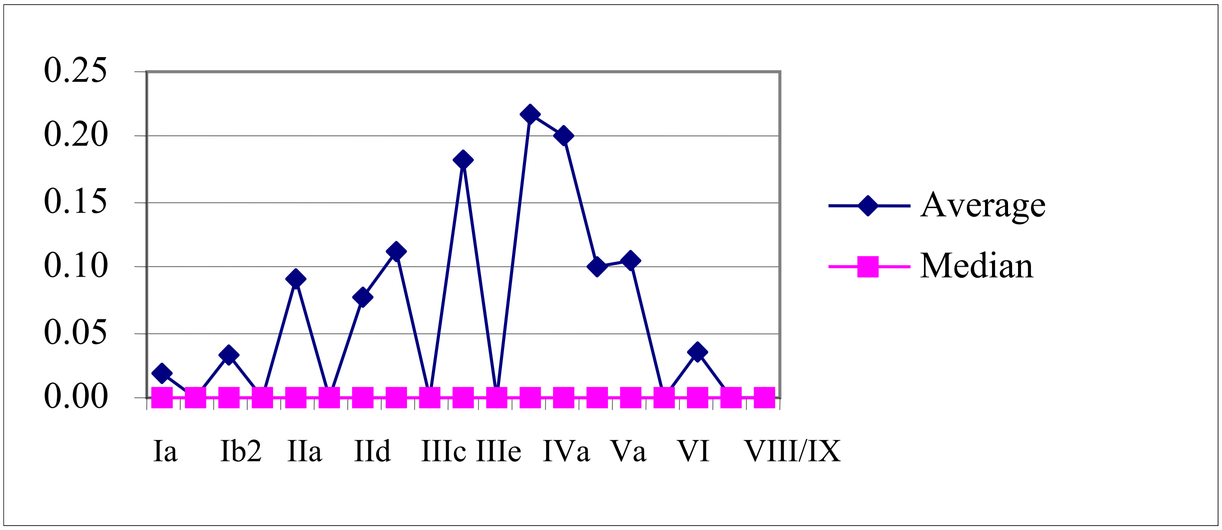


Figure 31 Number of flakes recovered for each piece of ground stone (0 = no ground stone recovered in stratum).

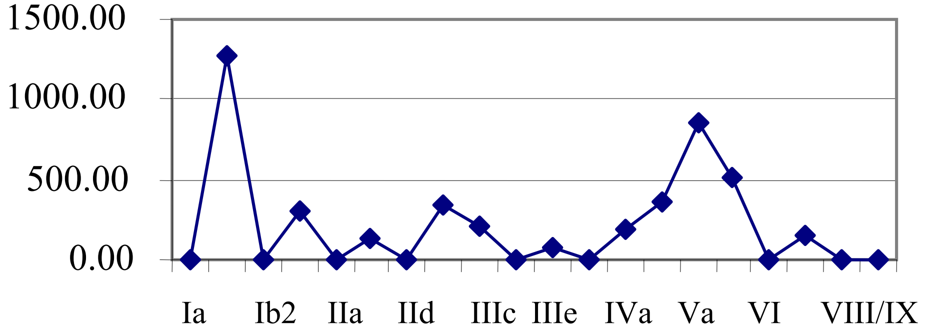


Figure 32 Average and median number of bone or other faunal material recovered per level by stratum.

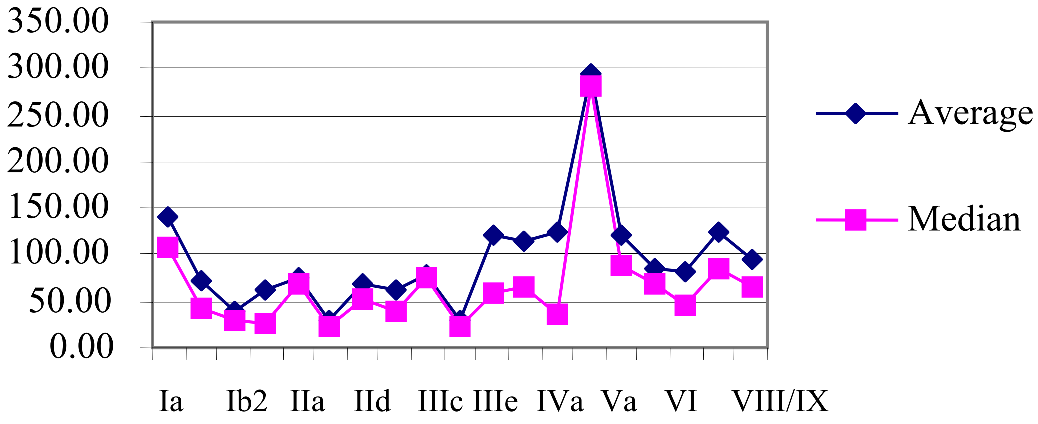


Figure 33 Average and median ratios of the number of large mammal bone fragments recovered for each piece of other faunal material (small mammal, armadillo, turtle, *etc.*)

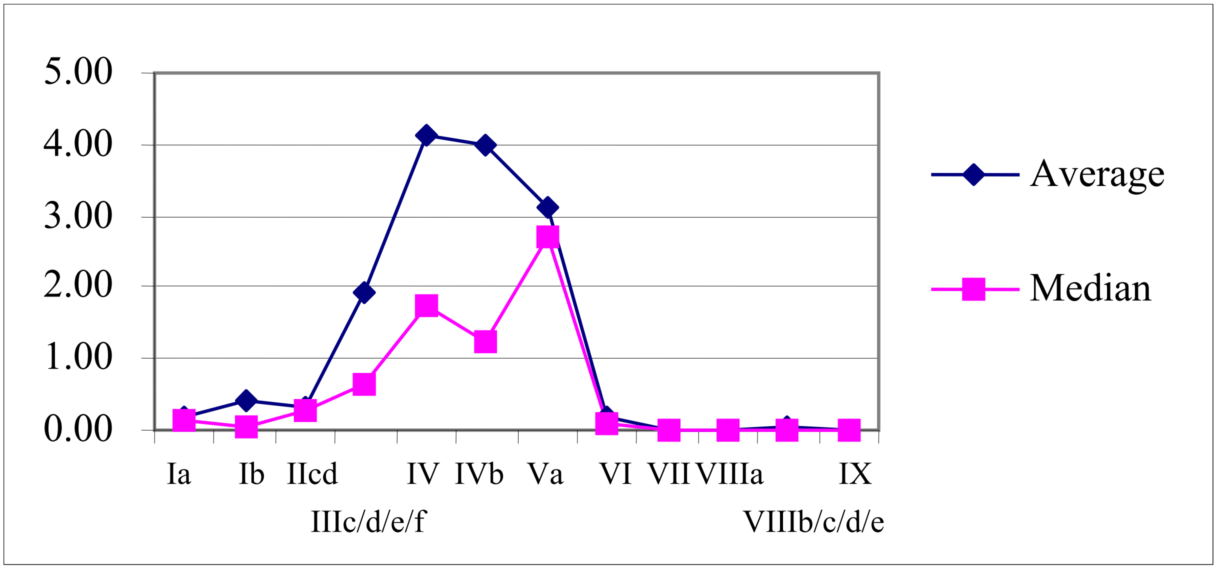


Figure 34 Average and median weight (grams) of a fragment of large mammal bone in each stratum.

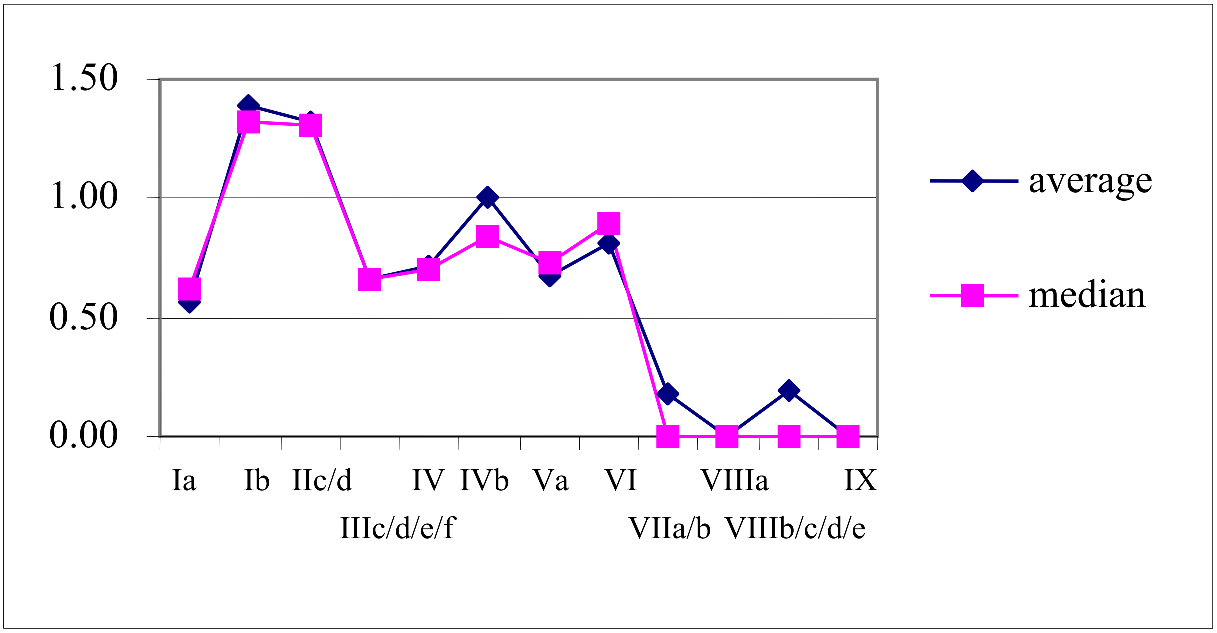


Photo 27 Fired ceramic clay balls, Late Formative Period.

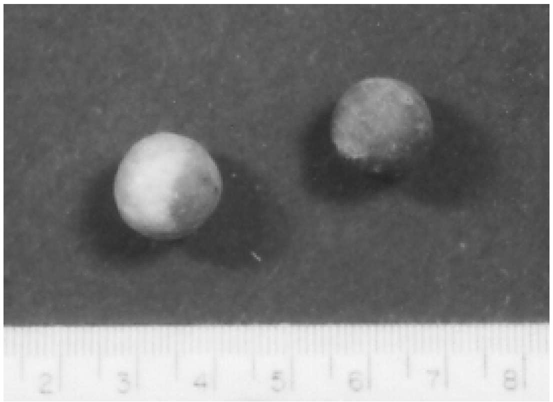


Photo 28 Paleoindian projectile point (Unit 18, Level 35).

Photo 29 Paleoindian projectile point (Unit 19, Level 37).

Photo 30 Bovid (*Euceratherium* sp.) tooth found in association with Paleoindian artifacts.

Photo 31 Skull reported to have been taken from El Gigante.

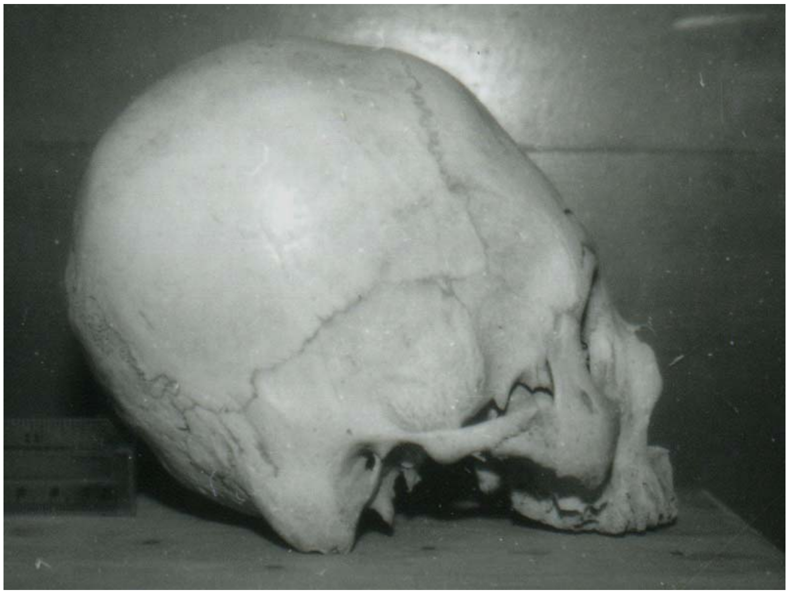


Photo 32 Bone awls ("tapizcador")from the Marcala Period (Archaic).

Photo 33 Shell beads from Formative Period contexts.

Photo 34 Paleoindian cordage (AMS dated material) Unit 1, Level 23b, Sub-stratum VIIIa.

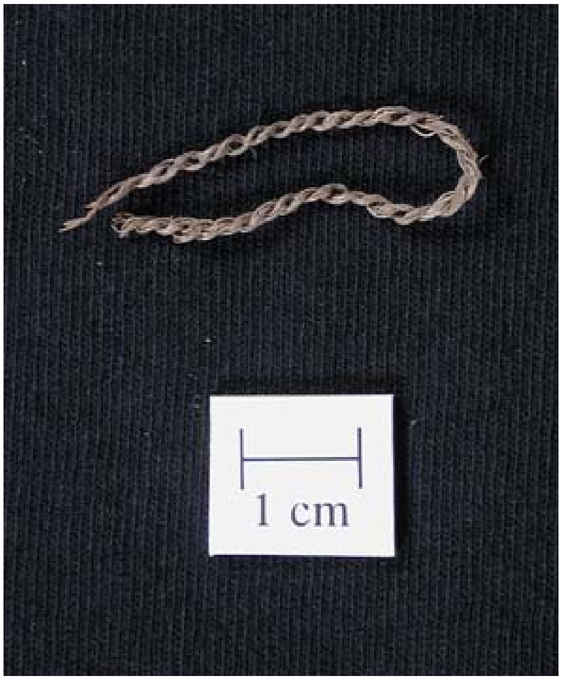


Photo 35 Cordage, Unit 1 Level 5, opposite twisting.

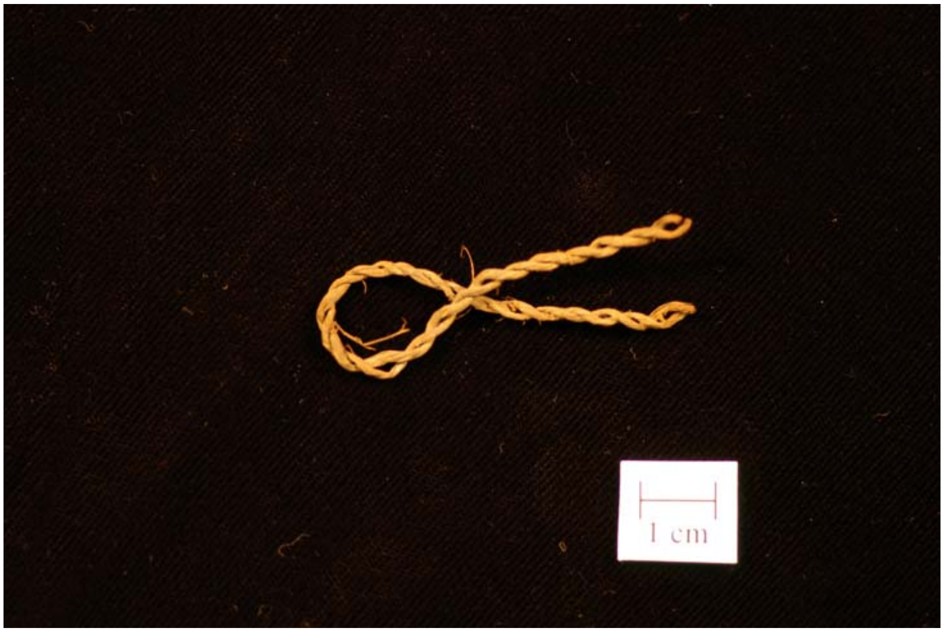


Photo 36 Cordage, Unit 2 Level 6b, Formative, well used and knotted.

Photo 37 Basketry from Unit 2 Level 4c, Formative.

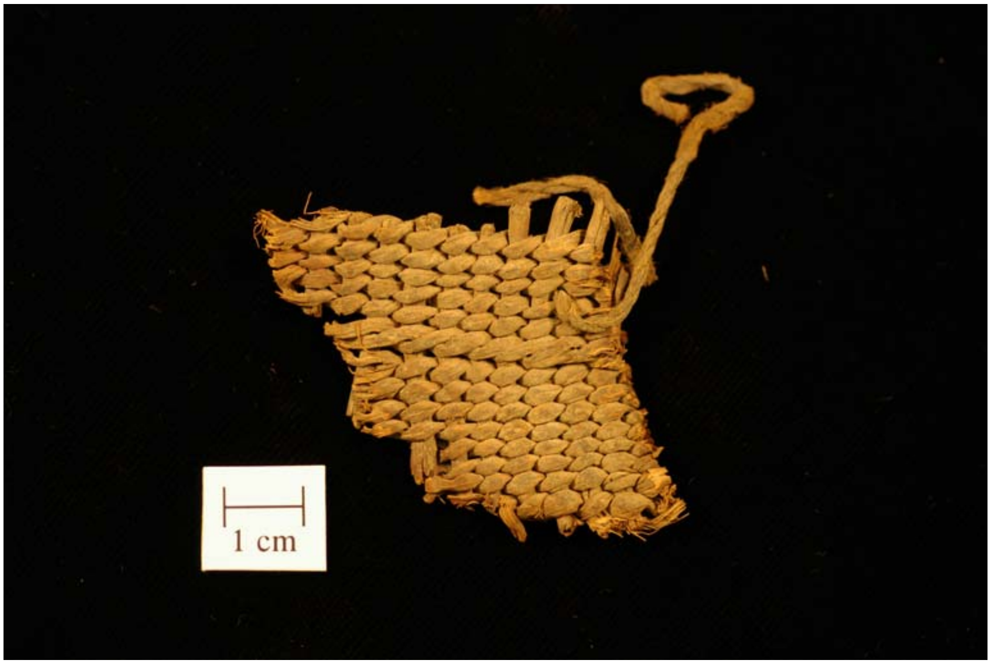


Photo 38 Textile from Unit 1, Level 2, possibly cotton with selvedge.

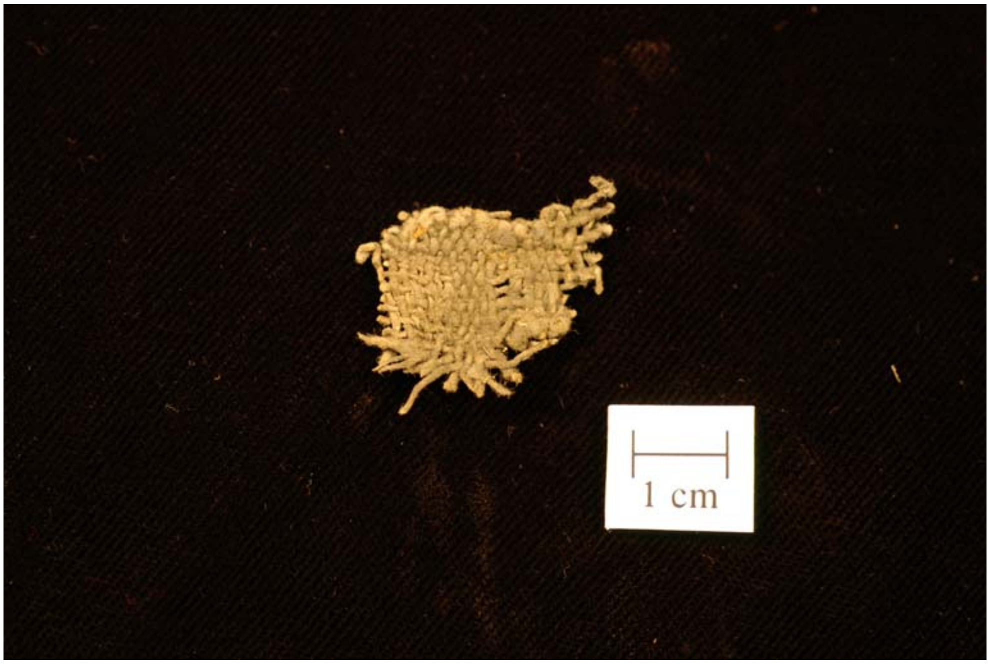
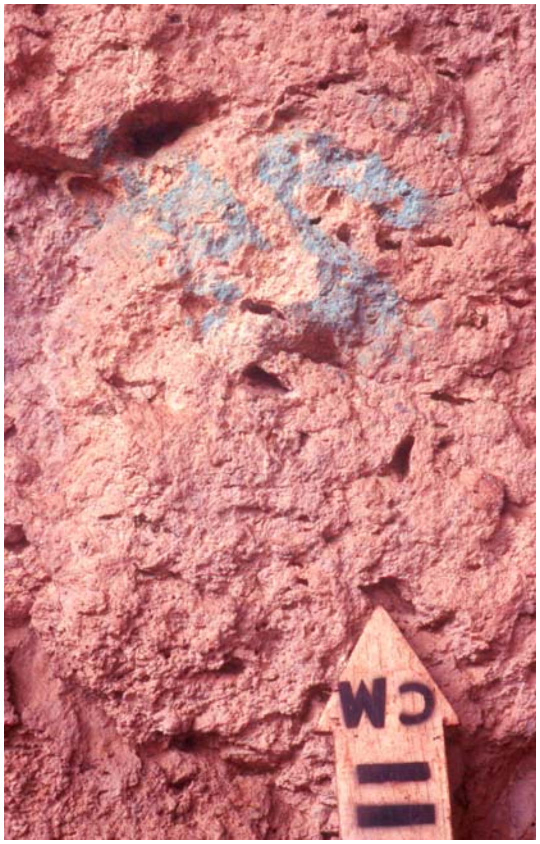


Photo 39 Hide bag with rope, Late Estanzuela Period (Late Formative).

Photo 40 Painted textile fragment from Late Estanzuela Period (Late Formative).

Photo 41 Pictographs, hand "stencils"

Photo 42 *Cisne* pictograph (swan, goose or other bird form?)



CHAPTER 6: THE PLANT REMAINS

Introduction to the Assemblage

A large number of well-preserved botanical remains were recovered from the El Gigante shelter. The primary goal of the current project was to provide a first order description and identification of as many of the remains as possible. Some amount of preserved macro-botanical material was present in all cultural strata. There were 31,001 sorted specimens in all excavated units. A tabulation of all archaeobotanical remains cataloged from the main block of excavations at El Gigante is presented by stratum in Tables 7 - 10. Table 7 is an inventory of all the plants in the assemblage that had edible parts. Table 8 lists the unidentified botanical assemblage. Table 9 is a list of items that were not used as food (though if they had dual functions, such as agave, they are listed in Table 7). Finally, Table 10 lists plant remains found that are known to be contact period or historic imports, these serve as a gauge of mixing through the strata.

Complete lists of all the plants mentioned in the text, sorted phylogenetically, by species and by common name are attached as appendices for reference. The appendices include some species which were not found or, are not yet identified in the El Gigante assemblage. They are mentioned in the text as descriptive and comparative examples, including related plants and patterns of plant use at other sites. These lists also are intended to alleviate confusion over plant taxonomy and the usage of Spanish and/or English equivalents in the text.

Each archaeological plant category is discussed one by one in order of their first appearance in the archaeological record at El Gigante (refer to Tables 7 - 10 for the exact counts and locations). This list includes data on the first appearance of each plant in the archaeological sequence and its condition and form. The inferred use of the plant at El Gigante and its relevance within the greater Mesoamerican cultural sphere are then discussed.

This is a preliminary identification and tabulation of the many plant remains. The existing catalog consists of classes of plant remains that mostly are identified only to the genus level. The species is given only when known. Several determinations were made by Dr. Lee Newsom, though she has not examined the entire assemblage. These macroremains offer great potential for future detailed taxonomic study. Once this task is accomplished, more rigorous quantitative methods can be applied to the material; at this point, most of these statistical approaches would require more rigor than the data are capable of sustaining (Pearsall 2000:196).

A secondary goal of the research project was to identify the operation of directional selection on the phenotypes of some plants. Morphometric analyses were employed to determine if there was evidence for directional selection and, by implication, domestication of plants. The data for each species examined in this way is presented in the following inventory.

When looking at the place of plants in a subsistence system, it is important to distinguish between domestication, a process affecting the evolution of individual plants, and agriculture. Agriculture is a mode of production (Wolf 1982) that includes qualitative social relations and often dozens of plant species. Because cultural information can be passed between individuals as acquired characteristics the origin of "agriculture" cannot be easily framed in strict Darwinian terms (*cf.* Boone and Smith

1998; Boyd and Richerson 1985; Dunnell 1996). However, domesticates are biological entities subject to Darwinian laws and can be evaluated in strict, quantitative terms. Like diagnostic projectile points, or typical ceramic wares, domesticated species are extrasomatic culture traits. However, they are unique, because they are constrained by their inherent biological parameters. Cultural traits like stone tools or ceramics are constrained by their own parameters, and thus each reflects differently on the culture which produced them.

One definition of domestication is the "human creation of a new form of plant or animal, . . . one that is identifiably different from its wild ancestors and extant wild relatives" (Smith 1998:18). In this case, the mechanisms of species diversification do not differ from Darwinian models of selection, even though they are controlled by humans, not “nature.” In this chapter, I measure changes in plant phenotype that I propose indicate degrees of commensalism between plant and human. Archaeological markers in seed plant population morphologies "can be strongly and directly linked to the earliest stages of plant domestication" (Zeder *et al.* 2006). Zeder *et al.* (2006:140) list the five most important and archaeologically visible markers of adaptive response by a target plant. Among them is increase in seed size, the focal trait in many of the following analyses.

What I am *not* doing in this exercise is attempting to differentiate wild types from domesticated types. Simple size data are insufficient for archaeobotanists to make this differentiation. The identification of a domesticate must rely on a multiplicity of factors including both quantitative and qualitative variables in combination with a knowledge of the context and natural history of the taxon. Others have done this with *Cucurbita pepo*, for example (Decker and Newsom 1988), and with *Chenopodium* sp. (Fritz and Smith 1988). Diachronic morphological changes, from which directed selection of plant traits are inferred, occur at El Gigante. It may be evident as early as the Palaeoindian Period in the avocado sample, and continues to be evident in the Formative Period manipulation of squash seeds. Directional selection implies no fixed threshold or event. Its development shows the extent to which a specific population (of plants) was manipulated by distinct selective forces.

In the book Evolutionary Ecology, Eric Pianka (2000) identifies several possible types of natural selection. The variation of a trait within a population is presented as a Poisson distribution and the affects of selection on the distribution of a phenotype's fitness are described statistically. Three general types of selection acting on populations are stabilizing, directional and disruptive in nature. I believe one of the three general models of phenotypic selection can be used to evaluate changes in the archaeological assemblage at El Gigante.

Stabilizing selection reinforces the central tendency of the traits distribution within a population, whereas disruptive selection creates a bimodal distribution within the population. Under conditions of directional selection the modal phenotype or, average individuals, are not the most fit under changing environmental circumstances and a shift occurs. "The population mean shifts toward a new phenotype." (Pianka 2000:124). Environment is meant holistically and refers to the all the pressures on a species' fitness, not just the physical environment but including those altered by human behavior. Having measured attributes of species' phenotypes over time in the botanical assemblage, I seek to infer domestication activities through the identification of directional selection.

Other types of selection in nature, include frequency dependent, selection, kin selection, sexual selection, density dependant and independent selection as well as age-specific selection (*ibid.*126),. Frequency dependent selection may have played a significant role in the potential of some plants to become domesticates, too, For example, a single large seed mutant in a population is not as likely to be picked out of a population for special treatment as are seeds belonging to a bush whose seeds, by a majority, are larger. I do not exclude the possibility of human beings exerting other types of selection on the species that make up the assemblage. These other types of selection are not measured here but, considered as possible confounding influences on the make-up of the assemblage. The “directed” attributes discussed below are those whose relatively recent (in evolutionary time) modification is inferred to be the exclusive result of "artificial" selection. I believe they are therefore indicative of the domestication process.

Macrobotanical remains such as those found at El Gigante are indirect, but substantive, indicators of both dietary and non-dietary plant use. A third goal of this chapter is to begin to outline broad dietary patterns and their change thorough time. Due to the non-random bias of their preservation, however, it is difficult to quantify a direct relation to the actual diet (Pearsall 2000). That is, certain plants that might have been significant contributors to the diet (such as tubers) might not have left any archaeological traces due to the (non-random) manner in which they were collected, processed and consumed. Direct indicators of dietary components such as coprolite, stable isotope or trace element analyses are necessary to be certain of the proportional contributions of certain classes of food (Hastorf 1999:76).

Nevertheless, the macroscopic remains I present form the basis of our reconstruction of the plant-portion of the diet, and are a first attempt to interpret broad patterns and trends in the assemblage. Some plants are under-represented and some are over-represented due to either their physical make-up and durability or behavioral variables involved in the harvest, processing, consumption and disposal of waste components. Hammond and Miksicek (1981) have demonstrated the difference between the make-up of an actual Maya diet and the remains recovered archaeologically. At Cuello, Belize they are able to show that the relative proportions of the recovered food remains from the site are similar to those observed in ethnoarchaeological work. Therefore, they make a strong (and experimentally tested) case that archaeological food remains at Cuello, indicate an even distribution of food classes in the actual diet, despite their uneven archaeological representation. In this case, they argue that shellfish, animal protein, plants with dense inedible parts, fleshy fruits, and root crops all represented about 20% of the diet (Hammond and Miksicek 1981:263). However, assumptions such as these can not be made for El Gigante. Species-specific ethnoarchaeological work is required to bolster the mid-range theory necessary to link archaeological plant frequencies with associated activities (Hastorf 1999:73). I also do not attempt to assess the proportion of any given class or species in the total diet because coprolite, trace element, isotope, and other skeletal indicators are presently unavailable for El Gigante. There are very likely distinct seasonal and locational biases represented in the El Gigante material, as is noted in critiques of other dietary reconstructions from cave material (Farnsworth, *et al.* 1985).

Following the descriptions of the individual plant categories and the consideration of the physical measurements and their implications I proceed to examine the general level of diversity in the botanical assemblage. Three indices of diversity are calculated for each stratum. These indices are species richness, the Simpson’s Index (1949) and the Shannon-Weaver Index (1949). These indices quantify the variety present in the assemblages and enable a comparison through time. The Simpson's and the Shannon-Weaver indices were chosen in an attempt to partially mitigate preservation biases and the under-representation of rare items in the assemblage. Both analyses were explored because they are widely used in ecology to account for sampling bias that gives proportionally more weight to rare species in ecological communities (Riklefs and Miller 2000:547). They are different mathematical means of correcting for evenness in populations. The Simpson's Index is more influenced by common species (Magurran 1988) than the Shannon Index. The utility and implications of these measures are explored.

Finally, I discuss the plant remains and the possible roles they played in the subsistence economy throughout the year (seasonal variation). This discussion includes the comparison of the El Gigante material to other sites in Mesoamerica where subsistence practices are evaluated from the perspective of the seasonal round.

Macrobotanical methods

The categories of plant remains that make up the catalog (Tables 7 - 10) were constructed by the author as a working framework for quantifying gross differences among and between the plant remains recovered from the three archaeological periods of occupation at El Gigante. The best catalog, of course, would be a list in which every item is identified to the species level. The current inventory for the site of El Gigante does not approach this "gold standard." It has sought the best level of identification possible given the volume of material. For some taxa, Dr. Lee Newsom's help in identification has put the category on solid botanical footing. However, many items examined and cataloged by the author are only identified to the genus or even family level. None of the archaeological specimens (with the exception of Dr. Newsom's identifications, as indicated) have been compared with proper botanical reference collections. I have therefore added the prefix "cf." to many of those items in Tables 7 and 9.

In order to incorporate unknown items into the catalog, a system was used in which these items were sorted by “morpho-species”. Morphologically similar plant parts were assigned a name, for example, "Small Seed #3." The first encountered "type specimen" was set aside and referred to later if/when a similar unidentified small seed was found from a different provienience. Many minor components of the assemblage (items that occur one to few times) are identified in this way. They are described at the end of the inventories for each period. Some of these morpho-species were later identified and assigned species names, leaving the list of categories in Table 8 with numeric gaps.

The sorting was done with the help of several undergraduate volunteers on the basis of gross visual distinctions that could be made by non-specialists. No reference collection from the region was available during the sorting process. These methods resulted in categories that are bound to be somewhat mixed between two or more species. The catalog serves the purpose of examining very broad trends through the assemblage. At this time, the volume of material is so great that an exhaustive identification of all the diverse array of remains by a trained botanist was not feasible. The categories are used in some of the following analyses as proxies for species.

The modeling of plant trait variability through time was accomplished using simple linear regression. That is, the significance of changes of plant phenotype are evaluated statistically as outlined below. At El Gigante, physical remains of several plant species have been preserved at marked points in time. In this analysis I measured select traits of these plants' phenotype in order to compare the later forms with early ones. The comparisons are confounded by the assumption that the species identified early in the archaeological sequence are ancestral to the later species. This may not always be the case. Identifications of species affinity within the broad classification categories outlined are beyond the scope of this dissertation. The analysis provides an initial evaluation of morphological trends in the assemblage that I hope will be a starting point for future, more detailed taxonomic analyses.

I assume humans would have wanted to maximize size or robustness of targeted attributes desirable in the use of certain plants. Depending on the species in question, other attributes are measured such as those that might involve selection for ease of processing. The exaggeration of some traits that are the hallmarks of domestication, may or may not be the result of conscious human manipulation. They can be an indirect result of the combined effect of human manipulation with a plant's biology and susceptibility to random genetic mutation. A variant which predisposes certain plants to selection by foragers in a target population can create a positive feedback relationship between the trait's frequency and its reinforcement by human selection. For example indehiscence, which is not an uncommon occurrence in fruit (Newsom, pers. comm.), could be reinforced in this way, yet our morphological measurements would not reflect this aspect of a plant's phentotype. This reinforcement can be intensified in the extreme, however, when a portion of the selected individuals, on average, over long periods of time, are not eaten but stored and used to propagate the next generation of crop.

I measured maize (*Zea* sp.) cobs and kernels, beans (cf. *Phaseolus* sp.), squash (cf. *Cucurbita pepo*) seeds, bottle gourd (*Lagenaria siceraria*) rind, hog plum (*Spondius* sp.) seeds and avocado (*Persea* sp.) pits using a Digmatic™ electronic caliper accurate to one-hundredth of a millimeter. Additional measurements on bottle gourd seeds were done by Dr. Lee Newsom.

I distinguish statistically significant changes in size by using ordinary least squares linear regression and ANOVA (SPSS v.10.0, SPSS, Inc., Chicago, Illinois, USA). The dependent variable in the regression was the measured attribute of the plant part, and the independent variable was time (*i.e.,* the sequence of strata from which each sample of the species population was drawn). The slope (b) and significance (P-value) of the regression line indicates the direction and strength of changes in the trait. The R-square of the regression model reveals how much of the variation is explained by a simplistic linear model. This method also gives a general indication of how variable the trait is within the sample. However, a better and more standard measurement of this within sample variability is the coefficient of variation (CV). Where appropriate and necessary this statistic is calculated and presented to the reader. The CV is a measure which expresses the standard deviation of a sample relative to, or as a percent of, the sample mean.

Macrobotanical Results

The following descriptive inventory is a phase by phase itemization of the macrobotanical remains recovered from El Gigante's main block of excavations, quantified in Table 7 and Table 8. The format is consistent throughout and includes the form, preservation, abundance and provienience of the finds, followed by any morphological assessments and then by any cross-cultural or regional comparisons.

Esperanza Phase Remains

Agave/*Maguey*

Agave sp. remains, sometimes called *Maguey* in Spanish, were one of the earliest food items recovered in the Esperanza phase and was represented throughout the sequence at El Gigante. Agave leaf panicle, as well as spine and other plant parts, were found in addition to wads of masticated agave, known as quids (Photo 43 and 44). A quid recovered from Unit 3, Level 28 in Stratum VI (one of the oldest of evident occupation zones) was submitted for AMS dating (see Photo 43). This returned a date of 9,240 +/-40 radiocarbon years before present (Beta#171700), a 2-sigma corrected date of 8,580 – 8,300 B.C. or, as old as 10,530 years.

The Central American agaves are dominated by the subgenus Hiemiflorae, especially *Agave pachycentra, A. wercklei, A. seemanniana* (Gentry 1982). This group generally has broader, shorter, more open panicles than other species common to the north. The quids at El Gigante might be from one or more of these three species.

Pit baking became an almost universal means of processing the edible portions of the agaves and the practice is widely described ethnographically (Castetter *et al.* 1938; Dering 1999). Briefly, pit baking is a communal method of food preparation in which a large (meter or more diameter) pit is dug and lined with dense rock. A fire is built in the pit and heats the rocks. The agave is placed on top of the coals and covered with grass and earth to prevent steam from escaping; the pile is left for one or two days depending on the size of the agave heads. Dering (1999) notes that this method of food processing is extremely labor intensive, and would thus make agave a relatively low-ranked food item. However, agaves do not have to be intensively processed to derive nutritional benefit. At El Gigante, the practice may have started as the simple roasting of leaves and stem on an open fire, evolving later in to the more massive scale enterprise.

Many remains of agave plants were found not as masticated quids, but as burned and unburned portions of the sharp tips, bases and strips of leaf. Evidence for large scale roasting is apparent at El Gigante in the late Formative period. The morphology and content of Feature 1 fit well with such a function. The cooked "heads," once uncovered, could be eaten at once, or stored indefinitely for future consumption (Gentry 1982). These cooked chunks of agave contain considerable fiber. After they are chewed for their starch and sugar, the fiber is spat out as refuse.

Some agaves can provide a beverage drawn from the living plant called *aguamiel*. In regions of scarce fresh water this can be a significant benefit to people. In fact, the sap of agave was a source of water in places where otherwise there may have been none, acting as a "live spring" (Gentry 1982). It can also be used in the preparation of *pulque*, a fermented drink made from the sweet juice of the plant. It is unknown when the intentional fermentation of agave sap began. However, Gentry (1982) and others conclude that it was known long before the Aztec. Productivity of agave (in terms of pulque and sugar/starch mass) is highly variable by species (Gentry 1982).

The green leaves and, for finer work, the conal buds of the agave make excellent fiber. Ethnographically, the harvesting, processing and weaving of maguey was, and is, a significant cottage industry in Mesoamerica. The uses of the fiber were widespread and applied to the making of rope, nets, mats, blankets, clothing, sandals, pottery rests, hair brushes, needle and thread, *etc.* (Gentry 1982).

"The main source of food in agave is the soft starchy white meristem in the short stem and the bases of the leaves, excluding the green portion." (Gentry 1982:6). The green portions of the leaves are generally not used for food but for an array of other practical purposes ranging from house roofing "shingles" to fiber. The starch and sugar content of the edible portions increase with the plant's maturity (*ibid.*).

Agave has been a source of prehistoric food for a long time (Callen 1973). Results of coprolite analyses from Tehuacan cave material show that *Agave* sp. was present in 25 - 60% of all coprolites. Callen cautions that this may reflect "a cave diet, and not a city diet" and implies that the hunting and gathering bands that defecated in the caves were of a special dietary group (Callen 1967). This group may have been eating a limited or specialized diet during intensive hunting trips away from the domestic hearth. In Mesoamerica, many varieties of agave were available and undoubtedly used, moved around and interbred at the hands of humans; these hybrids and their individual beneficial traits were capitalized upon by people and fostered an "explosive evolution in agave diversification" (Gentry 1982:6). The timing of this diversification is unknown.

Estimates of yield have been made for Aztec period maguey production (Evans

1990). However, these estimates were derived from studies of domesticated species in systematically planted rows and they are not discussed here because they are derived from a different species produced at a different scale. In the U.S. Southwest, Hohokam archaeological sites have been investigated which have indications of agave cultivation; the practice is also documented ethnographically for Papago groups in the Sonoran desert (Fish *et al.* 1985). Cultivation of this plant was accomplished through a method known as rock mulching. This practice utilizes the physical properties of artificial rock piles to conserve moisture and promote soil development through mounding and composting in discrete piles. Rock piles have been documented that range in size from 3-30 meters in diameter. The average Southwestern variety of agave (which is much smaller than the Mexican varieties) takes up to ten years to mature and a single plant can yield a heart weighing 4kg. Fish *et al.* (1985) note that the heart has about 347 calories and 4.5g of protein per 100 grams, making agave a high value food item, albeit one that requires long-term planning to be a reliable cultivar. For this reason maguey is often dismissed as a starvation food (*e.g.,* Farnsworth 1985).

Hog Plum/*Ciruela*

Another of the earliest and most ubiquitous food remains identified at El Gigante is the pit of the hog plum (*Spondias* sp., Anacardiaceae). Sometimes also called Spanish plum or, *ciruela, jocote* or, *ovo* in other parts of Latin America. *Ciruela* was the colloquial term used by local people of this area of Honduras, and so is often repeated here. Twenty specimens of this fruit were found in the deepest cultural levels of El Gigante, in Sub-stratum VIIa. Its archaeological visibility is due in part to its hard and relatively large pit (Photo 45). Many of the earliest examples are carbonized, probably because they were discarded into a fire pit or hearth in the shelter, directly associating their presence with human activities.

Spondius mombin is native to the lowlands of Mexico, Central America and South America (Adler and Kielpinski 2000). *Spondius purpurea* is "native and common both wild and cultivated from southern Mexico through northern Peru and Brazil" (Morton 1987:242). *S. purpurea* ranges from sea level up to 1,800m in dry and humid regions (*ibid.*). *S. purpurea* are more palatable than the sometimes astringent *S. mombin* (Rehm and Espig 1991:215). At El Gigante the species identification is still ambiguous. Both are cultivated vegetatively today (*ibid.*). None of the specimens were directly dated. Evidence for changes in seed size is presented below. Mature fruits of cultivated *S. purpurea* vary in size from 3 – 5.5 centimeters in length (Miller and Schaal 2005:12801). No figures could be found for the average length of a cultivated pit. At El Gigante, the average length of a whole pit (from Unit 18 (n=189)) measured 2.44 cm.

After some initial exploration of the sample, I concluded that two separate populations were present. Morton (1987), notes that the fruit is highly variable and that *S. purpurea* is sometimes misidentified as *S. mombim*. For now, I call these hairy and skeletal *ciruela*, one being denser with a heavier fiberous body than the other thinner, and more delicately structured seed. It is possible that they represent separate species, perhaps *S. mombin* and *S. purpurea* or, even *S. cirouella* (Morton 1987). *Spondias dulcis* has a worldwide distribution and in addition to its edible fruits, the shoots and young leaves are used as a vegetable (Rehm and Espig 1991:214). However, these differences may not be species specific; it is possible that they are due instead to preservation or differences in the initial processing of the fruit for use. It is known that the difference was not due to burning because burned specimens of both types were recovered. Because of the conspicuous dichotomy in the population, they were treated separately as well as a pooled sample.

In Unit 18, 52 skeletal types were found in Strata VI through Sub-stratum Ia, and 137 hairy types were found in Sub-strata VIIa through Ia. I chose this unit as a representative sample for use in the analyses. For each specimen I measured seed length and diameter. I used a combination of these two measurements to calculate a size index equivalent to the volume of a cylinder with the same dimensions of height and diameter for use in the regression analysis of change in morphology over time.

The hairy *ciruela* produced a model with P = 0.172, an R-square of 0.014 and a slope of -0.7260 (see Fig. 35). The regression line from the skeletal *ciruela* had a P = 0.129, R-square =0.045 and a slope of 10.9781 (see Fig. 36). In both cases, because of the lack of significance and low R-square, it does not appear that directional selection affected the size of *ciruela* seeds. It is also possible that some unmeasured trait or traits of *ciruela* were selected for, or other forces were at work in the preferences of the inhabitants of EG for this fruit. This tree is widely listed as a domesticate or "tree crop" (Piperno and Pearsall 1998:156), and is a common cultivar today. It might be that seed size has no correlation with a larger edible fruit mass.

In the above analyses the hairy and skeletal morphotypes were subjected separately to the regression analyses. An idependant samples T-test was performed to compare the two assemblages. This resulted in a strong inequality of means (P=<.000), with the hairy specimen's volume averaging 3366.4 while the mean skeletal specimen volume was only 2217.6. Perhaps, though, the morphological differentiation is arbitrary or due to differential preservation and they belong in a single group. The same methods were applied to the pooled data sets for both morphotypes with more significant results. Though significant at P= .018, the R-square remains very low (.029) indicating that the result has limited explanatory value (see Figure 37). One indication that the two types are drawn from distinct populations is the fact that each type shows very different coefficients of variation. The hairy specimens coefficient of variation is 27.4, while the skeletal remains are even higher, calculated at 36.2.

Commercial varieties of *Spondias mombin* grow best at elevations between 800m and 1200m (Cuevas 1994) and a mature tree (20 years old) can provide up to 10,000 fruits (Adler and Kielpinski 2000). In the wild this fruit tree is partly dependant on frugivorous birds and mammals for its dispersal (*ibid.*). This poses a dilemma in terms of their inferred inclusion in the human diet. However, if their presence is due to dispersal by animals other than humans, they should be just as well represented in the pre-occupation layers of the site, which they are not.

The modern propagation of the hog plum tree is done almost exclusively vegetatively (Rehm and Espig 1991, Miller and Schaal 2005;2006). This ensures a quicker harvest than from seed. *S. purpurea* is said to grow “easily and quickly by setting large cuttings upright in the ground” (Morton 1987:243). It is probable that this method of propagation would have been known to prehistoric people as well. *S. mombin* is also highly drought resistant and can tolerate poor soils (Cuevas 1994; Macia and Barford 2000). This makes it an ideal crop for the somewhat marginal landscape of the

Highland Plateau. The tree is intolerant of low light conditions and is more common along forest edges or in secondary habitat (Adler and Kielpinski 2000), which also indicates its suitability to disturbed human-created habitats. The fruiting season of the tree is variable, extending across the wet season. For example, trees in Sinaloa, Mexico fruit in June but, in the higher altitudes of Puebla, Mexico, it can be harvested in April or May (Cuevas 1994); in Panama, the fruit takes five months to ripen and is ready between July and October (Adler and Kielpinski 2000). Modern agricultural genetic improvement efforts have shown that *Spondias* varieties are very difficult to cross (Cuevas 1994). This fact may have implications for its coevolutionary history with humans, limiting the potential for domestication. Vegetative propagation requires more investment of time and effort, but could, in the long run, provide a variety with larger or more consistent fruiting. In order for a tree to produce an optimum crop, the ground around it must be weeded 3-4 times annually, a labor-intensive process (Macia and Barford 2000). Green-picked *ciruela* will mature in 4-5 days, but can only be stored for an additional 2-3 days before beginning to decompose (Macia and Barford 2000) which means that this resource could have only been used during the fruiting season.

Spondias fruit is very low in protein and fat, but contains significant amounts of calcium, phosphorous, iron and vitamin C (Cuevas 1994). *Spondias* was grown widely at the time of European contact, and descriptions of it can be found in Sahagun and Bernal Diaz' sixteenth century accounts reflecting their 15th century experiences. *Spondius* fruit are tasty fresh and is also used in a variety of beverages and syrups. Cuevas (1994) notes the use of its pulp in the preparation of maize-based *atoles* and *chicha* (unfermented and fermented regionally-significant beverages). This fruit can be found growing in the gardens of the village of Estanzuela today, and is a common market item as well. The cultivated variety is usually *Spondias mombin,* or winter mombin. Technically, it can not be defined as a domesticate because no morphological changes from the wild state are present.

Genetic comparison of modern cultivated populations of *S. purpurea* with wild populations has reinforced the likelihood that this tree was domesticated multiple times, possibly in two core centers of Mesoamerica (Miller and Schaal 2005 and 2006). One center spreads from southern Mexico through Central America including the region of El Gigante. The second is located in western Central Mexico. The vegetative propagation techniques used in domesticating this species resulted in less of a genetic bottleneck in this case than in other domesticated species. *S. Purpuea* retain 90% of the genetic variation of their wild progenitors despite the "clear morphological differences beween cultivated and wild *S. purpurea* populations" (Miller and Schaal 2006:1468,1475). As the measurable changes in seed size over time are only very weak in the El Gigante samples, I am left to conclude that *Spondias* sp. was domesticated very early here alongside Palaeoindian occupation. In that case, the pits from El Gigante are all of a morphologically domesticated size. Alternatively, *Spondias* sp. was not domesticated and the sample represents a ubiquitous collection of available wild specimens. In my opinion, the former is a more likely explanation though only a precise species definition will clarify the situation. This would provide the possibility of comparing a sample of cultivated and/or wild fruit of the same species to the archaeological sample.

Sapotaceae

Specimens of *Manilkara* sp. and/or *Sideroxylon* sp. (Sapotaceae), are perhaps the only other class of botanical remains that rival the *ciruela* in prominence from early occupation through the latest phases (see Table 7). Over two thousand of these centimeter-long seeds were recovered in the excavations and were identified by Dr. Lee Newsom (Photo 46).

The category established for these remains may include some misclassified specimens of *Sapindus saponaria* (also identified by Dr. Lee Newsom). This member of the Sapindaceae is known as soapberry or *jaboncillo* in Spanish, a common component of indigenous housegardens (Rico-Grey *et al.* 1990). The fruits of the soapberry can be eaten and can also be used to produce a fish poison, an antifungal medicine, and, as the name implies, a lathering soap, in addition the seeds are used commonly across tropical Latin America as ornamental beads (Mabberley 1997:638).

I suspect that the *Manilkara* sp. and/or *Sideroxylon* sp. seeds were introduced to the site by human action (as opposed to say rodent stores or bat forage), because they are absent from the pre-cultural assemblage. *Sideroxylon* cf. *tempisque* were identified in the early El Riego phase of the Tehuacan materials and are said to be a popular fruit in the region (MacNeish 1967:246). Perhaps the El Gigante specimens are similar to these "cosahuico" of Mexico. Another popular species of *Sideroxylon* from Central Mexico is the *tempesquistle* (*S. palmeri*) whose fruits are regularly consumed in Tehuacan households. This species is gathered from the wild in the tropical deciduous forests as well as in managed stands, where prime trees have been spared during clearing land for agriculture and they are also grown in homegardens (Gonzalez-Soberanis and Casas

2004). The current sivicultural management of this tree fruit is proposed by Gonzalez-Soberanis and Casas (2004) to have determined a form of domestication of the tempesquistle analogous to the prehistoric situation described by Macneish for the area (see above). The cultivated trees display larger fruits and less amounts of latex. Specimens from El Gigante are not likely *Sideroxylon palmeri*, as the seed size for the species is repored to be from .8 to 1 mm in length (Gonzalez-Soberanis and Casas 2004:247), far smaller than the archaeological specimens. But these remains, the *Sideroxylon* and/or *Manilkara* type in the El Gigante assemblage, are consistent with a the pattern of tree species domestication proposed for the Tehuacan region and material.

Another candidate is *Manilkara bidentata*, cultivated in northern South America for its edible fruit (Rehm and Espig 1991:371). With the exception of the sapodilla (see below) the genus *Manikara* is largely known for it elastomer and latex producing species, however (*ibid.*).

The sapodilla, *Manilkara zapota* (L.) P. Royen, (synonyms include *Manilkara achras* (Mill.) Fosberg (= *Achras zapota*)) is an important economic tree crop which produces fruits and latex; however, specimens of this particular species have not been identified at El Gigante. *M. zapota* is distributed from Central to northern South America and is one of approximately five domesticated species of Sapotaceae widely known and cultivated in the region (Rehm and Espig 1991:231; Piperno and Pearsall 1998:157). There is evidence in the collection from El Gigante of other important species in this family, including *Pouteria* sp. and the *Manilkara* sp. and/or *Sideroxylon* sp. specimens. Some fragments of *Pouteria* sp. were identified by Dr. Lee Newsom; they had been mixed in with similar-looking palm (*Acrocomia* sp.) seed fragments (see below) during the initial botanical sorting.

Identifications remain at too generic a level to firmly assess the significance of the *Manilkara* sp. and/or *Sideroxylon* sp., with respect to the diet of El Gigante's inhabitants. However they are a major component of the assemblage, and as mentioned occur from the earliest contexts onward. Like other members of the Sapotaceae, the plants in these two genera have highly developed latex systems (Mabberley 1997:638). This milky latex was used as chewing gum (*chicle*) in some cases. The rubber-like like sap can be applied to many other practical functions as well and some species are of commercial importance in that regard today, especially, *e.g.*, *M. bidentata* (*ibid.*:437). The Sideroxylon and Manilkara genera contain similarly large numbers of species across tropical America (49 species of Sideroxylon (*ibid.*:661) and 30 species of Manilkara (*ibid.*:437)). The species typical of the Sideroxylon genus are noted for their latex as well as for their exceptionally hard wood (*ibid.*:661). This seed type (*Manilkara* sp. and/or *Sideroxylon* sp.) is so abundant and conspicuous throughout the deposit, that I infer it was an important asset to the inhabitants of the site. I also infer from the ubiquitous fruits, that the fruit of the plants was used as a dietary supplement or adjunct. Though the sap, which is tapped like rubber, may have also added to the diet in the form of a sweet chewable gum, there is no direct evidence for this practice, though it might be logically inferred as well. If other uses were prominent, or the wood was used for some non-dietary function, these remain to be explored with further studies of the site's wood and charcoal remains that are yet to be examined or identified. It is hard to imagine why so many fruits would have been transported back to the cave if not to eat. Mabberley (1997:437) notes that the presence of trees of this genus (especially *M. zapota*) at many sites, in fact, reflects the past practices of a “lost culture” (the Maya).

The other Sapotaceae remains may belong to the Pouteria genus. One commonly cultivated species in Central America is *Pouteria sapota* or *Calocarpum mammosum* Pierre (= *C. sapota,*), commonly referred to loosely as *sapote* in Spanish or, mamey in English. *Pouteria* sp. (unknown species) specimens occur as early as the Esperanza period (see Photo 50). They are far less numerous than the other Sapotaceae specimens (the *Manilkara* sp. and/or *Sideroxylon* sp.).

Sapote does best at elevations from sea-level up to about 1400m, and can be grown in heavy clays as well as in sandy clays (Morera 1994). *Sapote* does not tolerate low temperatures (below 15 degrees C) well. Rainfall required for optimal fruit production is high, between 800 mm and 2,500 millimeters per year. Prolonged dry seasons will concentrate the fruiting into shorter time periods (*ibid.*). Therefore the harvesting window is extremely variable, with commercial varieties in Florida yielding as early as August to as late as February (*ibid.*).

Sapote fruit are a nutritious food. Chemical analysis of 100g of *Pouteria sapota* flesh shows that it contains 65.6 percent water, 1.7g of protein, 0.4g of fat, 31.1g of carbohydrate, 2g of fiber and calcium, phosphorus, iron, vitamin A, thiamin, riboflavin, niacin, and ascorbic acid (Morera 1994).

Sapote seeds are sometimes ground with chocolate to give it a bitter flavor and characteristic aroma. In Guatemala and El Salvador, the seed oil is used as a skin tonic to treat baldness, muscle pain, and rheumatic illness. In addition, the tree produces latex which is used in a poultice to treat fungus on the skin (Morera 1994). *Sapote* is usually propagated by the easily stored and transportable seeds. These trees are also grown in mixed plots along with perennial crops such as cocoa and coffee near people's homes (Morera 1994).

Avocado

Also notable in the Paleoindian or Esperanza phase assemblage are the remains of avocados (*Persea* sp.). This includes the pit, stem and rough bumby rind of the fat-rich fruit (Photo 47 and 48). These remains first appear in the initial occupation phases, Strata VI and Sub-stratum VIIa, and become more and more ubiquitous through time. The species represented in the archaeological catalog from El Gigante is/are most likely varieties of *Persea americana.* These varieties are usually grouped into three categories. The Mexican avocados (*e.g., P. americana* var. *drymifolia*) which have typically small fruit but can tolerate poor conditions and frosts to -6 degree Celcius. The Guatemalan varieties (*e.g., P. americana* var. *nubigena*) which have large fruit and a thick rough skin surrounding a relatively small pit. The Guatemalan types are less tolerant of frosts and capable of surviving -4.5 degrees Celcius (Rehm and espig 1991:192). It is most likely one of these two or both species that are present in the El Gigante assemblage. The third, West Indian type, has a smooth skin and can not tolerate frost conditions below -2 degrees Celcius (*ibid.*). All are propagated vegetatively and can bear fruit in their 4th or 5th year.

Forty-two avocado pits (the entire assemblage from secure contexts) were measured to assess the change of this fruit's seed phenotype through time. These 42 pits came from fifteen distinct strata spanning the entire cultural sequence at El Gigante

(Table 7).

The pit of an avocado can be visualized as a sphere with one slightly pointed end. When physically possible, given the state of preservation, one or more of three possible measurements were taken on each specimen. These were the longitudinal axis length, the diameter at the midsection or, the radius at the mid-section (taken if an entire hemisphere was not preserved).

In this analysis it was assumed that the seed size correlates with the size of the fruit, and that people would have preferentially picked and then discarded or re-planted larger seeds. However, varieties with large seeds and relatively little fruit as well as those with a large amount of fruit and a small seed exist, and the analysis does not account for these extremes. In today's markets it is possible to find a wide variety of avocados, many named for the region from which they were "developed." In this analysis I must assume that the noise created by the possible presence of multiple species/varieties in the assemblage will not mask any general trends with respect to the seed size. The amount of this "noise" is measured by the coefficient of variation (Table 11). Although the sample size for the earliest strata is small, there does not seem to be any significant change in the CV over time.

Avocado trees do best in mesic, well-watered forests in the high mountains (Ebeling 1986). The Mexican avocado (*Persea americana* var. *drymifolia*) is the most cold-hardy, while *P. nubigena* var. *guatemalensis* [sic] (= *P. americana* var. *nubigena*) are also tolerant of occasional frosts (Ebeling 1986). Most investigators regard all of the varieties as cultivars of a Mexican *P. americana* (Traverse and Newsom *pers. comm.*).

At Tehuacan, in Central Mexico, Ebeling (1986) notes an apparent punctuation in the evolutionary history of fruit size that occurs after the Santa Maria Phase, post 850 BC. The original authors attribute this event as a sign of "active selection" and "cultivation" (Smith 1967:240). At El Gigante, plots of seed length and seed radius measurements were examined. Linear regression lines fit to the radius attribute plot were not significant ($P = 0.208$) but the length differences were ($P = 0.009$). The regression line for length had an R-square of 0.175. This result is significant and also indicates a range in pit size within any given population. The slope of the regression line (see Fig. 38) indicates a trend of increasing size thorough time. Therefore, in the case of the avocado, I conclude that directional selection was occurring.

However, in contrast to the Tehuacan material, El Gigante seed remains show active selection from the very beginning of the sequence. They never grow to the size of the Santa Maria (Classic period) Tehuacan avocado, however. Avocado pit sizes can be compared by calculating an index equal to the product of the pit length and width in centimeters. At El Gigante, the average pit size index was 5.06, 3.67, and 4.57 cm^2 in the Estanzuela (Formative), Marcala (Archaic) and Esperanza (Paleoindian) phases respectively (see Table 11). The earliest two specimens from Coxcatlan phase material at Tehuacan (mid-Archaic) are an average of 3.4 cm^2, two specimens from the Abejas (late-Archaic) phase measured an average of 3.78 cm^2, but the average Santa Maria (Classic) phase pit size index was 7.8 cm^2 (Smith 1967:240). Ebeling (1986) suggested that avocado domestication was affected in a punctuated fashion after A.D. 850, but at El Gigante there is no indication of anything but a gradual increase in size over time.

The intentional domestication of avocados would have been difficult for two reasons (Ebeling 1986). First, there is a long generation time between the fruiting of mature trees. The results of experimental propagation might not be observed within the span of a human generation. Because avocados, like most perennial trees, take a long time to bear fruit even if propagated from vegetative cuttings, it isn't possible to do as much experimentation within a single lifetime as one could with an annual. Second, avocado trees are pollinated "openly," and it is very difficult to make certain that two large fruited trees have been crossed (Ebeling 1986). In addition, unguided harvesting of all fruit, regardless of size, might have been common, resulting in a complete lack of selective sorting.

Palm

Palm leaf material was commonplace in the upper levels of our excavations. Fragments of what might be *Acrocomia* sp. seed coats are common in the early levels and throughout the sequence at El Gigante, from Sub-stratum VIIa onwards (Photo 49). Many palm fronds, often burnt, were recovered. This material was also often observed in wrapped bundles and/or tied strips.

Palms that provide the highly nutritious fruit such as the "*pejibaye*" (*Bactris gasipaes*) or "*asaí*" *(Euterpe oleracea*) which has more calories per unit than cow's milk and twice as much fat (Balick 1984), are typically lowland species (Rehm and Espig 1991:89) and would not have been available to the inhabitants of El Gigante. However, there are some species that would thrive in Estanzuela's climate. These include understory species used for thatch such as those of the genus *Lepidocaryum* (*ibid.*). David Lentz *et al.* (2005:122) note that *Acrocomia aculeata* was found in Formative

Cahal Pech (Central Belize). It is also listed as a cultivated plant with possible connections to other parts of Mesoamerica, including the Intermediate Area Formative site of Yarumela (Honduras) and the early Gulf Coast Olmec site of San Andres. Other palms including "*huiscoyol*" (*Bactris* spp.) and "*cohune*" (*Attalea [sic] cohune*) have been recorded at various lowland Maya sites as well (Lentz 1999:6).

The hard outer seed coats of *Pouteria* sp. (Sapotaceae) were mistaken during sorting for *Acrocomia* sp. remains, thus potentially inflating the counts for this category.

In addition to edible fruit, the palm frond, stem, and pith serve versatile uses. Palm fiber is used to construct many useful items such as baskets, mats, and shelters. Many species are widely cultivated throughout Central America both for their high starch fleshy fruit as well as for oil and other practical materials (Rehm and Espig 1991:89). The pith in the center of the stem of some palms can be eaten as a starch, or fermented to make wine. Starch is stored in the ground tissue of the stem, and is collected and consumed as an important carbohydrate. Fallen palms are often infested with insect larvae and grubs which can provide an important dietary protein for human groups. The fruit can be eaten fresh, made into beverages and types of flour, oil, ornaments, and medicines; many more items are extractable from various parts of the palm plant. Because of the multiplicity of both food and non-food uses the palm can be considered the lowland equivalent of the *maguey* plant in the highlands (Balick 1984).

In the Neotropics, "the dependence of an indigenous group on one or a few palm species for so many of their daily requirements is a common observation" (Balick 1984:10). Palm use is documented in Doris Stone's ethnographic description of the

Lenca in Highland Honduras (Stone 1963:206). She notes the use of royal (*Roystonea* spp.) and suyate (*Brahea dulcis*) palm hearts as food, as well as the early sprouts of the pacaya palm (*Chamaedorea* spp.)

This observation fits neatly with a pattern noted by Morcote-Rios and Bernal (2001) in their review of palm remains in archaeological sites of the New World. In their survey of the literature they see an increase in palm exploitation (both in number and diversity of species used) in the period from 9,000 to 5,000 years ago (Morcote-Rios and Bernal 2001:311). They list 29 genera and 50 species of palm that have been found across both North and South America: the most predominant are *Acrocomia, Attalea, Astrocaryum, Bactris, Syagrus, Elaeis,* and *Oenocarpus*. Dr. Lee Newsom has identified some of the remains from El Gigante as belonging provisionally to the genus *Acrocomia*. However tenuous the identification, in association with the archaeological palm fiber material, these remains show a clear association between prehistoric humans and the palm tree at El Gigante.

Wild beans

Wild beans are present at low levels in the very earliest levels are specimens of unidentified beans and bean pods (Photo 51). These belong to the Fabaceae (pea family). Their presence is recorded in Strata VI and Sub-stratum VIIa. There are only a few beans present in the early assemblage. However, the dried pods are common throughout the entire sequence. The early specimens might represent wild varieties of *Prosopis* sp., such as *P. jutiflora*, the wild mesquite bean.

Prosopis sp. a perennial tree legume, is often associated with agave, as well as with prickly pear (*Opuntia* sp.) (Piperno and Pearsall 1998:100). The Pacific littoral habitat of Panama, for example, is particularly dominated by this tree. Piperno and Pearsall (1998) suggest that this habitat was more extensive during the drier late Pleistocene. They propose that its extensive geographical range during that time fostered the use of these and other useful perennial plants, including the exploitation of the large herbivore populations that the habitat can support (Piperno and Pearsall 1998:228).

Acorns

The earliest acorns (*Quercus* sp., Fagaceae) were recovered from Stratum VI (Photo 52). There are few of these throughout most of the sequence but they begin to increase in number by the Formative period.

In California, acorns (Fagaceae, *Quercus* spp.) were a major staple in Archaic times (Basgall 1987), however, perhaps because of the high investment required to process and remove the tannic acids from the seed (*ibid.*), they were never utilized to the same extent across Mesoamerica. There is no indication at El Gigante that people were collecting or processing acorns *en masse* in this way.

Other Unidentified Remains from the Esperanza Phase

There were several unidentified items that occur in the earliest phases of El Gigante's occupation, between 9,000 and 8,000 BC. These include a rind designated as “type 10,” that also occurs in upper levels and several unidentified rind fragments that may be unique to the earliest phase (Photo 53). A large seed of “type 2” was found in

Sub-stratum VIIa and in successive phases (Photo 54). A large seed of “type 3” was found in Stratum VI and in successive phases (Photo 55). The large seed, “type 5” was unique to Sub-stratum VIIa (Photo 56).

Marcala Phase Results

Squash and Gourds

Several rind specimens of what might be *Cucurbita* sp. are identified in Strata III and IV (unidentified rind #5, and unidentified rinds "a" and "b", [Photo 57]). These fall in the pre-ceramic horizon of the Marcala phase. These may include both domesticated and wild species of squashes and gourds that can only be identified accurately by microscopic study of thin sections. The first evidence for gourd and or squash use is found in Sub-strata IVb in the form of unidentified rind fragments. A single seed possibly *Cucurbita pepo* (though heavily eroded and unmeasureable) is represented in Sub-stratum IVa (see Table 7). The combination of gourd/squash rinds with the isolated cucurbit seed indicates that the initial use of these plants can be placed back well into the Archaic, perhaps at 5,000 to 6,000 BC. For this reason they are listed here under the Marcala Phase rather than in the following section.

All but one (see above) of the squash seeds used in the morphometric analysis were found in the Formative, Estanzuela phase (Photo 58). Although many strips and fragments of rind were encountered in the previous phase, I focused the phenotypic analysis only on the available seeds from the early to late Formative. At this time it is impossible to associate any of the unidentified gourd/squash rind fragments (found in the Archaic) with the cucurbit seeds (found in the Formative) which are the only specimens in the current study which have been provisionally identified as “cf. *C. pepo*.” Rind fragments of the same species (cf. *Cucurbita pepo*) or ancestral wild types, would be a much stronger indication of an Archaic cultivation and or use of squashes and gourds. The discussion of the cucurbit seeds below is not meant to give a false impression of their presence in earlier time periods. I believe that the presence of unidentified gourd and squash rinds alone (perhaps undomesticated native cucurbits) can be used to place them in the earlier phase.

The one cf. *C. pepo* seed found in earlier contexts was too fragmentary to include in the study. So, I analyzed 42 seeds, the earliest of which came from Layer IIc3. The great majority of the seeds were in the uppermost levels of Sub-strata Ia and Ib (n = 37). It has been demonstrated that seed size and fruit weight are highly correlated (Cowan 1997:81). I assume that people would have selected for these general traits. However, non-morphological traits might also have been the subject of experimentation and selection, including flesh edibility or sweetness (Cowan and Smith 1993).

I measured three attributes of the seeds, including length, the width at the widest point, and the width of the neck at the inflexion point (Table 12). I generated the squash seed size index by calculating length multiplied by the width at the widest point, and also modeled the increase in width at the neck alone.

There was a significant change in seed size (length by width) over time (P = 0.02). The regression line showed a marked negative slope, (-0.9475) indicating that seed size increased over time (see Fig. 39). The R-square value is very low (0.154), which is indicative of the high variation in squash seed size. This may be due in part to the possibility that some varieties of squash may have been raised for their seeds and quantity of flesh while others might have been prized for the quality of the flesh and others for their rind and its suitability for containers (Cowan 1997). It is curious that we find so few squash seeds in the earlier phases of occupation. This pattern may indicate a shift in the practice of squash use due to the effects of domestication from a focus on the seeds to a focus on the flesh. Wild squash are far more valuable for their seeds than edible flesh. If the squash were not being grown for the edible seeds, the seeds would be more likely to be thrown out.

The width at the neck of the seed also showed a significant increase over time (P = 0.004), with a negative slope (-0.0293) indicating a trend toward larger size (see Fig. 40). The slightly larger R-square value of 0.220 may indicate that the neck width is a more consistent attribute with respect to all seeds.

Both measured traits in the squash sample increased over time. In Layer IIc3 and IIc1, seeds have a surface area index of around 125 mm^2. This is an overestimate of the actual size of the seed calculated by multiplying the length and width measurements. Whereas, by Sub-stratum Ia the size index approaches an average of 140 mm^2, with several specimens as large as 160-180 mm^2. Similarly, the neck width when squash first appears in the sequence ranges from 3.5-4.0 mm and by the latest phases grows to ranges from 3.0mm to almost 6.0 mm with an average of more than 4.5 mm.

In comparison to some published figures for modern species size, the average El Gigante squash seeds are relatively small. For example, the size index of *C. argyrosperma* seeds ranges from 120 - 480 mm^2, *C. pepo* from 12 - 240 mm^2, *C. moschata* from 40 - 231 mm^2, and *C. ficifolia* from 105 - 300 mm^2 (Saade and Montes-Hernandez 1994:66, 69, 72, 75). Table 13 and Figure 41 summarize and compare the squash seed size data from El Gigante to four other archaeological sites through time, as well as to two modern samples, one wild Ozark cucurbit, and a pooled sample of *C. pepo* ssp. *ovifera*. The pooled sample of wild North American *C. pepo* ssp. *ovifera* ("Ozarks") was found to be, on average, smaller than the El Gigante specimens. In comparison to the single dated seeds from the earliest levels of Guilá Naquitz and Coxcatlan caves, the El Gigante specimens are quite large. The only larger seeds, in fact, are found in the very late Venta Salada phase of the Tehuacan sequence at Coxcatlan cave, Central Mexico.

The El Gigante specimens are also quite large in comparison to the seeds recovered from the mid-occupation levels at Romero's and Valenzuela's caves in Tamaulipas, Mexico (Smith 1997). Smith reports average seed sizes of between 105 mm^2 at Romero's cave and a similar 99 - 107 mm^2 at Valenzuela's cave (Smith 1997:360,368). Smith notes that both sites exhibit similar trends of temporal changes in seed size and variability. At Valenzuela's and Romero's cave, seed size varies more in later time periods (*ibid*.:370). Variance in seed size (as measured by the Coefficient of Variation (CV) is very high across all phases at El Gigante (see Table 13).

More laboratory work is required to further compare the cucurbit assemblage from El Gigante to those from other sites. For example, a tabulation of wartiness and lobing of the fruit rinds, as well as the measurement of the thickness of the rind and the diameter of the fruits would be helpful in determining evolutionary affinities with other sites since seed size alone has been found to be inadequate (Cowan and Smith 1993:36,40,42). None of the El Gigante seeds have been directly AMS dated which would also aid interpretation. There are three changes in squash morphology that mark the development of domestic varieties on the Cumberland Plateau in North America

(Cowan 1997:73). The El Gigante sample meets two of these: (1) an increase in the size of the seed and, by extension, the fruit, and (2) significant variability and evidence for diversification. The third, changes in the fruit wall or rind thickness, was not evaluated in the current study. Future measurements on the fruit wall and rind, as well as peduncles in the collection might provide more evidence. It is interesting to note that although all the El Gigante squash seeds exceed the size threshold for domesticate status [*ca.* 11 mm (Cowan and Smith 1993:43)], the results of directional selection continue to be seen in further increases in size well beyond that mark.

The *Cucurbita* genus (collectively the squashes) is often grown alongside maize and beans in fields and gardens throughout Mesoamerica and the seeds can be dried and stored for periods from 18 to 20 months (Saade and Montes-Hernandez 1994). A single modest patch of wild squash like the Ozark variety discussed in the above section can yield 10,000 to 20,000 seeds in a season (Cowan and Smith 1993). Following Flannery's estimates on wild cucurbit seed yields (1986:304-305) this amounts to roughly 7,150 to 14,300 kilocalories.

Cucurbita argyrosperma are found at altitudes up to 1800m in areas with a defined wet and dry season, but they do not tolerate frosts (Saade and Montes Hernández 1994). They are sown at the initiation of the rainy season and young fruit can be harvested in about three to four months. *C. pepo,* on the other hand, is a diverse group of squash including pumpkin, zucchini, acorn, crookneck, scallop, straight neck, vegetable marrow, and cocozzelle. The species covers a wide range of altitudes. For example, in Guatemala and Mexico the native cultivars the *güicoy* or *güiches* are grown above 1,000 m and even as high as 2,000 m respectively, while some *tsol* varieties are adapted to the semi-dry, coastal Yucatan and others to the hot and humid Petén lowlands (Saade and Montes Hernández 1994:69). The timing of sowing and harvest is variable by variety (Saade and Montes Hernández 1994). Electrophoretic analysis of isoenzymes has shown this group to be closely related to *C. argyrosperma* (Saade and Montes Hernández 1994) which does best in warmer, low altitude climates with high humidity (*ibid.*). However, *C. pepo* has been reported to grow in Oaxaca, Mexico up to 2,200 m and it is known to be a highly variable genetic stock. This species is also sown at the beginning of the rains and can be harvested in three to seven months (*ibid.*). *C. ficifolia* is widely cultivated from Mexico to Argentina in almost all the mountain ranges, from 1,000 m to 3,000 m. Compared with other species, *C. ficifolia* is more of a generalist and grows in a wider range of ecological conditions (Saade and Montes Hernández 1994).

Saade and Montes Hernández (1994:64) note that as with other crops, it was characteristics connected with handling and the preferred use of the particular squash that were transformed most by domestication. For example, within the context of human use the plants adapted to include a more uniform germination rate, a reduction in the size and abundance of trichomes (protective hairs on the leaves), an increase in the size of particular parts used (fruits and seeds) and a reduction of the bitter taste of the flesh. Some varieties of squashes were utilized exclusively for their seeds while others were selected for their flesh resulting in a great diversity of phenotypes and genotypes.

Squash seeds are generally more important nutritionally than the flesh because of their high oil (39%) and protein (44%) content (Saade and Montes Hernández 1994). As with the other squashes, *C. ficifolia* seeds are highly nutritious, but *C. ficifolia* has a white flesh and is deficient in beta-carotene (vitamin B) and other vitamins and minerals; it is also only a moderately good source of carbohydrate (Saade and Montes Hernández 1994). The squash is an important crop which supplies essential amino acids that are not found in carbohydrate-rich maize nor in protein-rich beans.

Cucurbita pepo is one of the oldest archaeologically recorded domesticated species, has the widest geographic distribution and displays an "extreme many forms" (Rehm and Espig 1991:147). Remains of the seeds, peduncles (stems) and rind fragments have been found in the Guilá Naquitz cave in Oaxaca, Mexico and have been AMS dated to between 10,000 and 8,000 years ago (Smith 1997). Specimens of domesticated *C. pepo* from the Coxcatlan cave in Tehuacan, Puebla, Mex., have recently been AMS dated and have turned out to be 7,920 cal years B.P., while *C. argyrosperma* does not appear there until 2,065 cal years B.P. (Smith 2005). In southwest Ecuador, Piperno and Stothert (2003) report on the identification of large (and infered to be domesticated) *Cucurbita* phytoliths present between 12,000 and 10,000 years ago. Piperno and Strothert claim that this shows the "independent emergence of plant food production in lowland South America that was contemporaneous with or slightly older than that in highland Mesoamerica." (Piperno and Strothert 2003:1054).

C. moschata, also sometimes called a winter squash, is widespread throughout Meso-, Central, and South America. Rehm and Espig (1991:147) call it the most important cultivated squash in Central America because of its many cultivar varieties and its keeping qualities. This is in comparison to *C. mixta* which has few cultivars outside of the immediate region of Central America. None of these squash varieties have been ruled out int the case of the El Gigante specimens. Its location of domestication is uncertain, but it has been found archaeologically in the Tamaulipas caves, and dated from 4,900 to

3,500 BC (Smith 1997). Like *C. moschata*, *C. ficifolia*'s (fig leaf squash) locus of domestic origin is unknown. Most archaeological indications are that the South American Andes are the likely center of origin (Saade and Montes Hernández 1994).

Bottle gourd

The first evidence for bottle gourds (Cucurbitaceae, *Lagenaria siceraria*) at El Gigante is found in Sub-stratum IIId in the form of four rind fragments (Photo 59). At El Gigante this stratigraphic zone is, unfortunately, the most tenuously dated because of the large discontinuity between the mid-Archaic and early Formative phases. Given its early occurrence at other sites, however, I would date its appearance at El Gigante by at least the fourth millennium BC. Several seeds of bottle gourd were recovered at El Gigante in addition to the rind (Photo 60). These were from rather late contexts dating to the Formative (Estanzuela period), but is notable as no seeds were found in either the Tehuacan or Guilá Naquitz material (Whitaker and Cutler 1986; Cutler and Whitaker 1967).

Bottle gourd seeds are edible. The seeds from the site (n = 9, two from mixed "pothole" units) show an interesting range of morphologies from wild to domesticated (Newsom *pers. comm.*). They range in age as well, a single seed came from as deep as Layer IIa6.1 which places it in the middle Formative, but the majority are from either Sub-stratum Ib (n=4) or Ia (n=2), the later Formative period. Dr. Newsom's measurements of the seeds are presented in Table 14 and include the length, width at proximal, medial and distal points, and thickness. The seeds range in length from 10.15 mm to 15.76 mm. While it may be a function of the small sample size, there does seem to be a significant difference in average size between the earlier specimens (n=4, from Sub-stratum Ib) and the later ones (n=2, from Sub-stratum Ia), in all of the traits. Unfortunately, the two relatively large "pothole" seeds can not be placed chronologically with respect to the others. Direct AMS dates on one of these large seeds, as well as on the small specimen from Layer IIa6.1 would provide a test of the validity of this trend. The increase in size in such a short time span, so late in the Formative, would indicate intensive selection at the time.

The bottle gourd may have been originally domesticated in the context of its use as a tool not a food, some propose that this original context was one in which a coastal or maritime focus required the infrastructure of terrestrial resources, including the gourd (Moseley 1992). A functional and reliable container would be one with relatively thick and durable walls.

To see if prehistoric peoples selected bottle gourds for attributes beneficial to containers, I measured the rind thickness on all bottle gourd rind specimens. In gourds with non-textured epidermis, such as these, rind thickness is fairly uniform from one place on the fruit to the next (Cowan and Smith 1993:40). A total of 107 fragments of bottle gourd rind were assessed. These derive from twelve distinct strata with the first appearance in Layer IIId2. This was a surprise because Layer IIId2 is no older than 5,000 B.C. and previous placements of the domesticated bottle gourd place it as early as 8,000 B.C. (*e.g.* Piperno and Pearsall 1998).

The regression results for the bottle gourd wall thickness measurements over time were significant (P = 0.034, R-square = 0.042). The range in wall thickness is very high, from less than 2 mm to just under 6 mm. The regression line shows, however, (see Fig.

42) that the average gourd wall gets *thinner* over time since its first appearance in Layer IIId2. At Romero's cave in Tamaulipas, Mexico, a sequence of 251 gourd rinds was assigned to occupation zones and measured (Smith 1997). Smith notes that the average gourd rind thickness is about 3 mm and remained "fairly consistent" (Smith 1997:353). While the average size at El Gigante is similar, the trend toward a thinner gourd wall remains unexplained.

The bottle gourd is one of the earliest domesticates found in the New World. This may be because it was encountered in an already domesticated state, perhaps dispersed by natural mechanisms between the continents. Alternatively, it has been proposed that while it may have been already domesticated (in Asia), it was brought to the New World with colonizing Paleoindians (Erikson *et al.* 2005). Regardless of its nativity, it was critical resource to prehistoric people, as a utilitarian vessel well-suited as a container for any number of purposes.

In Mesoamerica domesticated *Lagenaria siceraria* is found in Tamaulipas caves as early as 9,000 BP and at Tehuacan by 7,500 BP (Pickersgill and Heiser 1977). It is surprising that it was found so late in the deposits at El Gigante, given its documentation and occurrences at sites in Mexico and at other sites in North America by 7,290 BP (Doran *et al.* 1990). Measurement of the El Gigante gourd rinds may tell an interesting story of the effects of a shift in plant use coincident with the use of pottery. Perhaps more significant, however, is the sample of gourd seeds. No seeds were recovered from the Mexican sites in the Tehuacan Valley caves or at Guilá Naquitz (Whitaker and Cutler 1986; Cutler and Whitaker 1967). Three rind fragments were found in the Coxcatlan phase material and six in the succeeding Abejas phase from Tehuacan, dozens are reported from later contexts, however, they were described simply as "similar . . . to other Mexican sites." (Cutler and Whitaker 1967:216). Similarly, the sample of *L. siceraria* seeds is lacking from the Guilá Naquitz inventory and rind remains are limited to three fragments in the Archaic "zone C" with only seven total recovered from the site (Whitaker and Cutler 1986:278).

The native ancestor to the domesticated *L. siceraria* has never been identified and, again, it is likely that the bottle gourd arrived on the shores of this continent in an already domesticated form (Heiser 1979). The importance of gourds in the symbolic culture of early civilizations has been noted as well, including as central motifs in 1st millennium B.C. religious art of the Chavin culture of Peru (Lathrap 1973). Far from being an instance of bottle gourd domestication, a complex and convoluted story, the changes observed in the gourd wall thickness at El Gigante may represent changes to the adaptive context in which this domesticate found itself.

The early cultivation and use of bottle gourds in the New World has been shown repeatedly to have had a key role in maritime subsistence systems where they were used as net floats (Moseley 1992). Assuming the identification (by the author) of the bottle gourd rind specimens is correct and the samples representative, perhaps the seeds became the focus of selection (for food) rather than, as in the original domestication, the sturdy gourd wall (for a vessel). This much more recent shift in the selective forces acting on New World bottle gourds could have been triggered by an increased reliance on pottery in the Formative period and the corresponding decrease in need for gourd containers or fishing floats away from the coasts.

Annonaceae

Custard apple seeds (Annonaceae, *Annona* sp.), make their first appearance in the intermediate strata of the Marcala phase. The earliest specimens (n=6) were found in Sub-strata IIIf, IVa and IVb (see Table 7 and Photo 61). These are identified only to the level of genus and could include several fruiting varieties.

There are at least six different domesticated species in the *Annona* genus that that grow as small trees or shrubs and provide a sweet, though easily spoiling fruit. Of these, the soursop (*anona* in Spanish, *A. glabra* and *A. reticulata*) and the "sweet sop" (*A. squamosa*) are common to Mesoamerica (Rehm and Espig 1991:193; Piperno and Pearsall 1998:156). Soursop trees thrive in climates similar to that of the Estanzuela Valley. They tolerate elevations to 1,800 m and are acclimated to prolonged dry seasons (from December to March), annual rainfall of 1,000 mm to 1,400 mm, and rich volcanic soils (Mahdeem 1994).

Soursop are highly nutritious, abundant in carbohydrates, protein, calcium, phosphorous, iron, thiamin, niacin, and riboflavin (Mahdeem 1994). Soursop were widely cultivated throughout Mesoamerica, the inter-Andean valleys and in the Amazon region (Mahdeem 1994). One species, *cherimoya (Annona cherimolia),* is sold internationally (Mahdeem 1994). The origin of this domesticated species is known to be the highlands of Peru or Ecuador, adapted to cooler temperatures and occasional drought (Rehm and Espig 1991:193). Another species, *A. diversifolia,* is commonly propagated by seed by the indigenous people of Guatemala, sown most intensively between 200 and

600 m on the Pacific slopes of the Southwest, and known as *anona blanca* or *ilama*. In southwest Guatemala it is grown with other fruit trees in the mixed patio gardens and small holdings of rural subsistence farmers (*ibid.*). These small trees and shrubs come in many varieties and many cultivated species are of only local importance (Rehm and Espig 1991:193).

Hackberry

Celtis sp. (Cannabaceae), seeds are encountered for the first time at El Gigante in Sub-stratum IVb, and date to at least 6,000 BP (Photo 62). Originally classified as "Medium Seed Type 8", the hackberry is another item found at El Gigante which is also a common modern component in Maya house gardens (Rico-Gray *et al.*1990). Nutritionally, hackberries can provide 16.2 kcal/gm, and contain 19% crude protein by weight. They have a higher quantity of the minerals Na, K, P, Mn, Ca, Mg, and Zn than the peanut (Demir *et al.* 2002).

Other Unidentified Marcala Phase Remains

There were many unidentified specimens in this phase owing to the sheer volume of remains recovered. Rind Type 5 is found in Sub-stratum IIIf (Photo 63) and there are many unidentified rinds apparent in these levels that were heretofore not seen in the assemblage. For example, unidentified medium seeds include seven different varieties which are found only in this period. Medium Seed Type 3 (Photo 64) occurs for the first time in Sub-stratum IVa, Medium Seed Type 12 in Sub-stratum IIIf (Photo 65) and Medium Seed Type 19 enters the diet set in Sub-stratum IIIf (Photo 66). Large Seed

Type 12 is first noted in Sub-stratum IIIf (Photo 67) and there are at least two additional varieties of large seed added to the assemblage during this period. Because of sampling bias, small seeds are underrepresented. A single unidentified small seed appears in the pre-ceramic levels, occurring in Sub-stratum Va. We suspect that this seed was brought in by resident bats because it was also observed in dense quantities in thick (1-2 cm) mats of accumulated guano.

Estanzuela Phase Results

Maize

The maize cobs at El Gigante are a tantalizing set of archaeological remains. A paucity of macrofossil maize has been a major stumbling block to resolving the debates surrounding the origins of maize agriculture in Mesoamerica. The bulk of the information concerning its early use come from five cave sites in Mexico (Romero's and Valenzuela's cave in Tamaulipas, Coxcatlan and San Marcos caves in Puebla, and Guilá Naquitz cave in Oaxaca) excavated in the 1950's and 60's (Smith 2005).

Fully domesticated maize (*Zea mays* ssp. *mays*) cobs were recovered from the lower levels of Stratum II and the upper levels of Stratum III, placing them early in the Estanzuela phase. No remains of non-domesticated *teosinte* (*Z. diploperennis*, *Z. luxurians*, or *Z. nicaraguensis.*) were identified. Two early specimens of domesticated maize were submitted for radiocarbon dating (Beta #171701 and Beta #159055, see Photo 79). The dated specimens were selected with special care as to the security of context. They were not necessarily the deepest cobs recovered (see Table 7), but were deemed to represent the earliest examples from undisturbed contexts. These two assays returned dates of 2,010 +/-40 and 2,280 +/-40 radiocarbon years BP (2-sigma corrected date = 100 BC – AD 70, and 310 – 210 BC). The results of the direct dating do not contradict dates that might be assigned by association alone, in this case, confirming solid archaeological control of the material. More cobs should be dated to confirm this tentative chronological assessment.

The maize cobs that were directly AMS dated from EG were barely more than 2,000 years old, although many other cobs were found in direct association with strata dating to 1,440 B.C. It is during the later time frame that I suspect maize was first cultivated at El Gigante. In addition, it is just below these levels in the excavation (below Sub-stratum IIIa) that we find a large gap in the chronological sequence; there are no dates from El Gigante for the period between 2,430 and 4,850 B.C. This is the time when the earliest, widely accepted dated maize shows up in the Southern Mexican Highlands of Oaxaca at the site of Guilá Naquitz (Piperno and Flannery 2001).

A more extensive series of AMS dates must be performed on the cob assemblage to more precisely answer when maize became the subject of cultivation at El Gigante. More dates would determine if any cobs or other *Zea* plant parts are indeed from this earlier and critical period from the third to the fifth millennium B.C. For the time being I conclude that maize arrived in this highland region very late in comparison with the Mexican data cases.

The assemblage represents a Formative period sequence of samples of the maize population cultivated by the farmers of the Estanzuela Valley in the first millennia B.C. and A.D. In addition to addressing issues of directed selection of maize plant attributes, the following descriptive measurements are important in the eventual evaluation of questions such as: Where did the founding maize type originate? Was there an increase in the number of maize varieties or races cultivated during this period at this site? These preliminary measurements will allow the cobs to be compared to others from different sites as well.

Of the 8,727 cobs and cob fragments recovered from the main block of excavations, I measured a sample of all 1,365 cobs and cob fragments from Unit 19. One-hundred and seven whole cobs and 48 individual kernels were pooled from both Units 18 and 19 to provide a larger sample of whole specimens and measurements were made on these as well. Measurements included the length (if a whole cob), the diameter at mid-section, tip, and base, the pith diameter (if cross section was exposed by breakage) and the row number. In addition, several qualitative notes were made for each, including whether burnt, the strength of row pairing and the general shape of the cob (tapered, cylindrical, *etc.*). All measurements taken on the cobs follow Bird's (1994) guidelines in the *Manual for the Measurement of Maize Cobs*. Kernel height and thickness were recorded along with its width at three points (proximal, medial, distal). Lastly, the height from the proximal tip (the pointed, attachment end) to the widest point of the kernel was measured (this measurement is called the "D1" following the methodology of King 1987). These measurements are not intended to be exhaustive; many more measurements could be taken (see Bird 1994, Benz and Long 2000). With this analysis I seek to present a quantitative, descriptive account of the findings at EG in order to stimulate the formulation of further questions. This analysis also serves to test some basic assumptions regarding the assemblage (*e.g.,* do the cobs become larger over time?).

The sample of 107 whole cobs was selected from the two units with the best archaeological control. These were found in ten distinct strata and placed into seven groups based on strata: Ia (n=10), Ib (n=18), Ib2 (n=33), IIa1 (n=28), IIa3/IIa4 (n=7), IIc3 (n=8), and III/IIIc4/IIIf2 (n=3). (refer to Figures 43 - 45 and Tables 15 - 17 that show the average measurements and coefficients of variation (CV) for the length, diameter at mid-section and row number for the cobs). These strata span a period back to 4,850 B.C. The cobs, however, are presumed to represent only the last 2,000 years, as evidenced by the direct dating discussed above. The oldest cobs could be as old as 3,000 years, as suggested by conservative estimates based on stratigraphic association of cobs with strata as deep as Layer IIIc1. This raises the unfortunate possibility of stratigraphic mixing. To avoid the possibility of young cobs being mixed into an older dated stratum, the sample of cobs and kernels for this analysis were drawn from Units 18 and 19. These two units were excavated with three profiles exposed. They were chosen to represent the maize assemblage specifically because provenience for these two units was exceptionally well controlled during excavation. Although it is cannot be assumed that there are no mixed cobs in this sample, the likelihood is low. Despite inadequate numbers of dates, the relative sequence of the cobs is quite secure and mixing "noise" has been minimized to the extent possible.

I applied linear regression models to the entire sample for the attributes of length, diameter at midsection and row number. This was done in the same manner as with the plants examined previously. None of the statistics describing these attributes changed significantly over time (see Fig. 46 - 48).

To further and more rigorously examine the relationship of the cobs, I performed a one-way analysis of variance (ANOVA "F-test") with Tukey's Honestly Significant

Difference (HSD) for post-hoc comparisons. In the case of length, there were no differences between the groups ($p = 0.956$). Diameter and row number did show distinguishable (or nearly so) populations ($p= 0.103$ and $p = 0.016$ respectively). However, the differences were not great enough to be distinguishable through Tukey's HSD at the $\alpha = 0.05$ level.

Three qualitative variables were also tabulated for the whole cob assemblage. The first of these three, cob shape, suggests weakly that this trait was selected for through time. In the earliest samples, with the exception of Layer IIc3, tapered, cylinder and cigar shaped cobs represent roughly one-third each of the total assemblage. This proportion seems to increase through time in the case of the tapered cobs (see Table 18). In the later samples the proportion of tapered cobs rises to between 40 and 70 percent. This might indicate a narrowing of experimentation and the selection and/or specialization toward tapered types.

The second qualitative variable, the strength of row pairing, refers to the patterning of the cupules on the cob, strong pairing allows for efficient packing of the kernels along the cob axis. This is a common trait recorded in the analysis of prehistoric maize remains (Bird 1994). Although this feature was noted for each cob, its tabulation in this case does not reveal any distinct trends: row pairing is absent to weak throughout the sequence.

The proportion of burned cobs was tabulated in qualitative terms as well. No apparent patterns are noted in this third respect. In general, the majority of cobs were not burned and none were completely carbonized. This does mitigate some of the confounding effect that the burning of cobs can have on measuring their morphology

(Goette *et al.* 1994). Cobs shrink when they are burned and a large proportion of burned cobs would have given a false impression of smaller cobs in our analysis. Moreover, as a cultural phenomenon, the relatively low amount of burning in the assemblage might indicate that the cobs were not used as a significant source of fuel.

As a final attempt to distinguish patterns of modification and evolution of the maize from El Gigante, I measured individual kernels that were found detached from the cobs (see Tables 19 - 24). With the possible exceptions of kernel height and "D1" measurements that do get progressively larger, there do not seem to be any trends in the mean for any of the variables. Further statistical analysis, and perhaps a replication of the measurements from a sample of kernels from another unit, could confirm if these trends are real. Many of the exceptional values, for example the Coefficient of Variation for Sub-stratum Ia, are undoubtedly influenced by the small sample size. As with the assemblage of cobs, average trends are masked by intra-stratum variability. This variability must be examined in more detail by maize experts to determine if more than one variety of maize is present or if we are seeing a single variable type.

In addition to the individual measurements, I incorporated five of the variables (height, width at proximal, mid, and distal points, and thickness) into an index that represents the overall size of the kernel in a single statistic (Table 25). The volume was (roughly) calculated to be the product of thickness and height divided by two (a cross-sectional area or, base of the solid), multiplied by the average of the three width measurements from proximal to distal end (the height of the solid). This size statistic for 48 kernels was then analyzed as above. There is a slight negative slope indicating a trend towards larger seeds, however, the difference is not significant by either method of analysis (p = 0.227, linear regression) and (p = 0.475, one-way ANOVA).

Maize is one of the most important crops in the world today, referred to by Walton Galinat in 1995 as "*El Grano de Humanidad*" ("Humanity's Grain"). It is grown by subsistence farmers from Latin America to Africa and East Asia. It is also a major industrial crop and a possible source of future alternative fuel (processed into ethanol) in the U.S. One of maize's strengths as a crop is the enormous number of varieties that are available, each "adapted" to specific regional climate and soil conditions (Sanchez 1994). In general, maize does best at temperatures above 66 degrees Fahrenheit, in well-drained soils and in areas with a frost-free growing period of 90 - 160 days. The maize plant has many uses beyond the edible grain, including being a source of sugar (stem), fiber (leaves), and fuel (cobs) (Iltis 2000; Smalley and Blake 2003).

Following a discussion of maize in several parts: first is an outline of the ancestry of maize and its biological origins, I describe maize's age and appearance in various archaeological cases, finally, I discuss its potential as a staple crop and the significance of its variability with respect to the assemblage recovered from El Gigante.

Ancestry

There are at least two competing perspectives on the biological and geographical origin of maize. Under one perspective, it is proposed that teosinte (*Zea mays* ssp. *parviglumis*) is the direct wild ancestor of domestic varieties of maize (*Zea mays* ssp. *mays*) (Doebley 2004; Iltis 2000; Beadle 1939). This implies that its geographic origin lies in the Lower Balsas river valleys of Guerrero, Mexico, where wild teosinte still grows. This is the most parsimonious explanation for maize's origins (*e.g.,* Smith 1995) and is increasingly supported by genetic studies (Bennetzen *et al.* 2001). Early microfossil (pollen and phytolith) remains of *Zea* have been published for coastal areas of Belize (Pohl *et al.* 1996) and Tabasco, Mex. (Pope *et al.* 2001), and as far South as Ecuador (Pearsall 1995), which suggests that maize was domesticated in a "lowland" context of a relatively rich ecosystem. However, these finds have been seriously questioned (Rovner 1999) and further research has suggested more recent dates for some of the finds in Mexico (Sluyter and Dominguez 2006).

There is no evidence of teosinte hybridization at El Gigante. The only other case where teosinte has been reported is in the Archaic material from the Basin of Mexico (Niederberger 1979) and this was not *Z. mays* ssp. *parviglumis* (the Balsas variety) but classified at the time as *Zea mexicana* a highland Mexican variety of teosinte.

Botanical geneticists are beginning to apply sophisticated methods to the issues relating to maize ancestry. It has now been shown cytologically that the mutation(s) that created today’s maize occurred as a single event. Micro-satellite grouping has confirmed that domestication occurred only once, and has established that it most likely occurred in a population of teosinte now found wild only in the region of the Lower Balsas river (Matsuoka *et al.* 2002). Similar methods have been used to investigate the single locus origin of other domesticates such as einkorn wheat in the Near East (Heun *et al.* 1997). The El Gigante assemblage has great promise for future genetic studies that could help to identify wild progenitors of domesticates, document in more detail the timing and location of domestication events (at the level of specific traits) and dispersals, as well as refine the temporal sequence of domestication (Zeder *et al.* 2006).

Another, less well accepted, perspective is that the emergence of maize was the result of intensive cross-breeding with other species of grass. Tripsacum grasses are the favored ancestral candidates in this hybrid hypothesis (Mangelsdorf and Reevey 1959). In this alternate scenario, it is hypothesized that maize has a highland origin that is not restricted to teosinte's wild range (Eubanks 2001, 2001a; MacNeish and Eubanks 2000). Proponents regard the location of the earliest accepted macrofossil of domesticated corn in the Southern Highlands of Mexico as support for their position.

The Highland/Lowland debate is further clouded by the possibility that maize, though a descendant of Lowland Balsas teosinte, may have been physically removed from its home origin and domesticated elsewhere (Iltis 2000). This kind of "interzonal interaction" and movement of crop plants has been documented in southern Peru (Perry *et al.* 2006). In this case, domesticated arrowroot is shown to have been brought to the Andes from the Amazonian rainforests.

What is more, corn may have been domesticated for uses unrelated to the production of a large cob or kernel, thus undetectable by these metrics. The corn plant is descended from a family of species as dynamic as the palms and agaves. The edible parts that may have been selected for include the sugary pith that the stalk produces and the sweet green (immature) ears that were highly desired (Iltis 2000, Smalley and Blake 2003). We do not know how many traits, or combinations of them, were the original subjects of modification. It is possible that morphological characteristics such as large cobs were secondary to traits such as frost tolerance or speed of maturity as well also invisible in this analysis.

The Timing of Maize Domestication

The timing of domestication as well as the shift toward maize-based agriculture across Mesoamerica is also still under debate. The earliest maize from the Tehuacan caves was dated *by association* by MacNeish to be as early as 5,000 B.C. This estimate contrasts markedly with recent AMS dates taken directly from a sample of 12 of these cobs. The oldest of the twelve cobs dated to 3640 – 3360 BC (cal, one-sigma) (Long, *et al.* 1989; Smith 2001a). However, MacNeish claims that the cobs were contaminated or otherwise affected by laboratory error (MacNeish and Eubanks 2000). Recent AMS dates on two "primitive maize" cobs from Guilá Naquitz support domestication occurring by about 4,300 B.C. (Piperno and Flannery 2001) and are independent of the controversy surrounding the Tehuacan material.

The question of the timing and origin of maize domestication rests on the dating of only a handful of cobs from very few sites. Palynological and opal phytolith data from lower Central and South America (Pearsall 1995), indicate the presence of maize before 3,000 B.C. in lowland contexts quite distant from the geographic origin of maize's domestication. However, not only does some of the evidence rely upon contested methods of opal phytolith identification (Staller and Thompson 2002), but bioturbation could be a factor in many of the cases as well (Sluyter and Domingues 2006).

Therefore, we do not know for how long or, from where the incidental and incipient use of maize began. It is difficult to say how fast maize spread across the continent and more difficult still to determine if these specific agricultural systems were always focused on maize.

Given the re-dating of the Tehuacan maize (the earliest cob dated to 3,560 +/- 60 cal B.C.), Smith (1997) reviewed the collections from the Ocampo sites in Tamaulipas, and dated the squash and maize remains directly as well. This research, in combination with the work by Long *et al.*, has led to a revised chronology for the introduction of crops in Mesoamerica. In the case of maize, the chronology is shortened by about 1,500 years. Does this imply a similar shortening of the "era of incipient cultivation" (*sensu* Mangelsdorf *et al.* 1964) and of the period in which agriculture developed? At the very least, these direct dates on the specimens have put the gradual, linear sequence of the origins of agriculture (as presented by MacNeish) into question. Let us suppose, for example, that maize diffused at a constant rate out from the center of a single locus "lowland" event in the Balsas region of Mexico (Smith 1997; Pohl, et al. 1996; Pope, *et al.* 2001). One might expect a similar date for maize's arrival at El Gigante as at the Ocampo caves in Tamaulipas, Mexico, about 2,455 B.C. since both sites are approximately equidistant from the Balsas region. However, maize appears in the El Gigante botanical assemblage much later, in fact, not until around 300 B.C. This reinforces the generalization that the spread of single cultigens (even those that would eventually become as central to the overall continental subsistence economy as maize) was anything but gradual, linear or uniform.

The Ocampo caves (Romero's and Valenzuela's caves) are located on the northeastern periphery of Mesoamerica; like El Gigante, they are in a relatively arid highland ecozone. Smith's (1997) reanalysis of the material from these sites emphasized one critical factor: it was the *combined* triad of maize, beans, and squash which led to exponential human growth and florescence in Mesoamerica, not the isolated domestication of maize. A single species of domesticate cannot define an agricultural adaptation. Agriculture was not taken up everywhere at the same time, nor did its spread propagate as a uniform wave across the continents with maize riding along as a prime mover.

Early Maize Yield

In Mesoamerica, the use of maize is evident before it becomes a major staple. Along the southwest coast of Mexico, for example, maize has been found in relatively early contexts, but is thought to have had only a minor role in overall subsistence (Blake *et al.* 1992; Clark and Blake 1994). These people, however, had significant coastal and marine resources to augment their diet. This is also the case at sites from coastal Ecuador, where stable isotope evidence has shown a limited role for maize in the diet though its presence can be documented quite early (Tykott and Staller 2002). It is difficult to say what proportion of the El Gigante inhabitant's diet would have been made up of corn. I can however, present some data to show that it had the potential to be a significant addition to the diet, given sufficient available land and labor to cultivate it.

Modern varieties of maize can yield up to 10,000 kg per hectare (an Indiana record, Schroeder 1999), but yields in prehistory were much smaller. The highly productive *chinampas* or, raised field systems, in the Basin of Mexico were capable of producing perhaps 3,000 kg/ha/yr of domesticated corn (Sanders 1976).

One kilogram of shelled maize will provide about 3,600 calories (Schroeder 1999). The first maize at El Gigante had the potential to be a significant staple crop. Early cobs found at El Gigante are between five and six cm in length, and are fully domesticated. Flannery and Ford (1972) estimated that wild teosinte with a single row of grains yielded between 152.5 and 627 kg per hectare. This being the case, I think a conservative estimate for the yield of the early ten to sixteen row corn found at El Gigante could be in the range of 450 - 1200 kg/ha (three times the yield of undomesticated teosinte).

If we assume that a single family could reasonably farm one hectare of corn, this would allow for a potential harvest at El Gigante in the Estanzuela period of 1,620,000 – 4,320,000 calories/ha. Not all of this product could be eaten though. Perhaps as much as half of the harvest would have been allocated to replace seed stock, been lost to pests or rot during storage, and or given away (perhaps in the context of ritual and political tribute). So, the "Total Edible Yield" (Schroeder 1999, Baden and Beekman 2001) at El Gigante could have been on the order of 810,000 to 2,160,000 calories per hectare.

An average family of two adults, each consuming 2,500 calories per day, with three children consuming an additional average of 1,900 calories per day results in a daily requirement of 10,700 calories (*cf.* Schroeder 1999). So, the corn encountered archaeologically at El Gigante, had the potential to have supported a family's caloric needs for 75 - 202 days! Because corn can be stored and the yield spread across the entire year, a one hectare crop of these small early domesticated cobs could provide one-fifth (75/365) of the family's caloric intake per day in a bad year and up to more than half (202/365) of their daily caloric needs in a good year. This is certainly enough of the overall diet for this item to be considered a staple. Unfortunately, we have no way of estimating how much land was under cultivation in the Late Formative and therefore, whether corn indeed made up such a large proportion of the diet.

Racial classification of maize

Secondary to the question of its original domestication, is the issue of how maize developed such enormous varietal diversity and what these patterns of diversity mean. Bruce Benz (1994), who has been investigating this question for decades, asserts that maize phylogeny will provide a basis for the reconstruction of cultural historical relationships. Just as a differentiation in language can mark the splintering of cultural groups, the racial diversification of maize may track exchanges and interactions of specific cultural groups. Benz (1994) states that we do not know whether to expect periods of homogeneity followed by diversification or, if originally heterogeneous populations were replaced by newer populations that were also heterogeneous. Robert Bird (1984) proposed that a *South American* maize variety, accompanied by some of the earliest pottery, appears in Mexico sometime around 1500 BC, and that another "South American-like" maize had arrived in Belize, again with a distinctive and unique pottery, several centuries earlier (Bird 1984:40). Botanical geneticists are beginning to pursue these kinds of questions: posing scenarios of cultural interaction on the basis of maize ancestry (*cf.* Freitas *et al.* 2003).

Another issue is the rate at which this diversification of maize occurred. Benz undertook a study of the Tehuacan maize with the object of documenting the rate and direction of its evolution (Benz and Long 2000). Using a unit called a "Darwin," which refers to the proportional rate of change in the average phenotype, he found that the greatest amount of morphological change occurred in two bursts, one before 2,700 B.C. and a one post-dating AD 150. This result presages the findings (see below) based on genetic work of Jaenicke-Despres *et al.* (2003).

At this point, I rule out the possibility of *in situ* maize domestication in highland Honduras. This is an initial conclusion based on the direct dating of two fully domesticated cobs, recovered in early strata (one from Unit 2, Level 14a: 400 – 350 B.C. and 310 - 210 B.C., and the second from Unit 18, Level 20: 100 B.C. to AD 70). I also base this conclusion on the fact that no teosinte or teosinte-like "transitional" specimens, such as those described and directly dated from Guilá Naquitz (Benz 2001, Piperno and Flannery 2001), were found.

There are two species of teosinte native to highland Honduras, *Zea luxurians* and *Zea nicaraguensis* (Benz, *pers. comm.*). The origin of the founding maize stock in this area is unknown. The maize that we found in the Formative levels could represent a locally-derived variety of independent evolution, perhaps even a hybrid produced in conjunction with one of the native species of teosinte. Alternatively, the initial germplasm might have been imported. Neither of these scenarios is mutually exclusive. Racial classification and the timing of the arrival of certain varieties of maize have great potential in establishing connections between distant geographic areas (Benz 1994). Classifying the El Gigante maize assemblage (which has yet to be done) could establish the extent of El Gigante's connections to other parts of Mesoamerica.

In fact, there is the possibility that further classification of the maize could establish connections to South America. The geographic patterning of races of maize shows several interesting groupings. One of these groups, a highland southern Mexico and Guatemala population, is dominated by varieties of South American origin, predominantly from Colombia and Ecuador (Sanchez Gonzalez 1994). If El Gigante's prehistoric corn can be associated with this group, the "evolution and reintroduction" (*ibid*:156) might account for the delayed introduction of the crop in the highlands of Honduras, whereby, the originally domesticated varieties (Mexican) bypassed these Highland areas on their way to South America, perhaps along a coastal route. On the other hand, the corn may show stronger affinity to one of the other major groups, for example, those of the Pacific coast. This could even substantiate ties to central Mexico proposed by others (*e.g.* Reyes Mazzoni 1976).

Bio-chemical methods show that, as suspected, the domestication of maize involved the selection of traits which were not necessarily morphological. Jaenicke-Depres *et al*. (2003) investigated this possibility in a study of three genes involved in plant architecture, protein synthesis and starch production. These results show that alleles typical of contemporary maize were present in Mexican varieties 4,400 years ago. Interestingly, Jaenicke-Depres *et al.* (2003) go on to show that one of the alleles (*su1-m1*) involved in starch quality was not present until much more recently, perhaps not until 2,000 years ago. This study represents yet another case of agreement between recent AMS dates on prehistoric cobs and the revolutionary genetic work now possible (Smith 2001a).

Simple descriptive statistics hint at interesting patterns, concerning diversity in the assemblage of maize remains. One revealing statistic is the Coefficient of Variation (CV) for some traits (see Table 15-17). Though it may well be due to the limited sample size of the older levels, there is less variation in the earliest two groups. Standard deviations for cob length in Layer IIc3 and Strata III (early Estanzuela period) are around 13-14 mm corresponding to a CV of around 25, however, in later Estanzuela contexts where cobs are more common, the standard deviation of the measurement is 20-23+ mm and the CV's are in the high 30's. This trend is only apparent in the length measurements. Although there is substantial variation in all the assemblage, with cob sizes ranging from 50-60 mm, standard deviations of this magnitude represent up to 30% difference in size between contemporaneous cobs. The CV statistics suggest that on average a narrower range of maize phenotype may have been grown in the early stages of maize production at El Gigante.

The suite of attributes measured allows for the calculation of three characteristics recommended by Sanchez *et al.* (1993) for the racial classification of maize. These are, kernel width, ear diameter/length, and kernel width/length (see Table 26). The average kernel width of the entire El Gigante sample shows a CV of under 3.5, leaving us with little basis for the classification of separate races using this trait. However, the average ratio of both kernel height to width and ear diameter to length, show more significant variation. These traits have CV's at El Gigante of 10.07 and 7.91, respectively but, are still considered relatively low. On the whole, levels of variation within the maize assemblage indicate little if any racial diversity in the population represented by the archaeological collection. This might represent a conservative adaptation to the increasingly fluctuating bioclimatic circumstances of the late Holocene. For example, in times of increasing El Niño drought stress and associated population pressures, it may have been perceived as too risky to experiment with anything other than what worked and what was familiar. Further more rigorous taxonomic identification by botanical specialists is necessary to evaluate this hypothesis.

Maize incorporation

Items incorporated into existing diets at El Gigante seem to appear in an additive rather than substitutive manner. This pattern has been described as "stepped agricultural adoption" (Hastorf 1999). It is increasingly accepted, for example, that there were many local domestications in North America, especially of the starchy seed species that formed crop complexes preceding maize (Hastorf 1999:69).

The adoption of maize at El Gigante might be likened to the process as it played out in the American Southwest, where maize was apparently accepted in a stepped manner, that is, in multiple episodes of increasing acceptance and reliance beginning with small "experimental" trials and developing bit by bit into a major mono crop. In the Southwest, maize was incorporated into existing hunting and gathering economies, not as a staple, but to augment natural resource occurrence (Wills 1995; Minnis 1992; Adams 1994). Wills (1995) argues for a sort of "ecological fine-tuning" that created the observed lag in the adoption of agriculture. Wills refers to increased seasonal contrasts during an altithermal period when overall precipitation increased to create occasional abundances. This situation was highly variable between 5550 - 3050 B.C. (Wills 1995). This climatic setting precluded maize from spreading to the North as the boom and bust cycles of the Mogollon Highlands and Colorado plateau were too risky for the efficient adoption of the crop. It was only later, he proposes, that increasing competition over upland hunting territory reached such a high level that residents were faced with accepting this risk in order to intensify production. In this case, plant husbandry became necessary only as a result of increasing competition with people of the Lower Sonoran desert who were successfully relying on maize as a staple during periods of climatic amelioration between 1000 and 2000 B.C. This scenario illustrates how changing circumstances can determine acceptable subsistence practices and the extent to which domesticates are used to adapt to them.

Barlow (2002) reaches similar conclusions to explain why the Fremont people adopted corn, or not, on the basis of the energetic costs and benefits of maize farming. While she finds maize farming economically comparable to local hunting and gathering, return ratios from very intensive farming are more on par with low-ranked seed collection. Barlow concludes therefore, that increased agricultural investments can be expected whenever there are decreased opportunities for higher ranked food items, and conversely that decreases in farming might only be expected when alternative economic opportunities are presented.

In fact, maize enters the archaeological record at El Gigante at about the same time it does at the extreme peripheries of South America. Stable isotopic studies of human bone collagen from southern Argentina and Patagonia show that in this case, the crop was probably used first around 2000 years ago for ceremonial or other non-staple use (Gil 2003). Similar methods have shown that maize, although present two thousand years earlier, was also not an economically important crop during its initial use in coastal Ecuador (Staller and Thompson 2002).

Maize Summary

Currently, the El Gigante maize assemblage should be viewed as a single population, representing one race, a flour type (Newsom pers. comm.). From its first appearance in the early Formative, maize morphology changes measurably but, not significantly. Conclusions at this stage are summarized as follows:

1) The current research indicates that *Zea mays* ssp. *mays* was not domesticated in the highlands of Honduras. Note that wild species of teosinte were not found archaeologically, though *Z. luxurians*, and *Z. nicaraguensis* are native to the area. Also, there is a large temporal gap just preceding the reported occurrence of the first maize specimens. It is possible that other sites will be excavated in the future that will contain these two pieces of critical evidence for the region.

2) Maize appears late in comparison to other (*known*) areas of Mesoamerica (see note above).

3) Maize phenotypic diversity was maintained throughout the Formative, whether developed at El Gigante or stimulated from outside. However, the relative level of variation is not inconsistent with the presence of only a single variety (Newsom *pers. comm.*)

4) Maize (upon its immediate arrival at El Gigante) had the potential to be a valuable staple.

The people of El Gigante seem to have collected a diversity of naturally occurring tree fruits, and maguey, hunting smaller game and remaining seasonally mobile with little labor cost. There might have been no reason to adopt a novel and therefore more risky strategy of maize field cropping (Nichols 1987), especially considering the poor slope and soil conditions of the region, when an unspecialized, mixed subsistence strategy was functioning efficiently.

Domesticated beans

I preliminarily identified specimens of the common bean (*Phaseolus* sp., cf. *P. vulgaris*, Fabaceae) as appearing first in Sub-stratum IId (Photo 68). A total of 103 common beans was recovered from the excavations and were measured. All are from Formative (Early and Late Estanzuela phase) contexts. The types encountered at EG were either a dark rusty red or black in color. The two colors may indicate separate sub-species or varieties of beans, but they were not separated from one another in this analysis.

The beans were recovered from eight distinct strata, spanning the Estanzuela phase of occupation at El Gigante (Sub-strata Ia - IId). The length, width and thickness (perpendicular to the width) were measured for all beans. The measurement of the overall size of a bean was indexed using the product of all three measured parameters in millimeters. In addition, the hilum (the attachment scar, where the bean was attached to the pod) length was measured. I assumed that plants yielding larger beans and those which held their beans in the pod for longer (*i.e.,* larger hilum attachments) would be the preferred varieties and those that foragers would have selected, stored and sown, or lost near their camps.

Stratum (age) was not a good predictor of overall bean size (see Fig. 49): the significance value (P) for the model was only 0.553, with a R-square of 0.004. Independent of the decision to regard these beans as wild or domesticated, it seems that they underwent little, if any, selection for greater size through time. This is the same conclusion reached with respect to the Tehuacan material where there was no archaeological evidence for selection (Kaplan 1967). Domesticated *Phaseolus vulgaris* (a variety Kaplan refers to as “Type I”) appeared at Tehuacan in the Palo Blanco phase, between 1,100 and 1,800 years ago (note: this estimate was made in 1967, before AMS dating, see below). Beans are a similar size at the Tamaulipas caves where they are found in the contemporary Palmillas phase. Both these appearances are also contemporary with the El Gigante dates. The Tehuacan beans, however, have an average size index of 554 mm^3 (Kaplan 1967:209). El Gigante's average is only 245.46 mm^3 (standard deviation = 76.54 mm^3, CV = 31.18, n = 99, combined Strata I(a,b,c), and II(a,c,d)). At Guilá Naquitz, Kaplan (1986) reports finding pre-ceramic wild *Phaseolus* but no domesticated forms of *Phaseolus*. These wild type beans are very small: the pre-ceramic and post-Classic sample combined have an average size index of only 60.37 mm^3 (Kaplan 1986:283). Once again we see the El Gigante material fall between the two extremes of a wild type and domesticated type.

The scar of attachment of the funicle of the bean to the pod, called the hilum, would seem an appropriate trait to look for the operation of selective sorting. The strengthening of the funicle (and thus enlargement of the hilum scar) would make the bean pod a more convenient “package” for human collection. This strengthening would inhibit the natural dispersal of the seed from the pod and lend the beans to easier, or at least less time sensitive, collection. However, the funicle structure of the bean is a complex trait, and such a simple inference might be unwarranted. The regression results evaluating trends in the changing size of the hilum were not significant and are not presented here.

Neither of the phenotypic traits I measured differed statistically over time. If their identification as domesticated species is correct, there are two conclusions to be drawn.

One: beans were brought to El Gigante from an exogenous origin and were not selected *in situ* at El Gigante from native wild ancestors. Perhaps from as far as Peru, in fact (see below). Or, alternatively, traits subjected to human selection were not apparent in the morphology; for example, people could have selected for frost-tolerance, ripening rate, or seed density. The evolution of these traits may well have been affected at El Gigante after its initial arrival, but they would not appear in this analysis. In general, the El Gigante beans are small (see above), which may be due to the desiccating nature of the rock shelter environment. It is possible, as mentioned already, that these beans were not yet domesticated. I few assume that they are, the addition of the domesticated common bean would complete the "triad" of foods that are so commonly referred to as the basis of Mesoamerican agricultural production. The beans from El Gigante need to be directly dated. The current stratigraphic evidence suggests that while maize might have arrived "late" at this site, beans and the coincidence of these two items with squash could have occured relatively "early" in comparison with other sites (see below).

More recent and direct AMS dates on bean specimens from key sites show their occurrence at Tehuacan no earlier than 2,500 B.P., 1,300 B.P. in Tamaulipas and 2,100 B.P. in Oaxaca (Kaplan and Lynch 1999). In contrast, beans are thought to occur as early as 4,400 B.P. in the Peruvian Andes (*ibid.*). No direct dates on the El Gigante beans have been obtained. However, by association with charcoal from Sub-stratum IId, the beans could be as old as 3,500 BP. This date, if confirmed by a series of AMS dates, would create a geographic and chronologic gradient in agreement with respect to the other archaeological assemblages from South to North America. Such a pattern would be in marked contrast to that of maize and interesting in light of the potential for a "triad" production system that eventually became so successful across the entire continent.

El Gigante bean sizes are intermediate between the wild Guilá Naquitz type and the domesticated Type I variety found at Tehuacan. Until a wild ancestor can be identified, the issue of domestication will remain difficult to resolve. Kaplan and Lynch (1999) suggest that more DNA work be done before concluding only a single domestication in South America. Domesticated beans are late arrivals in the North American Eastern Woodlands, where they are not in evidence until the 13th Century AD (Hart *et al.* 2002). Of the 55 wild species of the *Phaseolus* genus in Mesoamerica, only five species were domesticated, and only four were widely cultivated (Kaplan and Kaplan 1992). These were *Phaseolus vulgaris* (common bean), *P. lunatus* (sieva bean), *P. acutifolius* (tepary bean), *P. coccineus* (runner bean) and *P. polyanthus* (not found archaeologically) (Debouke 1994).

Other Estanzuela Phase Remains

Cacao, tenuously identified by the author, may be a rare component of the assemblage. The large "chocolate bean" (*Theobroma cacao*, Sterculiaceae) appears in the archaeological sequence in Sub-stratum IId (Photo 69). At El Gigante, cacao beans tended to be found in caches or clusters, together in a single level rather than evenly distributed through the late Estanzuela period strata. This might suggest a special use for the beans, perhaps even of a ritual nature.

The occurrence of cacao seeds in the assemblage is notable because the cacao tree could not have grown at El Gigante's elevation. They are incapable of enduring prolonged dry-seasons such as that of the Estanzuela Valley. Cacao, South American in origin (Schultes 1984), usually grows below approximately 300 meters, although it has been cultivated in Venezuela at up to approximately 1,200 meters (Schultes 1984).

It is widely known that cacao was a particularly valuable commodity in Mesoamerican civilization, especially among the Maya (Gomez-Pompa *et al.* 1990; Powis *et al.* 2002). Indeed, its very name implies such: *Theobroma* is from the Greek for "food of the gods." Its presence at El Gigante indicates some level of contact and interaction with the wider culture sphere of the region. South American indigenous people utilize the pulp surrounding the seed but do not use the seed itself. The processing required to produce chocolate is apparently of Mesoamerican origin, this innovation presumably happened after the tree had been spread north from South America for the consumption of the fruit.

Also a valued commodity, cotton (*Gossypium* spp., Malvaceae) was possibly recovered in Sub-stratum IIa in the form of the fibrous flower. No seeds were identified. This fiber is a single rare item in the assemblage and because it was identified by the author there is the possibility that it is actually another soft, fine, white fiber such as kapok (*Ceiba pentandra*), which is native to Central America.

Other unidentified specimens in the Estanzuela phase include an arboreal legume (Fabaceae, Photo 70). Several other classes of plant food items are notable in this upper zone of the deposits dating to the first one or two millennia BC. An unidentified rind of Type 7 is found in Sub-stratum IIa (Photo 71). Small Seed Type 1 is also noted here for the first time (Photo 72) and Small Seed Type 4 is found in Sub-stratum Ic (Photo 73). Several medium sized seeds are also novel, including Medium Seed Type 7 in Sub-stratum IIc (Photo 74), Medium Seed Type 11 in Sub-stratum IIc (Photo 75), Medium Seed Type 9 in Sub-stratum Ic (Photo 76) and Medium Seed Type 17 in Sub-stratum Ic (Photo 77). Lastly, a large seed of Type 10 was recovered from Sub-stratum IId (Photo 78).

Several seeds identified by L. Newsom as *Manihot* sp. or *Jatropha* sp. (Euphorbiaceae) in the assemblage are worth mentioning (Photo 80). It would be very unusual to see cassava, a South American domesticate, so far north any earlier than the Formative period. Unfortunately, all of the specimens of this species were recovered in the West Block of excavations and are without provenience as all of Units 5, 8, 10, and 14 were severely disturbed by looting.

Microbotanical Methods and Results

Pollen Extraction Attempts

Plant microfossil studies are often employed to help understand ecological and plant-use data from archaeological sites. These analyses have the potential of identifying the presence of maize at the landscape level. The incipient phase of maize cultivation, before its domestication, has never been documented by other means. The palynological and phytolithological studies are important independent tests and can be crucial in cases in which maize macrofossils are missing. Pollen recovered from the site of Guilá Naquitz, for example, was helpful in determining the presence of maize-related grasses, and for reconstructing prehistoric ecological communities. The fossil pollen from Guilá Naquitz showed that plants available to those Archaic foragers were similar to those present in todays landscape (Schoenwetter 1974, Schoenwetter and Smith 1986, Smith

1978).

Experts cannot indisputably distinguish separate species of *Zea* pollen or phytoliths. Individual grains of pollen or silica structures from plant bodies are very easily mixed in archaeological deposits. These methods have introduced valuable data, mainly from regions as far removed from maize's original Mexican hearth as Central and South America (see below), that confront orthodox models. However, the ultimate proof regarding the timing of maize domestication will come from further direct AMS dating of cobs at sites across many regions.

Disagreements over the timing of domesticated maize’s arrival stem in part from the inability to distinguish *Zea mays* var. *mays* (domesticated maize) remains from *Zea mays* var. *parviglumis* (Balsas teosinte) or any other teosinte (*Zea* spp.), in archaeological sites from which pollen or phytoliths but neither cobs nor kernels have been found (Staller and Thompson 2002, Fritz 1994, Russ and Rovner 1989, Rovner 1999). The oldest maize pollen and phytoliths recovered from sites in Central and South America are from early periods of highly mixed resource production. The microfossil remains may represent non-domesticated varieties of *Zea mays'* ancestor, incorporated into and experimented with, in these flexible subsistence regimes.

Wild and domesticated maize share very similar phytolith morphology. Nevertheless, distinctions between the wild and domesticated species are made on the basis of phytolith morphology. The classification rests on probabilistic statistical methods (Piperno 1984). Piperno and Pearsall (1998) used phytolith evidence from archaeological soils at the Ecuadorian site of Valdivia to argue that maize was in use at this site as early as 8,000 to 7,000 BP. This is remarkable because there is no evidence yet of maize that old in its proposed hearth of domestication in Mexico. Some researchers are uncomfortable with the assumptions underlying phytolithological methods and how they are applied to maize (Fritz 1994; Smith 1995:158; Rovner 1999; Rus and Rovner 1989). Staller and Thompson (2002) and Staller (2003) contest Piperno and Pearsall's conclusion. They use multiple lines of evidence, including unquestionable food residue analysis, and bone isotope data to conclude that a more reasonable arrival date in South America is around 2,000 B.C. Furthermore, they refute Piperno and Pearsall's (1998) notion that maize was a major staple crop at the time of its arrival, and argue that it was used for ceremonial practices.

As outlined above, the location and timing of maize origins are still hotly debated (MacNeish and Eubanks 2000). Most recent support for an early lowland presence of domesticated *Zea* has been based on the identification of single pollen, phytolith or starch grains at archaeological sites which are often on the coast near wetlands (Pope, *et al.* 2001, Piperno *et al.* 2000, Pearsall 1995, Jones 1994, Pohl *et al.* 1996). For example, in Cob Swamp, Belize, a single pollen grain was argued to represent early maize agriculture dating to 3,360 cal B.C. (Pohl *et al* 1996). Similarly, Pope *et al.* (2001) report on single pollen grains appearing about 5,000 B.C. on the Gulf Coast of Tabasco. To date, no similarly intensive searches for fossil pollen have been undertaken in Highland areas of Mesoamerica. In addition to the questionable link between plant microfossil morphology and domesticated forms of *Zea* (Fritz 1994; Smith 1995:158; Rovner 1999; Rus and Rovner 1989), there are questions of provenience. This problem may be solved in the future if a means of dating single grains of pollen becomes routine.

Perry *et al.* (2007) have recently been successful at identifying starch fossils belonging to domesticated chili peppers. These starch residues have been found in association with preceramic maize assemblages suggesting the spread of a plant food complex through the Neotropics beginning as long as 6,000 years ago and reaching as far south as Ecuador. It is important to couch these findings with some caution, as the method is not yet indisputably accepted. There may be problems with some identifications of starch grains made without the appropriate range of background flora for comparison (Newsom and Traverse pers. comm.)

I was unable to extract fossil pollen from any of the small samples from El Gigante. This attempt was made in conjunction with Professor Andrew Sluyter (then in the Department of Geography at the Pennsylvania State University, now at the Dept. of Geography and Anthropology at Louisiana State University). Four samples were processed, representing Sub-strata IIIa, IIIc, Stratum IV, and V. The methodology conformed to standard practice for palynological studies (Traverse 2007).

Samples of archaeological sediments from the site were limited (see Chapter 3, and Appendix C for an inventory of all the sediment samples collected). In the future, more promising results may be achieved when larger volumes of sediment are collected and screened. These should include samples from the accumulated bat guano deposits at various depths which have higher potential for positive results. The four samples that I processed weighed (dry) 9.55 gm (sample P8, sub-stratum IIIe), 6.4 gm (sample P9, sub-stratum IIIf2), 3.82 gm (sample P10, substratum IVb), and 4.34 gm (sample P11, sub-stratum Va). These consisted of only about one half to three-quarters of a standard 35mm film canister worth of sediment and is considered far too small a volume in general, and the negative results are held with some suspicion.

After failing to encounter pollen in my trials, I accepted an offer by Dr. John Jones (then at Texas A&M) to process samples himself. These were similar quantities of sediment (5-10 gms) taken from the same provienience as before, including 14 samples (P1-14) ranging from Sub-stratum Ie to stratum IX (see Table 3b). After screening two initial samples from Strata IVb (P10) and IX (P14) using methods similar to those described above, Dr. Jones' lab confirmed my negative results.

Small Seed Component, Methods and Results

All of the macrobotanical remains described above were recovered by dry-sieving sediments through a hardware cloth screen with 1/8 in. mesh. Many edible plants have seeds considerably smaller than this and, therefore, are not represented in the summary above. To try and correct for this, three 100% bulk sediment samples (Appendix C, B1, B2, and B3) were processed by Dr. Lee Newsom. These samples were sieved in the lab down to a 0.42 mm fraction.

A light microscope was used to sort the three samples, one from each archaeological phase. Two of the samples were removed from features (F#3 and F#9) and the third was taken from an unusually organically dense zone of Sub-stratum IVb. Feature #9 (Layer IId2) directly overlies Stratum III which is dated by associated charcoal to 2,300 years ago, or during the mid- to late Formative. Material from Feature #3 (Layer IIId3.3) was dated to the Marcala phase at around 6,600 years ago. The final sample is from a lens of material that dates stratigraphically to the very early Archaic or Paleoindian occupation of the rock shelter (Sub-stratum IVb).

The results of the preliminary sorting and identification are presented in Tables

27, 28 and 29. The analysis indicates that panicoid grasses such as *Setaria* sp. and *Panicum* sp. are present in all the samples. In addition, both features from the Formative and Archaic, and the bulk soil taken from the earliest of occupation contexts, contain further evidence of either the presence of more grasses (Poaceae) or sedges (Cyperaceae, cf. *Scleria* sp.).

The Paleoindian material contained the possible remains of peppers (*Capsicum* sp.), evidence for Chenopodiaceae (goosefoot) and cf. *Galium* sp. (bedstraw) as well as *Psidium* sp. (guava). The Archaic material contains the largest number of identified species of the small seed component. It includes the potentially important food grasses, S*etaria* sp. and/or *Panicum* sp. (*e.g.* Farnsworth *et al.* 1985), as well as possible sedges and goosefoot (as in the previous phase but with some interesting additions). Specimens possibly representing the cactus family (Cactaceae), the mustard family (Brassicaceae) and the mint family (Lamiaceae) were identified from Feature #3. Also, there is an additional grass seed present not found in the Paleoindian assemblage. It has been preliminarily identified as *Poa* sp. a member of the festucoid sub-family of Poaceae. This grass is also found in the Formative feature (#9) along with the others already mentioned (including possible *Setaria* sp. and/or *Panicum* sp. grasses). The small seed assemblage from the Formative is unremarkable, other than the addition of possible sedges and more specimens from what is possibly the mustard family.

Dr. Newsom noted that the cactus seeds found in the Marcala phase were highly worn and could have been brought into the cave by bat or bird frugivory. All samples contained many unidentified seed/fruit fragments, some of which are described more specifically in Tables 8-10. These samples also included the unidentified remains of many insects. The adult of the white grub (family Scarabaidae), a known root pest of the Poaceae (including maize), was noted during the excavations as being especially common in the dry 1/8" screen.

It is possible that some of the grass seed remains found throughout all the archaeological phases derive from the grass matting that was so prominent in the excavation. More bulk sampling and fine seiving of excavated features will clarify the exact role these grasses may have played. However, grasses such as these are thought to have been very important to pre-maize subsistence (Callen 1965, 1967b, 1973). A use and/or dependence on wild grains like these grasses would perhaps have predisposed people to the acceptance and spread of maize (*ibid.*), therefore their presence at El Gigante is notable.

In central Mexico, pre-maize cereal crops may have formed templates upon which maize was integrated into cultural practice (*ibid.*). Farnsworth *et al.* (1985) explore this possibility based on analyses of carbon and nitrogen isotope ratios from bone collagen taken from individuals found in the archaeological sites and caves of the Tehuacan Valley. These indicators correlate with the macrofossil record, especially from coprolites, that are interpreted to include *Setaria* sp. as a significant component of the diet (Callen 1965, 1967b, 1973). Together, these stable isotopes show a shift from a mixed hunting and gathering diet, dominated by C3 plants such as legumes and/or the animals that ate C3 plants, to a diet dominated by C4 or CAM plants. Wild grasses, including S*etaria* sp., *Panicum* sp., as well as *Zea* sp., and domesticated maize are C4 plants. CAM plants, including maguey and cacti, for example, are deemed "starvation foods" by the authors and generally discounted (Farnsworth *et al.* 1985:112). The authors conclude that by 4,500 B.C., the Tehuacanos diet consisted of 90% C4 or CAM plants. They go on to say that it is "unlikely that CAM plants could have sustained the population for any length of time," and assume that C4 plants (grasses) filled that role (Farnsworth *et al.* 1985:114). Farnsworth *et al.* (1985) do not convince me of this assertion, especially in early or middle Archaic contexts where population density would have been very low. Given the consistent and long-term presence of maguey remains at El Gigante, I think that CAM plants should not be discounted so easily, especially under conditions of low population density subsisting off an extensive land base. This remains a question for further research which could be addressed with additional sampling targeted at the small seed component of the site.

Plant Assemblage Diversity

This section explores an aspect of the archaeobotanical assemblage that has been a central facet of many models of the rise of subsistence evolution. Binford (1968) states that over the long term, subsistence evolved from a specialized to a generalized (and more diverse) mode; this fostered the initial use of plants which became the central staples of agricultural economies. Rindos (1994), in his model concerning the coevolution of humans and plants that culminated in agro-ecological systems, proposes that after the expansion of diet came a contraction (a loss of diversity) due to the dominance of agricultural strategies. Some, however, have suggested that the trends in evolution toward complexity and diversity may be just chance (Blumler 1996).

Following is an assessment of the dietary diversity of the archaeological assemblage at El Gigante. Such assessments have been made tacitly concerning archaeological assemblages throughout the history of the discipline (Jones and Leonard 1989). Recently there has been much greater effort, through the borrowing of concepts from the field of community ecology, to rigorously quantify amounts of diversity in archaeological collections (Pearsall 2000:211). These types of analyses have often been carried out using faunal material (Cruz-Uribe 1988; Byrd 1997).

First, it is important to distinguish clearly between what I call botanical assemblage diversity, actual dietary diversity, and what has been called diet breadth. Diet breadth is best defined in an ethnographic context. The list of resources referred to when talking about diet breadth is not only exhaustive, but because they can be quantified down to the last calorie, each item can be ranked by its overall net return. The botanical assemblage diversity indices are independent of the mechanics of optimal foraging theory, but they can be used to infer diets composed of a greater range of items. I have not made an attempt to separate or weight those items that might have multiple functions other than food. For example, some *maguey* remains may be the result of waste during cordage production, or some of the unidentified species may in fact have been used as medicine, not food. This distinguishes the raw botanical assemblage diversity measure used here from an actual dietary diversity estimate. I also do not attempt to estimate the proportions of different foods contributing to the diet (as was done by MacNeish for the Tehuacan Valley project (Byers 1967)). I do suggest that high botanical assemblage diversity reveals a broad diet and can be used as a rough proxy for actual diet breadth. This proxy is simply a measure of the number of different resources that are exploited at any one time; it is sometimes referred to as niche width (Jochim 1981).

Another difference between diet breadth and botanical assemblage diversity is that the measurement of diversity has relevance only for intra-site comparison, and can not usually be used for direct comparison to other sites (Pearsall 2000:212). On the other hand, diet breadth would be useful for inter-site comparisons where similar known species were exploited. Unfortunately, unlike ethnographers and animal behaviorists, archaeologists cannot directly measure diet breadth. Such a measure would have to quantify the exploited range of foods from the total possible options that were available prehistorically.

The diet breadth model borrowed from optimal foraging theory provides a predictive framework for the incorporation of novel foods into the diet that has been utilized by archaeologists (*e.g.,* Winterhalder and Goland 1997). Measurements of diet breadth involve bracketing a set of ranked resources that are calculated to include all of those resources that can be exploited without reducing the marginal return of the entire enterprise. No rankings are made here with respect to the species composing the diversity measures. Diet breadth and diversity are presumably highly correlated, but this is very difficult to substantiate because foragers may not map precisely onto the environment in which they live, or they may derive resources from foreign environments. In this sense, optimality models operate on somewhat artificial and etic assumptions. Their only requirement is that the "mapping on" be not so sub-optimal that it threatens reproductive success. Also artificial is assumption of models such as these that the "predator" or "individual forager" acts alone and with complete information. Collective decisions often override individual ones and what is "optimal" for humans is quickly conditioned by cultural values.

Seventy-eight different categories of plants were identified and cataloged for this analysis. The incomplete identification (not all items are recognized even to the genus level) of the assemblage means there may be more or fewer taxa present than the number of categories defined for this analysis. Many groups remain unidentified and are labeled as “morphotypes” (*e.g.,* large seed type #x, or rind type #y). I think the result has been a more conservative estimate of diversity. However, it is possible that further examination of these groups by an archaeobotanist with a suitable reference collection would result in a decrease in the number of species represented across all stratigraphically defined groups. I assume at this time that the collapse or expansion of categories would be equivalent across strata. (I have chosen to exclude all animal remains under ideal circumstances this would be included in the indices of assemblage diversity) from the analysis because, at present, their identification is at a far more general and tenuous level than that of the plant remains. This exclusion does less violence to my analysis than a similar one would occasion in, say, a Near Eastern site where animals were a much more important dimension of the diet).

Two factors confound the measurement of diversity. First, the abundance of a species in nature often varies proportionate to its function within the community (Ricklef and Miller 2000:547), just as the abundance of a food item found archaeologically will be affected by its function in the diet (or other activity). Give examples of this problem Second, richness values, defined as a count of the number of species in a sample, give undue weight to very rare species. In raw species richness values, rare and commonly occurring forms contribute equally to the index.

Ecologists have devised measures of diversity that weigh each species by its relative abundance or, evenness, in the sample. In my analysis, two of these indices of diversity were used in addition to species richness because they are widespread in the ecological literature (Magurran 1988). These are Simpson's index of species diversity (Simpson 1949) and the Shannon-Weaver index (Shannon and Weaver 1949). The formula for Simpson's index is:

$$D = 1/\Sigma p_i^2$$

Where, p_i is the proportion of the species (i) in the total sample. The closer Simpson's index is to the value for richness, the more even the distribution of species in the sample. The formula for the Shannon-Weaver index is:

$$H = -\Sigma p_i \log_e p_i$$

Where, again, p_i indicates the proportion of the species (i) in the total sample.

A summary of the ranges of values for each stratum can be seen in Fig. 41, 42, and 43. In these box plots, the solid line in the center of each bar represents the median, the solid box the inter-quartile range and the whiskers represent the entire range of the distribution.

The results show that there is a gradual trend towards increasing diversity measured by the richness variable (Fig. 50). OLS linear regression was used to test the hypothesis that there was a positive trend in the richness of botanical remains found. Because both Simpson’s and Shannon-Weaver indices are proportional type data they violate the parametric statistical assumptions of regression analysis and a statistical test of these data could not be performed. The changes in species richness ($p \leq 0.001$) indicate that there is a strong general trend through time toward a more species-rich assemblage. Obviously, much of this trend is due to preservation bias. For this reason the weighted measures of diversity, accounting for relative abundance, are more indicative of actual patterns. When evenness is accounted for (Fig. 51 and 52) the trend toward increased diversity is much less obvious, if at all apparent.

A regression line fit to the richness variable shows a significant slope. While this slope indicates significant differences between the groups (in this case between the average richness values of individual strata), it does not tell us which or how many of these groups are different from one another. To access the pattern in more statistical detail, between and within group differences were evaluated in a one-way ANOVA of the richness variable (again such statistical techniques are invalid for the weighted diversity measures). A post-hoc comparison using Tukey's test of Honestly Significant Difference (HSD) identified six homogeneous sub-sets within the data set. This data set was composed of 17 discrete strata spanning close to 10,000 years (see Table 30). The overlap between groups is large, that is, each stratum is a member of as many as three groups. I had hoped to see less overlap, and thus to have been able to infer distinct diversification events based on the membership of the groups. Instead of revealing moments of punctuated equilibria, the groupings reinforce a pattern of the gradual accumulation of richness.

There are several major confounding factors in this analysis. First, is the effect of preservation bias. No attempt was made to weight samples to correct for this with regards to richness. However, the effects may be partially mitigated by the use of the other diversity indices which consider evenness in their calculation. Given the decreasing odds of preservation with age, the older the group in question, the more likely it is that diversity is *underestimated*. This could account for some of the trends outlined above. In addition, our sampling bias must be made clear. Many seeds smaller than the

1/8" sieve screen (such as those of grasses) were certainly lost in the field. This also would tend to underestimate the actual diversity present in the assemblage. However, this is mitigated by the fact that the loss of small botanical remains was constant throughout sampling.

Lastly, and more significantly, is the problem with sample size. This serious issue has been raised by several researchers with regard to the measurement of diversity (Dunnell 1989; Meltzer *et al.* 1992; Cowgill 1989). They all caution strongly that diversity statistics are highly subject to sample size effects. For example, there is a high degree of correlation between larger samples and greater diversity. Similarly, there is a low probability that small samples will achieve diversity values representative of the larger "real" population. This undoubtedly affects the earliest levels at El Gigante and, again, is likely to cause an underestimation of the actual diversity. This also accounts for the results of Tukey's test of HSD, where Sub-stratum Ic (n = 9) was placed in the same group with the youngest Sub-stratum (Ia, Table 9, group 4) as well as with one of the oldest (VII, Table 9, group 2). Kintigh (1989) has suggested methods for overcoming this problem using probabilistic simulations, but such calculations are beyond the scope of this dissertation. Given the inherent problems with using diversity indices on archaeological remains, they are still good first approximations. Despite the statistical hurdles, it is my opinion that they provide a more useful reflection of the El Gigante botanical assemblage than could qualitative measures alone.

Seasonality

Humans perceive and react to risk at different scales of variation in time and space (Smith 1988, Winterhalder 1986, Winterhalder and Smith 2000, Halstead and O'Shea 1989). This "perception influences and limits our understanding of nature" (Riklefs 2000:13). In the tropics, temperature is not the major factor influencing annual changes in vegetation or availability of game; rather, it is the wet/dry cycle of rainfall through the year that has the biggest impact. El Gigante lies just to the Pacific side of the *cordillera* (Continental Divide) of Central America which is very dry in the winter. Prevailing winds are from the Caribbean side so there is a rain shadow cast by the isthmus. In addition to the somewhat predictable annual variation of the wet and dry seasons, there are irregular fluctuations that are superimposed on these periodic cycles. El Niño/Southern Oscillation (ENSO) events can delay or hasten the onset and alter the intensity of the rainy season which has significant implications for food production.

Seasonality has been shown over and over to influence the organization of the economy and specifically the level of mobility. For example, the Great Basin Shoshone live in an area characterized by the vertical arrangement of microhabitats which are exploited in turn throughout the year. Julian Steward (1934) recognized that "the annual movement of populations responded to the seasonal cycle of resource availability" (in Johnson and Earle 2000). Similarly, the !Kung are said to recognize five seasons with distinct rainfall and temperature regimes, and these condition their movement in the Kalahari. Food availability doesn’t become more unpredictable, but the !Kung have to go further and further to obtain it, especially at the end of the dry season (September/October) when daily treks of 10-15 miles in search of *mongongo* nuts are not uncommon (Lee 1968).

Our goal is to see how behavior reflected in the artifactual and botanical and faunal material at El Gigante fits within existing models of forager subsistence. These include variations and generalizations of Binford's (1980) original formulation of "foraging and collecting." Lieberman (1993) uses the term "radial mobility" to describe the logistic planning and mobility pattern typical of the collector and describes the alternative, forager type, of behavior as “circulating.” Lieberman goes on to explain the inherent tendency of radiating mobility to deplete resources. He contrasts the response of archaic humans (60 -80,000 years ago) in Europe to this problem with the 12,000 year old Natufian response in the Southern Levant. While archaic humans seem to have increased their hunting efforts, the Natufians, Lieberman argues, put their efforts into the harvesting of annual cereals.

Was El Gigante a way-point on an annual circulating pattern of mobility, or was it perhaps a centripetal location, a semi-permanent wet-season hub? In part the answer to this question could be “both” depending on the scale at which we approach the problem.

El Gigante's environment would support a period of abundance in the wet season; unfortunately, if all the occupants abandoned the site, we don't know where they went. It is likely that encampments beginning in July were part of an annual circulating pattern cycling between the lowlands toward the Pacific. However, as the season drew on and occupants depleted local and easily available resources, they would have to begin to look further from their camp. In November, before the annual depletion of resource in the dry season, we would expect to see a pattern much more logistically planned and radial in structure. As more and more domesticates were added to the diet through the sequence, this structure and residence pattern would become increasingly radial until eventually there was a permanent presence in the valley.

There are two trends that I think have affected the food production strategies at El Gigante. These are an increasing seasonality (drier dry seasons and wetter wet seasons) at the end of the Pleistocene, and increasing incidence of ENSO events in the late Holocene. These changes may or may not have been perceived by the foragers at El Gigante, but they certainly would have had an impact on them.

Piperno and Pearsall argue that increased seasonality in the lowland tropics played a key role in influencing the rise of agriculture. The advent of a novel climatic regime after the Pleistocene, one of marked seasonality, gave an advantage to annual plant species over perennials. Many annual species are useful to humans as gathered seeds and grain. Piperno and Pearsall present this as a sort of coevolutionary preadaptation in which the eventual harvest, storing and sowing of these plants leads to their domestication. With the addition of human-induced fire regimes, they argue that the tropical deciduous forest is the most parsimonious place to look for the beginnings of this type of cultivation. Unfortunately, the tropical deciduous forest is almost non-existent today as a result of historic alteration.

Seasonality is a key component in Flannery's (1986) modeling of food production in Archaic Oaxaca. The wild foods which were recovered archaeologically, and thus inferred to be available at the time of the occupation of the Mitla caves, suggest that Guilá Naquitz's residents arrived in August or September when hackberries and mesquite were at their peak availability. Flannery hypothesizes that they resided at the cave until December or January, or through the piñon and acorn harvest. This implies residential stability for at least one-third and up to half of the year. Flannery cautions against regarding these estimates too rigidly. Although inhabitants were scheduling their movement with respect to this predictable seasonal fluctuation, the annual variation is decidedly unpredictable. In a wet year, for example, acorn mast might be twice that of a dry year. For this reason, foragers must be careful not to plan for "average" years but instead remain flexible and ready to adapt to local circumstances.

Despite a long standing interest in the early stages of human occupation in Mesoamerica, previous investigations have been limited by the paucity of well preserved archaeological sites (Zeitlin and Zeitlin 2000, McClung de Tapia 1992, Lange and Stone 1984). Much of the interpretation of the few archaeological sites which can add to the debate rests on the direct historical approach. The influence of Julian Steward's (1934, 1955) pioneering ethnographic work with the Great Basin cultures in North America is still tangible. This approach has been applied to Jennings' (1957) investigations at Danger Cave, as well as to MacNeish's work at Tehuacan and to Flannery's investigations of Guilá Naquitz. One of Stewards' major contributions to the field of cultural ecology was the recognition and description of regular, cyclical patterns of resource exploitation by indigenous people.

Research into the hunter-gatherer past at the site of El Gigante indicates a similar adaptation to local environmental conditions in the form of a seasonal round. However, the conditions are unique to highland Honduras and very dissimilar to the continental scale, semi-arid regions to the north.

The classic example of cultural behavior being shaped by a seasonal round is the Owen's Valley Paiute bands described by Julian Steward (1934). These groups spent the cooler winters on the desert floor, sometimes organizing collective rabbit drives, and fishing in the seasonal marshes. By May, spring growth enabled roots and seeds to be collected in abundance and small game like fowl and spawning fish could be trapped. The hot summer months were perhaps the leanest for these bands and it was during this period that people started the trip to higher altitudes; however, they still relied on desert seeds, rice-like grasses and wild berries. With autumn came the *piñon* harvest in the forested mountains, miles from the now-extremely parched desert. Harvesting the high-yielding *piñon* provided time for the pursuit of larger game (*e.g.,* deer) which, in other seasons, was too uncertain to be relied upon for any significant dietary contribution (Steward 1934).

This annual cycle of vertical migration is a pertinent model for a large part of North America: the Great Basin, California to some extent, and into the expanse of the Sonoran desert and Mountain highlands of Mexico. In the Tehuacan region, which is a broad arid valley c. 2,000 m above sea level, the model fit very well with the evidence uncovered by MacNeish. The Valley of Oaxaca, situated in the upland/lowland geography of the continental interior (a valley floor at about 1,500 m elevation with surrounding peaks to 3,000 m), was also suited to the interpretation of archaeological finds in light of such a generalized seasonal round.

The cultural historical sequence of the Tehuacan Valley region is described in seven phases (Byers 1967). The sequence begins with the Paleoindian Ajuereado phase (>10,000 BC – 7,600 BC) in which nomadic microbands hunted horse and antelope on a seasonal basis. The succeeding El Riego (7,600 BC - 5,000 BC) is characterized by a broadening of the diet to lower trophic levels, including small game like rabbits and the initial cultivation of plants such as squash (*C. mixta*), chili (*Capsicum annuum*), and avocados (*Persea americana*). C. Earle Smith also raises the possibility that during this phase, in addition to the above, ciruela (*Spondias* sp.), maguey (*Agave* sp.), mesquite (*Prosopis juliflora*), prickly pear (*Opuntia* sp.), cosahuico (*Sideroxylon* sp.), coyol (Acrocomia mexicana), the chupandilla (*Cyrtocarpa procera*) and *Leucaena esculenta*, *Bumelia latevirens* and the grass *Setaria* sp. were also cultivated and possibly domesticated (*ibid.*:291) . There is evidence that several of these species were used contemporaneously at El Gigante. The Coxcatlan phase (5,000 BC - 3,400 BC) is of particular relevance to the transition to agriculture. MacNeish argues that during this time, semi-sedentary macro-bands utilized the arid-steppe ecozone during the rainy season, cultivating squash and maize to augment the established broad-breadth pattern of plant collection and small game hunting. These macrobands are hypothesized to have dispersed and split-up in lean times (the dry season), traveling to different areas. These areas are presumed to have been lower elevation locales with different available resources. True *manos* and *metates* come into use during the Coxcatlan phase at the highland rock shelter camps described by MacNiesh; this indicates the further establishment of a higher cost/return subsistence focus on plants. The sequence continues with the Abejas phase (3,400 BC - 2,300 BC) in which the population becomes fully sedentary, and agricultural economies are elaborated upon with the addition of domesticated varieties of beans, pumpkin squash, and cotton. In the Purron phase (2,300 BC - 1,500 BC), fiber-tempered ceramics appear, and by the Ajalpan (1,500 BC - 850 BC) full-time intensive agriculture dominates, including highly labor intensive irrigation practices. The Santa Maria phase occurs during the Classic period in Mesoamerica and is not discussed here.

This sequence is relatively well established in New World conventional wisdom (Smith 2001a): the domestication of bottle gourd (*Lagenaria siceraria*) comes very early, followed sometime around 5,000 BC by different varieties of domestic squash (*Cucurbita* spp.) and quickly thereafter by domestic varieties of maize (*Zea mays*), and, finally, by the cultivation of the common bean (*Phaseolus vulgaris*). In MacNeish's sequence the constellation of cultivars that resulted in agriculture did not arrive all at once. The process of the adoption of agriculture must be viewed as a drawn out incorporation and integration of disparate species into a workable and sustainable system. This system is composed of local and regional groups of bands, fissioning and fusing in a generalizable seasonal pattern.

A pattern of seasonal occupation, giving way to sedentism by the late Archaic, is described by Flannery during the Naquitz and Jicaras phases (8,900 - 4,000 BC) at Guilá Naquitz. Guilá Naquitz and the caves of the Tehuacan Valley are located in comparable environmental contexts. Flannery (1986) advocates an even more flexible settlement system during the Archaic than a simple, wet-season-macroband, dry-season-microband, adaptations. Furthermore, risk-aversion and resource optimization in combination with consistent population expansion are proposed as mechanisms that drive long-term subsistence trends in Valley of Oaxaca during this period. A similar, though less sophisticated systems model, was applied by Flannery as early as 1965 to the domestication of sheep in Mesopotamia.

Flannery established that *Cucurbita pepo*, the first domesticated squash, was utilized at Guilá Naquitz as early as 8,000 B.C. (Flannery 1986). The morphologically transitional maize specimens from there have been dated to 4,300 B.C. (Piperno and Flannery 2001).

Flannery locates the Archaic hunter-gatherers of Highland Mexico at the forager end of Binford's forager-collector continuum. He describes their behavior as organized logistically around seasonal deer hunting (Flannery 1986). With the addition of a sophisticated ecosystems view and computer simulation modeling, Flannery incorporates hunter-gatherer scheduling cycles and their relation to specific seasonal plant availability that would have conditioned the behavior of such forager groups. This approach is a maturation and more quantitative application of his original (1968) theories on the organization of multiple procurement systems focused on different plants and animals. It includes a definition of regulatory mechanisms including seasonality and scheduling, the natural and cultural elements that vary throughout the year. He shows through computer simulation how a random phenotypic change in a plant (such as a mutation for larger seed size) would have initiated deviation amplifying processes systemically. The computer simulations show how feedback in the system can lead to the dominance of a plant and a particular sub-system of the subsistence regime.

With data from the Guilá Naquitz rock shelter, Flannery (1986) modeled the evolution of agriculture in terms of a seasonal round of multiple food production systems growing, being reinforced, and improved upon by selection. With the introduction of modified plants and agriculture, certain components of the system overshadowed the rest. These plant systems tended towards those plants that were efficient producers of carbohydrate or protein.

This did not happen at El Gigante. We see a late establishment of maize-bean-squash production at El Gigante, and though it appears to have been adopted rapidly in the early Formative, it does not seem to dominate at the expense of other aspects of plant food procurement. There are no data to assess this triad food complex's dominance through the Classic or Post-Classic periods.

Different food types reach their peak availability at slightly different times of the year. A simple, hypothetical schedule of resource availability can be given for El Gigante (see Table 31). For example, some perennial plants like *Spondias* sp. and *Pouteria* sp. can show two peaks of production, one in January and one in August. Annuals can peak twice as well, once in October, and sometimes for a second, minor period in January. Faunal resources, including migratory birds for example, would show a varied distribution throughout the year as well, with migrations in one direction bringing them through the area in December and back again in March. The riverine and terrestrial resources of the region and the Estanzuela Valley would show much broader flatter peaks of productivity, which would generally occur during the wet season .

Potential resource availability at El Gigante would have been at a seasonal low in March, perhaps the most risk-prone time to inhabit the rock shelter. From April through July there would be marked increases in available resources with the onset of the rains. August and September are the prime months in which to utilize a maximum number of resources at El Gigante before a sharp decline occurring in October/November coincident with the annual drought period. Inhabitants of El Gigante were likely to pack up camp and move to another location at this time unless stored resources could be relied upon.

If dried seeds and nuts such as wild mesquite beans (*Prosopis* sp.), acorn (*Quercus* sp.) and *piñon* (*Pinus* sp.) were stored (as described by Shipek 1981 , Basgall

1987, Flannery 1986, and Steward 1934) in the early phases of the occupation of El Gigante, they would substantially change the potential calendar of resource availability. Storage would increase availability of some products well past the wet season, softening the post-wet season decline, and eliminate the risky trough that occurs in February and March. Storage effectively extends relatively high resource availability throughout the year and could allow year-round occupation of the site.

Conclusion: Subsistence, Behavior, and Diet.

Fitting a regression line to a set of measurements taken on individual specimens of five species found at El Gigante has provided us with clues as to whether these species were under the influence of directional selection. Avocado, bottle gourd and squash, were undergoing directional selection and appear to have been cultivated at El Gigante. Common beans (provisionally identified - cf. Phaseolus sp.) and maize, were imported from elsewhere and remained unchanged during their use at the site.

It may be that the biology of some species is not amenable to the measurement of the type of selection that humans exerted. This would indicate that the inhabitants of El Gigante were, in fact, cultivating many more species than is apparent through our measurements. The fact that many botanical specimens do not reveal continuous morphological changes from their wild-type ancestors or, from domesticated predecesors, does not preclude their active and intensive cultivation. *Spondias* sp. (hog plum, or *ciruela*), a commonly cultivated tree crop (Piperno and Pearsall 1998:157), does not seem to have been influenced morphologically by human selection. The maize and beans at El Gigante, may have been altered through the selection of (phenotypic) traits that are not archaeologically visible. Botanical geneticists may be able to tease out some of these (genotypic) modifications in the future (*sensu* Smith 2001a, Zeder *et al.* 2006).

Of the five species investigated, the strongest case for *in situ* directed selection can be made for the avocado, squash and bottle gourd. The avocados do not follow the punctuated pattern of phenotypic change observed at Tehuacan, and instead indicate consistent growth in size since Paleoindian times. Squash, as evidenced by the seeds only, were "domesticated" upon their arrival, and there is evidence at El Gigante to indicate that they continued to be subjected to selection and modification for size. Beans seem to have come from elsewhere, and did not change in size since their first appearance. They are medium-size, intermediate between the wild type described from Guilá Naquitz and the domesticated types at Tehuacan. The bottle gourd is unique in that in it we may have a case in which a domesticate is “reprogrammed" to serve a changed function from the original. A change in the use of the plant as a container to a use for food may have revised the selective pressures that affected the bottle gourd’s phenotype. This hypothesis, that the replacement of the gourd’s vessel function by ceramic technology had had a measurable effect on bottle gourd morphology, remains for future investigation.

Plant foods of the Paleoindian diet at El Gigante continue to comprise a core plant diet that persisted for 7,000 years, or at least until our record ends in the Formative. Many of the archaeologically-documented categories of plants (which, in many cases, are probably comprised of multiple species) are still cultivated widely today, including agave, hog plum, avocado, sweet and/or sour sop, and many palms. Furthermore, all of the above-mentioned plants are perennial species. These are abundant and consistent throughout the sequence and suggest the possibility that they were highly relied upon and perhaps propagated. It is currently impossible, given the excavation methodology, to compare the relative frequency of these large scale remains (quids, pits, *etc.*) to the smaller scale seeds found in the bulk samples (grass grains and other taxa). Until further analysis of the small seed component is carried out is it probably premature to overemphasize an orcharding economy but, it is worth mentioning a recent claim by M.E. Kislev, A. Hartmann and O. Bar-Yosef (2006) that fig trees (*Ficus carica*), intentionally planted from cut branches, may have been the earliest Neolithic domesticates in the Near East between 11,200 and 11,400 years ago, predating cereal domestication by about a thousand years.

As mentioned at the beginning of the chapter, non-random bias may skew the assemblage towards plants which are easily preserved. These plants, because of their fibrous nature, or because of their woody pit (likely discarded and preserved), or their size, may be over-represented. Still, the annual tree species remain common even as other plants are added to the diet. My impression is that they represent not a minor or coincident subsistence component but a formal subsystem in their own right. Most of the tree species whose remains (seeds, *etc.*) were found in the El Gigante assemblage (described above) seem well adapted to live in the environs of El Gigante, this would be especially true during times of slightly wetter climate (see Chapter 2). At Tehuacan these tree species represented what MacNeish called "watered orchards" (1967:308). Piperno and Pearsall agree with this interpretation, commenting also that the Guilá Naquitz site is similar in the prominence of "imports." Fruits such as avocado, *ciruela*, and *coyol* palm are thought to have been taken from their preferred lower wetter Pacific and Atlantic slopes and grown at these highland sites (Piperno and Pearsall 1998:233). Given historical landscape degradation, the modern vegetation surveys did not clarify whether any of these important tree species grow wild in the area today. This remains an issue awaiting further study and in particular more information regarding the small seed component of the diet.

The Marcala phase remains are interesting from two perspectives. First, we see the introduction of cultigens including varieties of squash (*Cucurbita* sp., cf. *C. pepo*) and bottle gourd that may have been domesticated. In addition, the previously defined core plant diet is augmented with an increasing number of tree crops, such as the soursop and hackberry. Furthermore, many of the unidentified remains are large and medium seeds representing other perennial fruits.

The most notable additions in the Estanzuela phase remains are two New World keystone crops, maize and beans. The maize-beans-squash triad did not replace the existing core diet, but augmented it. Reconstructing the proportions of the diet that each species comprises is beyond the scope of this dissertation. The continued presence of the possible orchard crops mentioned above indicate that the production of maize, beans and squash supplemented a diversity of extant food items in a mixed and, no doubt, flexible subsistence economy. It may have been a necessity to become more resilient in the face of the late Holocene climatic regime of intensifying ENSO events.

The incorporation of annual field cropping and its intensification eventually precluded the subsistence methods of previous phases. When intensive food production systems began to impede the sustainable productivity of the previously extensive modified landscapes the system crossed Rindos' (1984, 1989) threshold for an agro-ecosystem. Unfortunately, the archaeological record at El Gigante does not record these events which are assumed to have occurred in the Classic and Post-Classic periods. Assessing this hypothesis would require a continuous assemblage from succeeding phases (*i.e.*, the Classic and Postclassic periods) which are absent from the record at El Gigante. By the Late Formative, El Gigante was still practicing a mixed subsistence economy, and we have no evidence that field cropping interrupted the previous generalized regime which by that point may have included foraging and home gardening.

Evidence for an Archaic orcharding system is largely circumstantial. For one, these species are suited to the elevation, frost potential and mesic character of the Estanzuela Valley. However, many of the species in question, particularly agave and palm, had multiple non-food uses that may confound the archaeological analysis. Also, for example, a majority of the plant food items found at El Gigante are perennial species that have high but seasonal yields requiring specialized technologies to be stored in any significant way (*e.g.,* drying, smoking, fermenting, etc.). This would make them difficult to count on as staples through an entire year. In addition, although these trees, (*e.g.*, avocado) are often difficult to hybridize and maintain genetic control over, they are easily propagated from cuttings or seed (Ebeling 1986). Existing vegetation, capitalized upon and augmented over time by the residents of El Gigante, could have created a "domesticated landscape" (Terrell *et al.* 2001) of the surrounding area. Nutritionally, this early "core" diet (composed of *maguey*, avocado, *ciruela*, *Manilkara* sp. and/or *Sideroxylon* sp., *Pouteria* sp., possibly wild grasses, and supplemented by extant game) would have been adequate and balanced. Once located, trees, or groves of trees, are easily encountered again and again and require low inputs to maintain (Peters 2000). Together these factors make reliance on them a very attractive, low cost-high pay-off enterprise. In addition, many trees and perennial species have uses other than just as food items. Multipurpose plants that provide many functions (for example, the palms and the agaves) are valuable regardless of their role in the diet.

The botanical remains from El Gigante present the opportunity to infer a great deal about the past human relationship with specific plants and landscapes. The macro-botanical remains suggest the expansion of a core diet originating in the Paleoindian period, broadening to include more and more species through the Archaic. We can also point to possible directed selection with respect to several of these tree crops, indicating a propensity for humans to cultivate and propagate these species as they also did with the cultivars they imported. These are, however, initial results. Further study of the growth and characteristics of individual species of trees may reveal other factors influencing fruit size and production that were not accounted for in this study. It appears that flexibility, embodied in dietary diversity, is central to a long-term, sustainable, low-level food production strategy at El Gigante. However, the record at El Gigante does not reveal the unfolding consequences of intensive field agriculture that are assumed to have occurred during the Classic and Post-Classic periods.

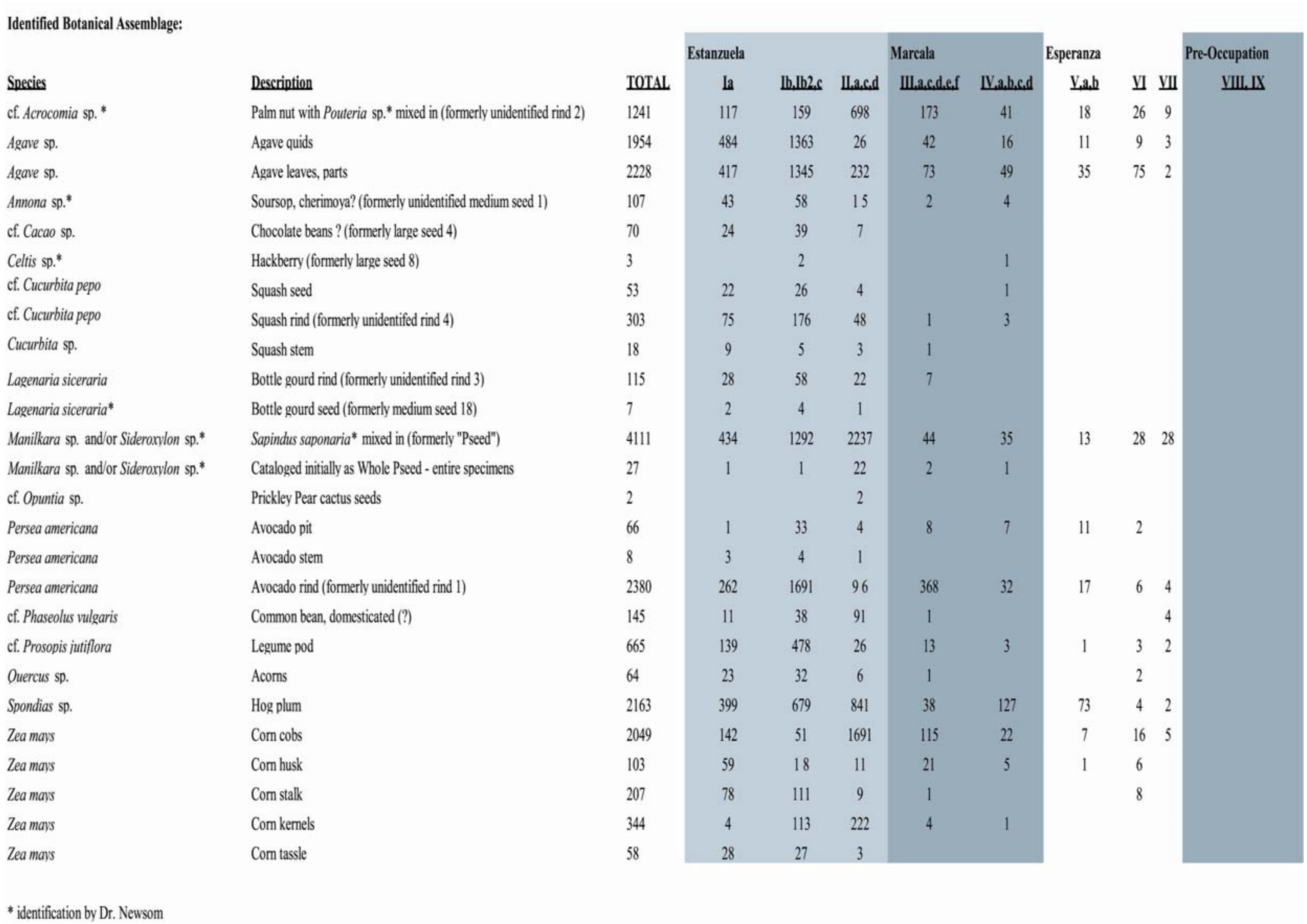
Whether based more on hunting and gathering, or agriculture, prehistoric subsistence economies share many common strategies and tactics for the provisioning of food (Redding 1988), and it may well be that mixed economies are the rule rather than the exception. The transition from one to another (if and when it happens) is best viewed as movement along a broad multi-dimensional continuum. Broad in the sense that it includes variable suites of different plant (and animal) species, and multi-dimensional in the sense that the behaviors ranged from exclusive foraging (food finding), to the logistically organized and planned activities that increased food availability and "low level food production" (*sensu* Smith 2001b), to full scale intensive agricultural production, non of which are mutually exclusive.

The fluctuating botanical assemblage diversity indices seem to be fluid and dynamic. The prehistoric subsistence regimes of the inhabitants of El Gigante do not fit a transition model that shifts gradually and linearly from one normative state to another. The variation in botanical assemblage diversity indicates a flexible adaptive regime in which local conditions drive behavior in multiple directions depending on the specific local context.

Also, as seen in the sequence of the incorporation of plant species through time, processes of subsistence change are additive, not substitutive. With the exception of very rare species, items that are found in deep strata at El Gigante are almost always found repeatedly in upper strata as well. There are periods of both declining and increasing species richness at El Gigante. This demonstrates the conservative nature of these changes, and, perhaps, served to minimize risk with respect to novel circumstances.

El Gigante data show significant increases as well as decreases in diversity preceding the appearance of domesticates, these episodes represent multiple moments of change in the diet. By examining changes in diet and patterns of local dietary diversity as I have attempted, archaeologists can observe individual cases in which it is clear that the environment both conditions and is conditioned by human action. This reveals a highly adaptable capacity and history. This is the essence of the human condition.

Table 7 Identified Botanical Assemblage.

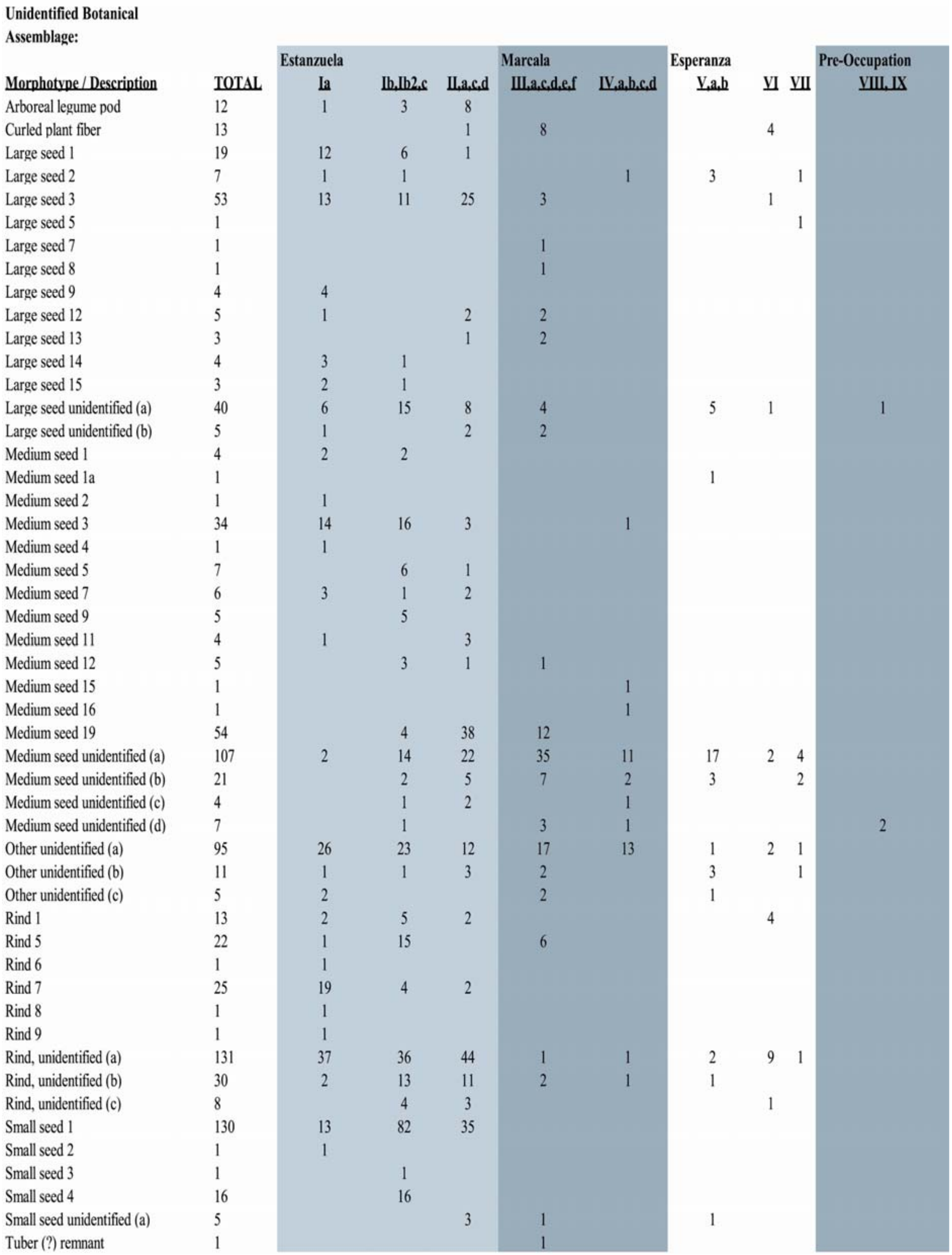


Identified Botanical Assemblage:

			Estanzuela			Marcala		Esperanza			Pre-Occupation
Species	**Description**	**TOTAL**	**Ia**	**Ib,Ib2,c**	**II,a,c,d**	**III,a,c,d,e,f**	**IV,a,b,c,d**	**V,a,b**	**VI**	**VII**	**VIII, IX**
cf. *Acrocomia* sp. *	Palm nut with *Pouteria* sp.* mixed in (formerly unidentified rind 2)	1241	117	159	698	173	41	18	26	9	
Agave sp.	Agave quids	1954	484	1363	26	42	16	11	9	3	
Agave sp.	Agave leaves, parts	2228	417	1345	232	73	49	35	75	2	
Annona sp.*	Soursop, cherimoya? (formerly unidentified medium seed 1)	107	43	58	15	2	4				
cf. *Cacao* sp.	Chocolate beans ? (formerly large seed 4)	70	24	39	7						
Celtis sp.*	Hackberry (formerly large seed 8)	3		2			1				
cf. *Cucurbita pepo*	Squash seed	53	22	26	4		1				
cf. *Cucurbita pepo*	Squash rind (formerly unidentifed rind 4)	303	75	176	48	1	3				
Cucurbita sp.	Squash stem	18	9	5	3	1					
Lagenaria siceraria	Bottle gourd rind (formerly unidentified rind 3)	115	28	58	22	7					
*Lagenaria siceraria**	Bottle gourd seed (formerly medium seed 18)	7	2	4	1						
Manilkara sp. and/or *Sideroxylon* sp.*	*Sapindus saponaria** mixed in (formerly "Pseed")	4111	434	1292	2237	44	35	13	28	28	
Manilkara sp. and/or *Sideroxylon* sp.*	Cataloged initially as Whole Pseed - entire specimens	27	1	1	22	2	1				
cf. *Opuntia* sp.	Prickley Pear cactus seeds	2			2						
Persea americana	Avocado pit	66	1	33	4	8	7	11	2		
Persea americana	Avocado stem	8	3	4	1						
Persea americana	Avocado rind (formerly unidentified rind 1)	2380	262	1691	96	368	32	17	6	4	
cf. *Phaseolus vulgaris*	Common bean, domesticated (?)	145	11	38	91	1				4	
cf. *Prosopis jutiflora*	Legume pod	665	139	478	26	13	3	1	3	2	
Quercus sp.	Acorns	64	23	32	6	1			2		
Spondias sp.	Hog plum	2163	399	679	841	38	127	73	4	2	
Zea mays	Corn cobs	2049	142	51	1691	115	22	7	16	5	
Zea mays	Corn husk	103	59	18	11	21	5	1	6		
Zea mays	Corn stalk	207	78	111	9	1			8		
Zea mays	Corn kernels	344	4	113	222	4	1				
Zea mays	Corn tassle	58	28	27	3						

* identification by Dr. Newsom

Table 8 Unidentified Botanical Assemblage.



Unidentified Botanical Assemblage:

		Estanzuela			Marcala		Esperanza			Pre-Occupation
Morphotype / Description	**TOTAL**	**Ia**	**Ib,Ib2,c**	**II,a,c,d**	**III,a,c,d,e,f**	**IV,a,b,c,d**	**V,a,b**	**VI**	**VII**	**VIII, IX**
Arboreal legume pod	12	1	3	8						
Curled plant fiber	13			1	8			4		
Large seed 1	19	12	6	1						
Large seed 2	7	1	1			1	3		1	
Large seed 3	53	13	11	25	3			1		
Large seed 5	1								1	
Large seed 7	1				1					
Large seed 8	1				1					
Large seed 9	4	4								
Large seed 12	5	1		2	2					
Large seed 13	3			1	2					
Large seed 14	4	3	1							
Large seed 15	3	2	1							
Large seed unidentified (a)	40	6	15	8	4		5	1		1
Large seed unidentified (b)	5	1		2	2					
Medium seed 1	4	2	2							
Medium seed 1a	1						1			
Medium seed 2	1	1								
Medium seed 3	34	14	16	3		1				
Medium seed 4	1	1								
Medium seed 5	7		6	1						
Medium seed 7	6	3	1	2						
Medium seed 9	5		5							
Medium seed 11	4	1		3						
Medium seed 12	5		3	1	1					
Medium seed 15	1					1				
Medium seed 16	1					1				
Medium seed 19	54		4	38	12					
Medium seed unidentified (a)	107	2	14	22	35	11	17	2	4	
Medium seed unidentified (b)	21		2	5	7	2	3		2	
Medium seed unidentified (c)	4		1	2		1				
Medium seed unidentified (d)	7		1		3	1				2
Other unidentified (a)	95	26	23	12	17	13	1	2	1	
Other unidentified (b)	11	1	1	3	2		3		1	
Other unidentified (c)	5	2			2		1			
Rind 1	13	2	5	2				4		
Rind 5	22	1	15		6					
Rind 6	1	1								
Rind 7	25	19	4	2						
Rind 8	1	1								
Rind 9	1	1								
Rind, unidentified (a)	131	37	36	44	1	1	2	9	1	
Rind, unidentified (b)	30	2	13	11	2	1	1			
Rind, unidentified (c)	8		4	3				1		
Small seed 1	130	13	82	35						
Small seed 2	1	1								
Small seed 3	1		1							
Small seed 4	16		16							
Small seed unidentified (a)	5			3	1		1			
Tuber (?) remnant	1				1					

Table 9 Non–food Items in the Botanical Catalog.

Non-Food Items:

Species	**Description**	**TOTAL**	Estanzuela **Ia**	**Ib,Ib2,c**	**II,a,c,d**	Marcala **III,a,c,d,e,f**	**IV,a,b,c,d**	Esperanza **V,a,b**	**VI**	**VII**	Pre-Occupation **VIII, IX**
cf. Gossypium sp.	Fiber only, ID tenuous	2			2						
cf. *Pinus* sp.	Sap or pitch lumps	8		7	1						
unknown	Beetles, maize borer (?)	204	73	127	3		1				
unknown	Coprolite, owl (?)	710	179	456	68	5			1		1
unknown	Flower petals	1		1							
unknown	Gall, plant growth	1									1
unknown	Grass	80	26	44	1	4	1	3		1	
unknown	Palm fiber	86	16	63	7						
unknown	Roots	2	2								
unknown	Unidentified epiphytic plant, possibly bromeliad	13	5	4		2	1		1		
unknown	Unidentified epiphytic plant, possibly bromeliad	2		1		1					
unknown	Unidentified fern frond parts	3	1	2							
unknown	Wood, unburned	668	133	286	114	63	15	12	19	26	

Table 10 Historic Introductions (intrusive items).

Historic Introductions

Species	Description	TOTAL	Estanzuela Ia	Ib,Ib2,c	II,a,c,d	Marcala III,a,c,d,e,f	IV,a,b,c,d	Esperanza V,a,b	VI	VII	Pre-Occupation VIII, IX
Musa sp. (tes)	Banana leaf	11	4	7							
Syzygium sp. (tes)	Rose apple	24	15	4	3		2				

Table 11 Avocado seed size index by phase.

Phase	**Count**	**Size Index (mm2)**	**Coefficient of Variation**
ESTANZUELA: I(a,b,c), II(a)	21	5.06	28.41
MARCALA: III(d,e,f)	4	3.67	30.23
ESPRERANZA: IV(a,b)	6	4.57	27.43

Table 12 cf. *Cucurbita pepo* seed measurements and descriptive inventory.

Unit	Level	Number	Entirety	Length	Width widest	Width neck	Comment
6	9	1	w	11.8	7.06	3.33	
6	13	1	w	15.33	9.41	4.68	
6	2	1	w	15.27	8.83	5.93	broken, 2pcs, hairy
6	2	2	b	15.11	11.04		tip/neck missing, L is estimate
6	4b	1	b		7.99		
6	4b	2	0.80	14.59	10.36	5.05	
6	4b	3	0.7	13.72	8.85	4.91	ext skin only
6	1	1	0.5	12.81			
6	8b	1	w	15.65	9.77	4.75	dirty
6	7a	1	w	13.82	9.88	4.15	dirty
3	9	1	w	12.38	7.53	3.72	
3	8	1	0.8	17.93		3.61	2 pcs
3	8	2	w	15.3	9.26	4.01	
18	5	1	b		11.15		W is estimate
18	13b	1	w	14.52	7.68	3.35	
18	8	1	0.9	14.48	8.61	3.45	
11	2	1	0.8		9.67		
15	1	1	w	14.08	8.99	3.95	
7	13	1	w	16.65	9.44	4.49	dark dirt
7	11	1	w	16.46	11.44	4.98	hairy
7	2	1	w	12.62	8.09	3.77	
7	7	1	b		9.07		W good
17	6	1	w	14.59	8.63	3.36	hairy
17	6	2	w	13.11	7.51	3.75	
17	5	1	w	14.83	9.59	3.28	
16	2	1	w	15.79	11.59	4.71	
16	8	1	w	15.26	9.29	3.87	
1	3	1	w	15.72	11.53	4.86	
1	3	2	w	13.37	7.97	3.68	
1	3	3	b		11.18		W?
1	3	4	b				frags
1	4	1	w	16.96	10.53	5.13	
1	4	2	w	14.02	10.34	3.23	Wn?
1	4	3	w	15.23	10.99	4.03	
1	4	4	b		11.06		
1	5	1	w	14.9	8.62	3.91	
1	5	2	w	13.07	8.01	2.9	
1	2	1	w	13.9	10.19	3.63	
1	2	2	w	14.17	9.7	3.76	
1	2	3	w	13.03	10.17	3.58	
1	2	4	w	15.04	10.91	4.17	
1	6	1	w	12.5	7.51	3.06	
1	6	2	w	12.68	6.8	2.97	
2	4b	1	w	12	6.77	3.08	
2	3a	1	w	13.46	7.41	2.87	

Table 13 *Cucurbita* seed measurements from archaeological sites and modern collections.

Site		Length	Width	Count
El Gigante, Honduras,				
El Gigante Ia, Mix of Late Formative to modern specimens	mean	14.40	9.93	20
	CV	8.34	13.44	
El Gigante I(b,c3), Late Estanzuela (Formative)	mean	14.47	8.74	18
	CV	11.90	15.17	
El Gigante II(a1,c1,c3), Early Estanzuela (early Formative)	mean	13.95	8.60	4
	CV	11.60	16.76	
Mexico, Prehistoric				
Guilá Naquitz (zone B1)***	mean	12.20	7.10	5
	CV	22.74	12.60	
Guilá Naquitz (zone C)***	mean	11.33	8.00	3
	CV	5.09	0.00	
Guilá Naquitz (zone D)***	na	10.00	7.00	1
Coxcatlan (Venta Salada)****, c. A.D. 1,000	mean	22.50	9.77	3
	CV	14.87	11.23	
Coxcatlan (El Riego)****, c. 6,000 B.C.	na	12.30	6.10	1
North America, Prehistoric				
Cloudsplitter, Archaic*	mean	8.70	5.40	2
	CV	1.61	5.19	
Cloudsplitter, Early Woodland*	mean	12.60	7.40	5
	CV	9.52	9.59	
Rogers Shelter, Late Woodland*	mean	11.60	7.30	363
	CV	8.62	7.67	
North America, Modern collections				
Ozarks**, Modern wild N. American sample	mean	9.20	5.90	300
	CV	5.40	6.60	
Cultivars**, pooled *C. pepo* ssp. *ovifera*	mean	9.30	5.80	70
	CV	9.00	6.80	

*from Cowan (1997)
**from Cowan and Smith (1993)
***from Whitaker and Cutler (1986)
****from Smith (2005)

Table 14 *Lagenaria siceraria* (bottlegourd) seed measurements from El Gigante.

Stratum	**Specimen Number**		**Length**		**Width**		**Thickness**
				Proximal	**Medial**	**Distal**	
Ia	6.5b		13.33	3.46	5.29	5.94	2.61
Ia	13.40		15.76	5.90	10.24	10.40	3.51
		average	**14.55**	**4.68**	**7.77**	**8.17**	**3.06**
		st. dev	1.72	1.73	3.50	3.15	0.64
		CV	11.81	36.87	45.08	38.60	20.80
Ib	3.80		10.15	3.07	4.38	4.42	2.66
Ib	3.80		12.00	2.59	6.10	6.38	2.87
Ib	9.40		10.32	3.70	4.74	4.88	2.02
Ib	17.50		12.48	4.64	6.96	7.64	2.64
		average	**11.24**	**3.50**	**5.55**	**5.83**	**2.55**
		st. dev	1.18	0.89	1.20	1.47	0.37
		CV	10.47	25.30	21.63	25.19	14.40
IIa6.1	6.15a		11.82	4.65	6.14	6.43	2.37
pothole	12.10		14.69	5.13	7.70	8.05	2.90
pothole	12.20		12.63	5.02	7.35	7.66	2.64

Table 15 Average cob length measurement by stratum and Coefficients of Variation (CV).

Stratum	**Mean**	**Standard Deviation**	**CV**	**Count**
Ia	53.41	18.60	34.83	10
Ib	58.06	22.17	38.19	18
Ib2	59.03	22.72	38.49	33
IIa1	59.12	21.20	35.86	28
IIa(3,4)	56.02	24.56	43.84	7
IIc3	51.21	13.78	26.91	8
III(c4,f2)	53.66	13.21	24.62	3

Table 16 Average cob diameter and Coefficients of Variation (CV).

Stratum	**Mean**	**Standard Deviation**	**CV**	**Count**
Ia	18.20	2.75	15.10	10
Ib	16.81	2.31	13.76	18
Ib2	15.92	2.94	18.45	33
IIa1	16.90	2.60	15.39	28
II(a3,a4)	16.77	1.25	7.43	7
IIc3	14.69	2.10	14.30	8
III(c4,f2)	17.02	3.28	19.24	3

Table 17 Average number of rows per cob and Coefficients of Variation (CV).

Stratum	**Mean**	**Standard Deviation**	**CV**	**Count**
Ia	13.00	2.14	16.45	8
Ib	13.86	1.83	13.23	14
Ib2	12.16	2.23	18.34	25
IIa1	11.85	1.83	15.47	27
II(a3,a4)	12.57	1.90	15.13	7
IIc3	14.00	1.51	10.80	8
III(c4,f2)	14.00	2.00	14.29	3

Table 18 Representation (proportion) by stratum of the qualitative attributes of the maize cob assemblage.

SHAPE

Stratum	*Tapered*	*Slight Taper*	*Cylinder*	*Cigar*	*Indeterminate*
Ia	0.40	0.10	0.20	0.30	0.00
Ib	0.67	0.22	0.00	0.06	0.06
Ib2	0.39	0.24	0.06	0.27	0.03
IIa1	0.50	0.18	0.07	0.25	0.00
IIa3/IIa4	0.29	0.29	0.14	0.29	0.00
IIc3	1.00	0.00	0.00	0.00	0.00
III/IIIc4/IIIf2	0.33	0.33	0.00	0.33	0.00

ROW PAIRING

Stratum	*Strong*	*Weak*	*No comment*
Ia	0.00	0.00	1.00
Ib	0.06	0.22	0.72
Ib2	0.06	0.09	0.85
IIa1	0.14	0.07	0.79
IIa3/IIa4	0.00	0.14	0.86
IIc3	0.00	0.00	1.00
III/IIIc4/IIIf2	0.33	0.00	0.67

BURNING

Stratum	*Unburned*	*Carbonized*	*Partial*
Ia	1.00	0.00	0.00
Ib	0.78	0.00	0.22
Ib2	0.94	0.00	0.06
IIa1	0.89	0.00	0.11
IIa3/IIa4	0.71	0.00	0.29
IIc3	0.63	0.00	0.38
III/IIIc4/IIIf2	0.67	0.00	0.33

Table 19 Maize kernel height (mm) measurements by stratum and Coefficients of Variation (CV).

Stratum	mean	standard deviation	CV	Count
Ia	7.30	0.79	10.8	3
Ib	6.50	0.87	13.4	11
Ib2	6.45	1.14	17.6	7
IIa(1,3)	5.94	1.07	18.1	19
IIc(1,3)	5.48	1.23	22.4	7

Table 20 Maize kernel proximal width (mm) measurements by stratum and Coefficients of Variation (CV).

Stratum	mean	standard deviation	CV	Count
Ia	3.01	0.23	7.5	3
Ib	3.24	0.59	18.3	11
Ib2	2.84	0.63	22.2	7
IIa(1,3)	3.09	0.63	20.5	15
IIc(1,3)	2.57	0.67	26.2	3

Table 21 Maize kernel medial width (mm) measurements by stratum and Coefficients of Variation (CV).

Stratum	mean	standard deviation	CV	Count
Ia	5.69	1.73	30.5	3
Ib	5.84	0.77	13.3	11
Ib2	5.26	0.74	14.1	7
IIa(1,3)	5.50	0.46	8.3	19
IIc(1,3)	5.49	0.86	15.7	7

Table 22 Maize kernel distal width (mm) measurements by stratum and Coefficients of Variation (CV).

Stratum	mean	standard deviation	CV	Count
Ia	6.34	1.28	20.2	3
Ib	6.28	0.83	13.2	11
Ib2	5.85	0.88	15.1	7
IIa(1,3)	6.32	0.65	10.3	15
IIc(1,3)	6.03	0.42	7.0	3

Table 23 Maize kernel "D1" (mm) measurements by stratum and Coefficients of Variation (CV).

Stratum	**mean**	**standard deviation**	**CV**	**Count**
Ia	5.41	0.64	11.9	3
Ib	4.37	1.22	27.9	11
Ib2	5.05	1.30	25.7	7
IIa(1,3)	3.89	1.10	28.4	19
IIc(1,3)	3.48	1.29	37.1	7

Table 24 Maize kernel thickness (mm) measurements by stratum and Coefficients of Variation (CV).

Stratum	**mean**	**standard deviation**	**CV**	**Count**
Ia	4.36	1.23	28.1	3
Ib	4.88	0.46	9.4	11
Ib2	4.61	0.45	9.7	7
IIa(1,3)	5.35	0.71	13.2	19
IIc(1,3)	4.66	0.42	9.0	7

Table 25 Maize kernel size index (mm2) measurements by stratum and Coefficients of Variation (CV).

Stratum	**mean**	**standard deviation**	**CV**	**Count**
Ia	85.32	49.29	57.8	3
Ib	82.57	18.18	22.0	11
Ib2	69.49	18.31	26.4	7
IIa(1,3)	83.09	20.24	24.4	15
IIc(1,3)	65.95	17.15	26.0	3

Table 26 Characteristics used in the racial classification of maize for the entire, pooled El Gigante sample (Sanchez *et al*. 1993).

	Ratio of ear diameter to ear length	**Kernal Width**	**Ratio of kernal height to kernel width**
mean	0.30	6.16	1.03
standard deviation	0.02	0.22	0.10
CV	7.91	3.49	10.07

Table 27 Small seed assemblage (Estanzuela phase, Feature #9).

Family	Species	Description	Count
Poaceae (Panicoideae)*	-	Large morphotype	7
Poaceae (Panicoideae)*	-	Small morphotype	2
Poaceae (Festucoideae)**	cf. *Poa* sp.	Grass family	2
cf. Cyperaceae or Poaceae	-	Sedge or grass families	1
cf. Brassicaceae	-	Mustard family	1
-	**-**	Unidentified spiny calcareous seed, same as below	1
-		Unidentified seed/fruit fragments	27

Table 28 Small seed assemblage (Marcala phase, Feature #3)

Family	Species	Comment	Count
Poaceae (Panicoideae)*	-	Large morphotype, same as above	86
Poaceae (Panicoideae)*	-	Small morphotype, same as above	14
Poaceae (Festucoideae)**	cf. *Poa* sp.	Grass family	4
Cyperaceae	cf. *Scleri*a sp.	Sedge family	3
Chenopodiaceae	-	Goosefoot family	1
cf. Cactaceae	cf. *Cereus* sp.	Cactus, seeds very worn possible bat frugivory	71
cf. Brassicaceae	-	Mustard family	1
cf. Lamiaceae	-	Mint family	3
-	-	Unidentified spiny calcareous seed, same as above	3
-		Unidentified small fragments of seed/fruit	12

Table 29 Small seed assemblage (Esperanza phase, Sub-stratum IVb)

Family	Species	Comment	Count
Poaceae (Panicoideae)*	-	Large morphotype, same as above	1
Myrtaceae	*Psidium* sp.	Guava, (e.g. *P. guajava*)	1
Chenopodiaceae	-	Goosefoot family	1
cf. Cyperaceae or Poaceae	-	Sedge or grass families, same as above	1
Rubiaceae	(?) *Galium* sp.	Unidentified seed type, spherical, bedstraw	2
-		Unidentified seed/fruit, tuberculate surface	2
Solanaceae	(?) *Capsicum* sp.	Unidentified seed/fruit fragments	22
-		Unidentified fine seeds and insect remains	n/a

* = tribe Paniceae, section Fasciculata
** = tribe Festuceae

Table 30 Between group significant differences for species richness values.

(assuming representative categories)

BOTANICAL SPECIES RICHNESS

Tukey HSD[a,b]

GROUP	N	Subset for alpha = .05					
		1	2	3	4	5	6
VIII	14	.21					
Vb	4	1.00	1.00				
VII	29	1.48	1.48				
VI	28	1.93	1.93				
IIIe	12	2.17	2.17				
IVb	30	2.60	2.60	2.60			
IV	10	2.80	2.80	2.80			
III	39	3.18	3.18	3.18			
Va	19	3.68	3.68	3.68			
Ic	9		4.67	4.67	4.67		
IIIf	23		4.78	4.78	4.78		
Ib2	30			6.43	6.43	6.43	
Ia	58				8.47	8.47	8.47
IId	13				8.62	8.62	8.62
IIc	13					9.38	9.38
Ib	64					9.47	9.47
IIa	22						10.77
Sig.		.239	.125	.111	.084	.480	.887

Means for groups in homogeneous subsets are displayed.

[a] Uses Harmonic Mean Sample Size = 15.362.

[b] The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table 31 Conjectural model of the seasonal availability of species at El Gigante*.

Plant Species Inferred from El Gigante	**J**	**F**	**M**	**A**	***M***	***J***	***J***	***A***	***S***	***O***	**N**	**D**
Avocado, cf. *Persea americana* (1)	x	x					x	x	x	x	x	x
Bottle gourd, *Lagenaria siceraria* (4)										x	x	
Ciruela (Hog plum), *Spondias* sp. (1)	x						x	x	x	x		x
Common bean, cf. *Phaseolus* sp. (4)	x	x	x	x					x	x	x	x
Hackberry, *Celtis* sp. (3)					x	x	x	x	x	x		
Maguey, *Agave* sp. (3)	x	x	x	x	x	x	x	x	x	x	x	x
Maize (corn), *Zea mays* (2)	x	x	x	x	x		x	x	x	x	x	x
Manilkara sp. and/or *Sideroxylon* sp. (4)								x	x	x	x	
Mesquite (wild) bean, *Prosopis jutiflora* (3)	x					x	x	x	x	x	x	x
Oak (Acorn), *Quercus* sp. (3)	x	x	x	x	x					x	x	x
Palm (nut and heart), e.g *Acrocomia sp.* (1)	x	x	x	x	x	x	x	x	x	x	x	x
Sapote, mamay, *Pouteria* sp. (1)	x	x		x	x		x	x	x			
Soapberry or Mamoncillo-like var., *Sapindus saponaria* (1)						x	x	x	x	x		
Soursop, *Annona* sp. (1)	x	x	x	x	x	x	x	x				
Squash, *Cucurbita pepo* (2,3)						x	x	x	x	x	x	x
Wild Grasses, *Zea* sp., *Setaria* sp. and/or *Panicum* sp. (3)									x	x		
Animal Species Possibly Present in the Assemblage:												
Deer, *e.g. Odocoileus virginianus (2)*				x	x	x	x	x	x	x		
Ground game birds, turkey, pheasant, quail, dove,. . . (4)	x	x	x	x	x	x	x	x	x	x	x	x
Migratory fowl, geese, ducks, coots, grebs,. . . (4)			x									x
Rabbit, *e.g. Sylvilagus sp. (2)*	x	x	x	x	x	x	x	x	x	x	x	x
Rodents (2)	x	x	x	x	x	x	x	x	x	x	x	x
Snails (2)					x	x	x	x	x	x		
Snakes, lizards (2)					x	x	x	x	x	x		
Turtle, *e.g. Kinosternon* sp. (2)					x	x	x	x	x	x		

1- from Morton (1987) and Martin (1987) also Popenoe (1920)

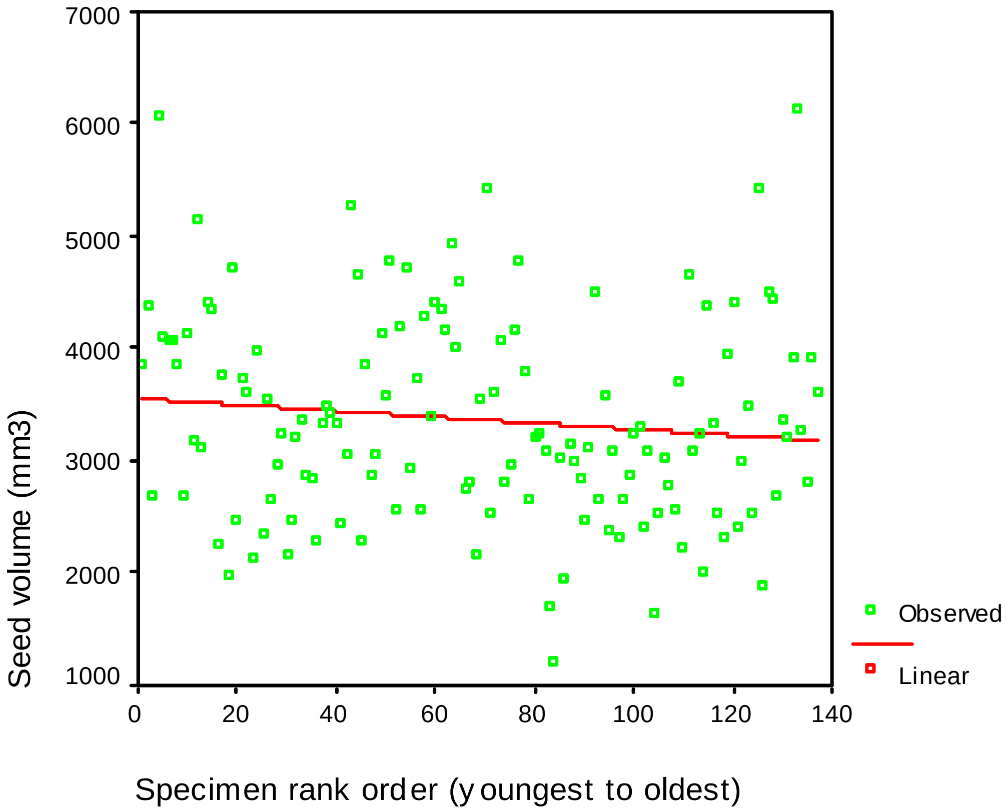
2- from Niederberger (1979), compiled largely from early Mexican naturalists

3- from Flannery (1986:259)

4- personal observation, preliminary estimate

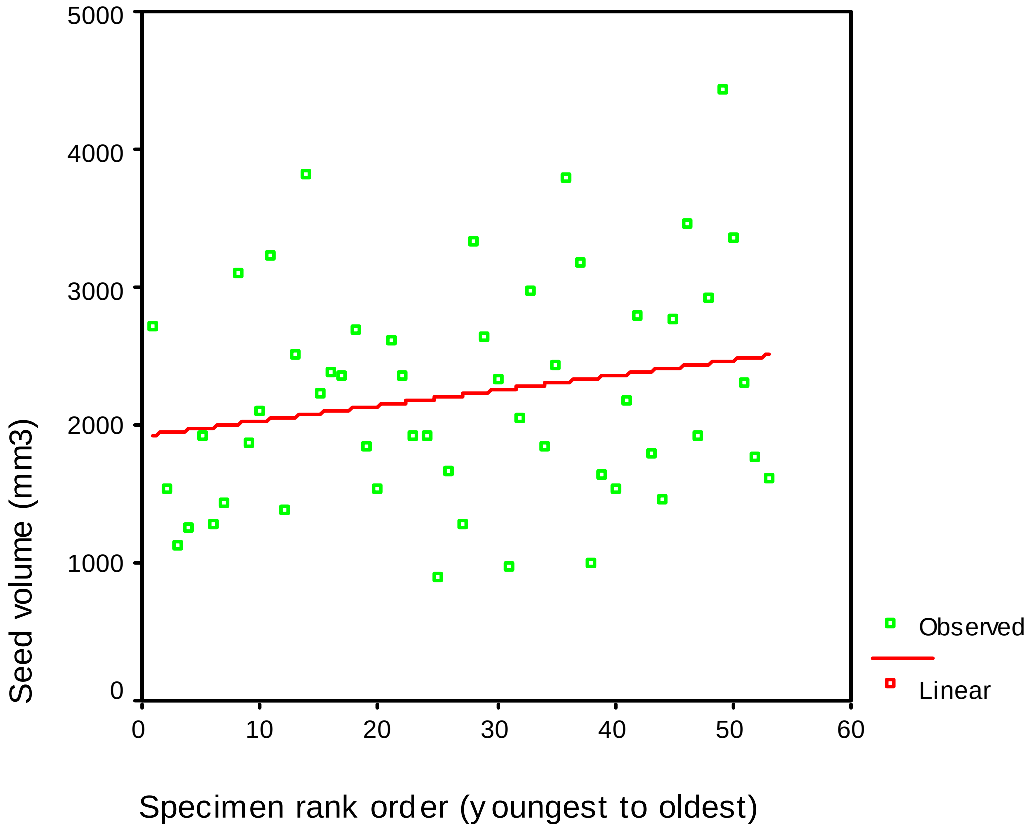
* -The list of species in this table include individual species identified in the El Gigante remains, as well as hypothetical listings which are inferred but not specifically identified at the site. These include all of the zooarchaeological classifications, as these remains have not been systematically examined by an expert. The list was constructed purely as a heuristic and visualization device to evaluate potential seasonal resource fluctuations in relation to the wet and dry seasons.

Figure 35 *Spondias* sp. (hairy) seed sizes (mm3) and best fit regression line.



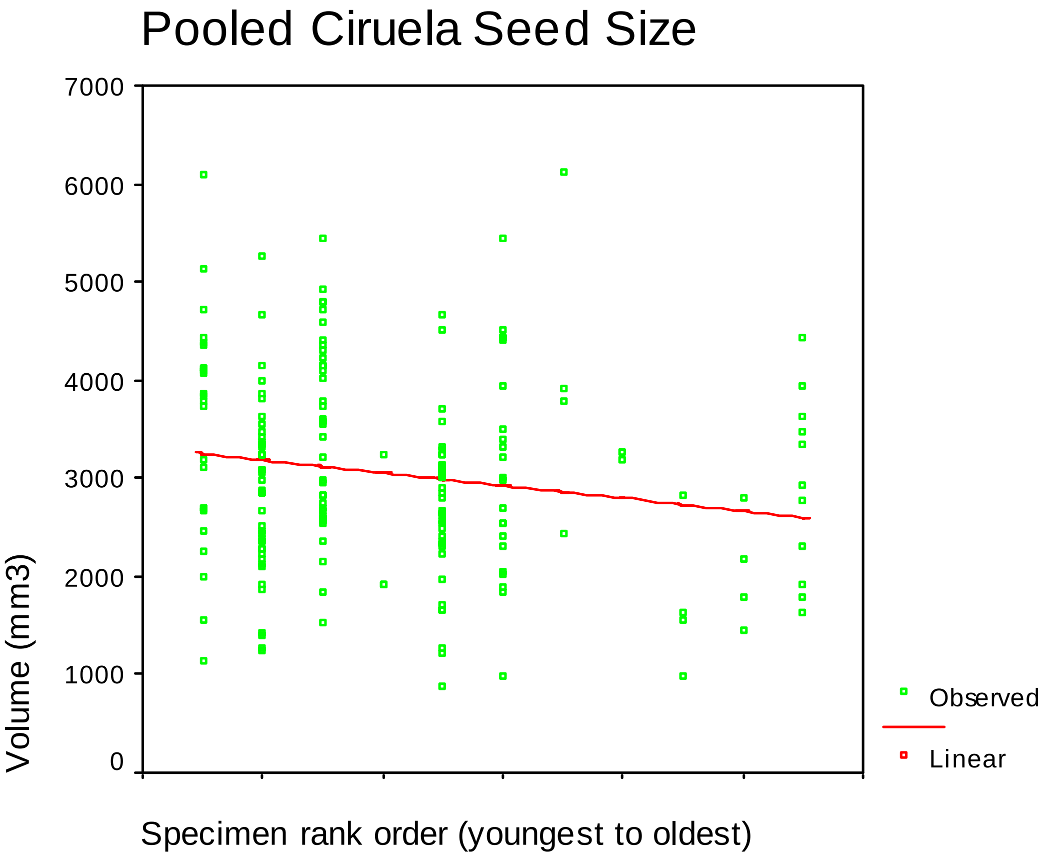
Rsquare = .014, Significance (p) = .172
Total number of specimens = 137
Strata Ia-b (n=49), IIc-d (n=82), IIId-f (n=4), Va (n=1), VIIa (n=1)

Figure 36 *Spondias* sp. (skeletal) sizes (mm3) and best fit regression line.



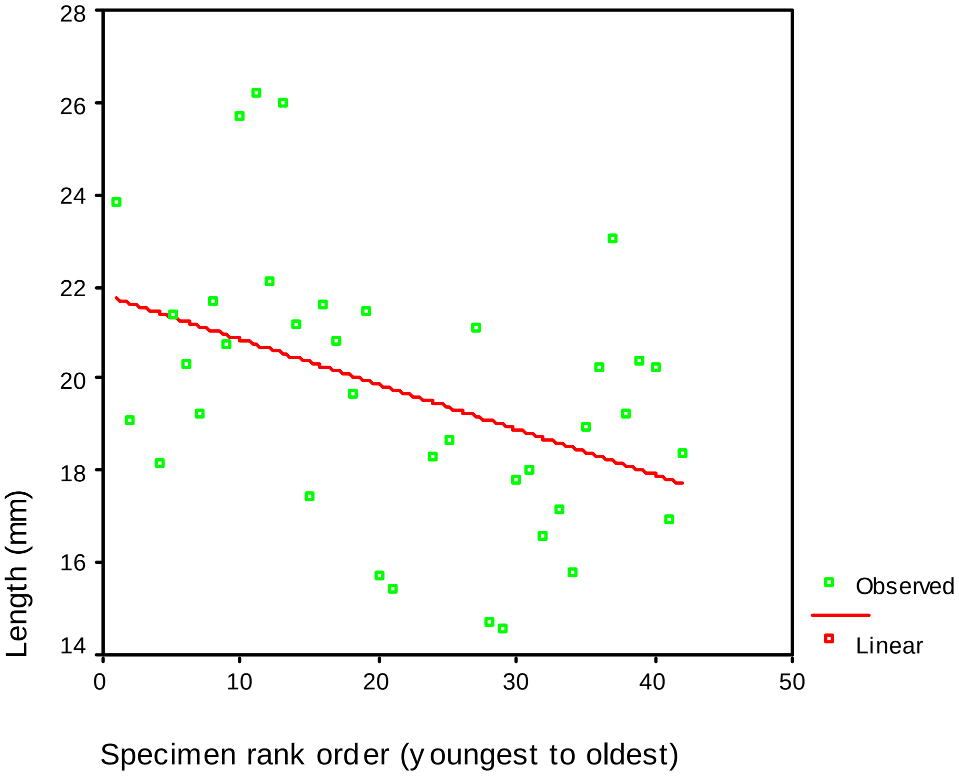
Rsquare = .045, Significance (p) = .129
Total number of specimens = 52
Strata Ia-b (n=17), IIc-d (n=16), IIId-f (n=6), IVb (n=4), Va (n=8), VI (n=1)

Figure 37 *Spondias* sp. pooled sample sizes (mm3) and best fit regression line.



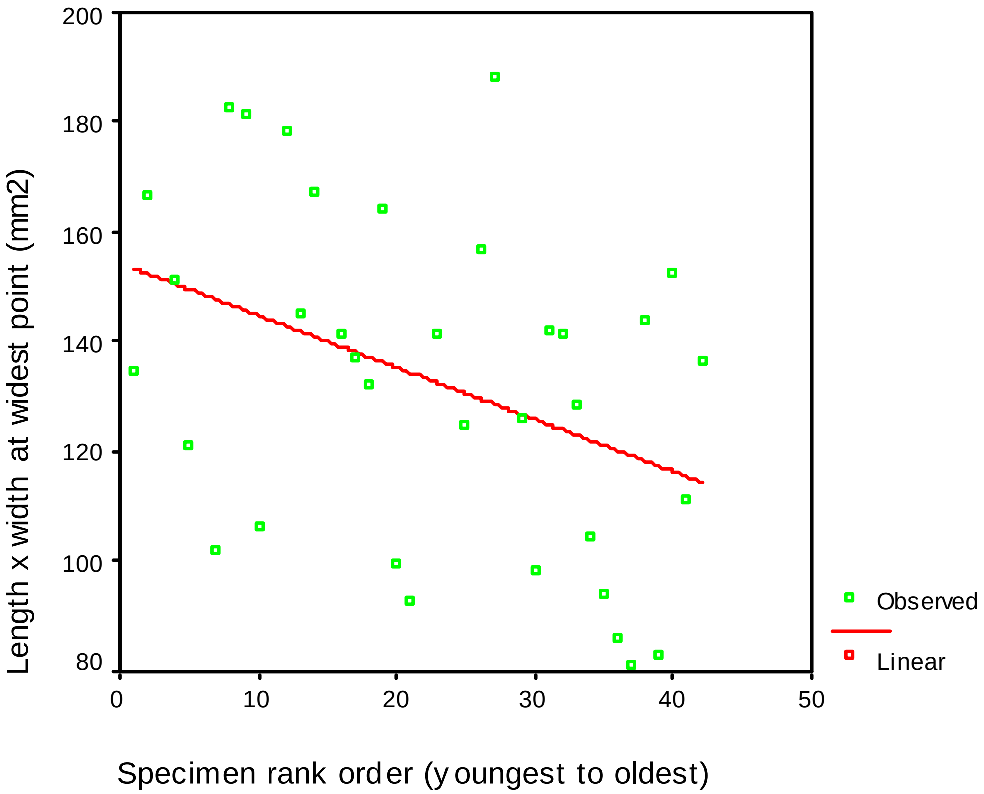
Rsquare = .029, Significance (p) = .018
Total number of specimens = 189
Strata Ia-b (n=66), IIc-d (n=98), IIId-f (n=10), IVb (n=4), Va (n=9), VI (n=1), VIIa (n=1)

Figure 38 Avocado (*Persea*) seed lengths (mm) and best fit regression line.



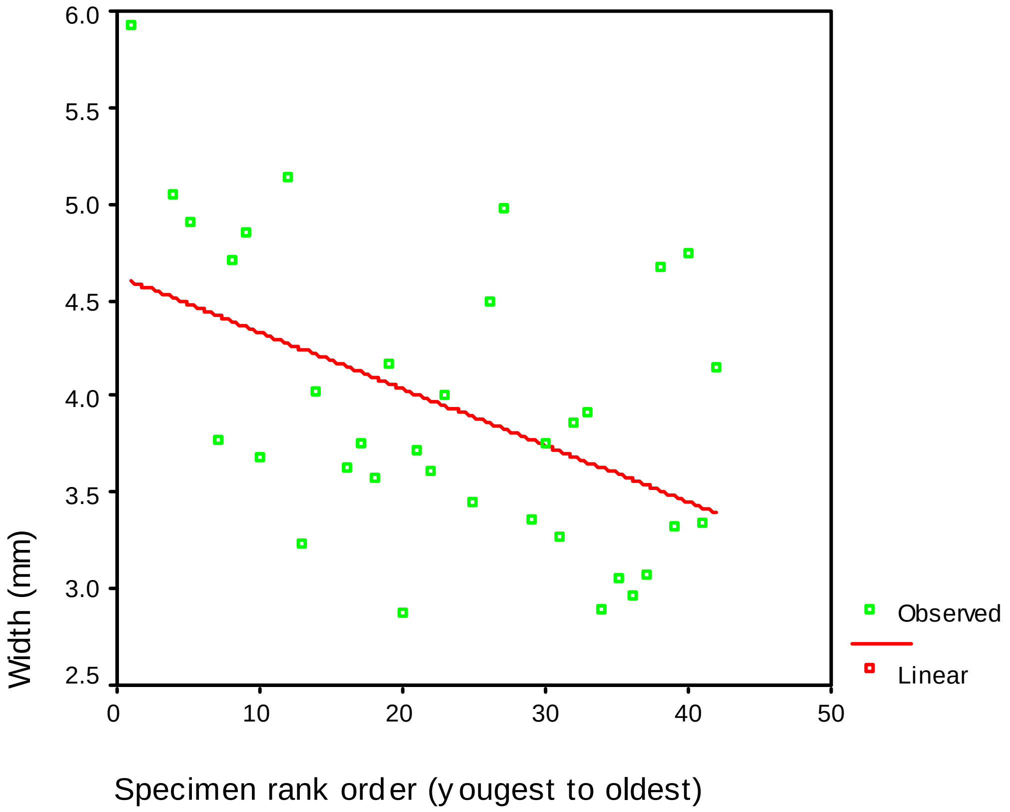
Rsquare = .175, Significance (p) = .009
Total number of specimens = 42
Stratum Ia-Ic (n=22), IIa-IId (n=3), IIIc-f (n=7), IVa-b (n=6), V (n=3), VI (n=1)

Figure 39 Squash (C*ucurbita* sp.) seed size (mm2) and best fit regression line.



Rsquare = .154, Significance (p) = .020
Total number of specimens = 42
Strata Ia (n=20), Ib-c (n=18), IIa (n=2), IIc (n=2)

Figure 40 Squash (*Cucurbita* sp.) seed neck (proximal end) width (mm) and best fit regression line.



Rsquare = .220, Significance (p) = .004
Total number of specimens = 42
Strata Ia (n=20), Ib-c (n=18), IIa (n=2), IIc (n=2)

Figure 41 Comparison of *Cucurbita pepo* seed size

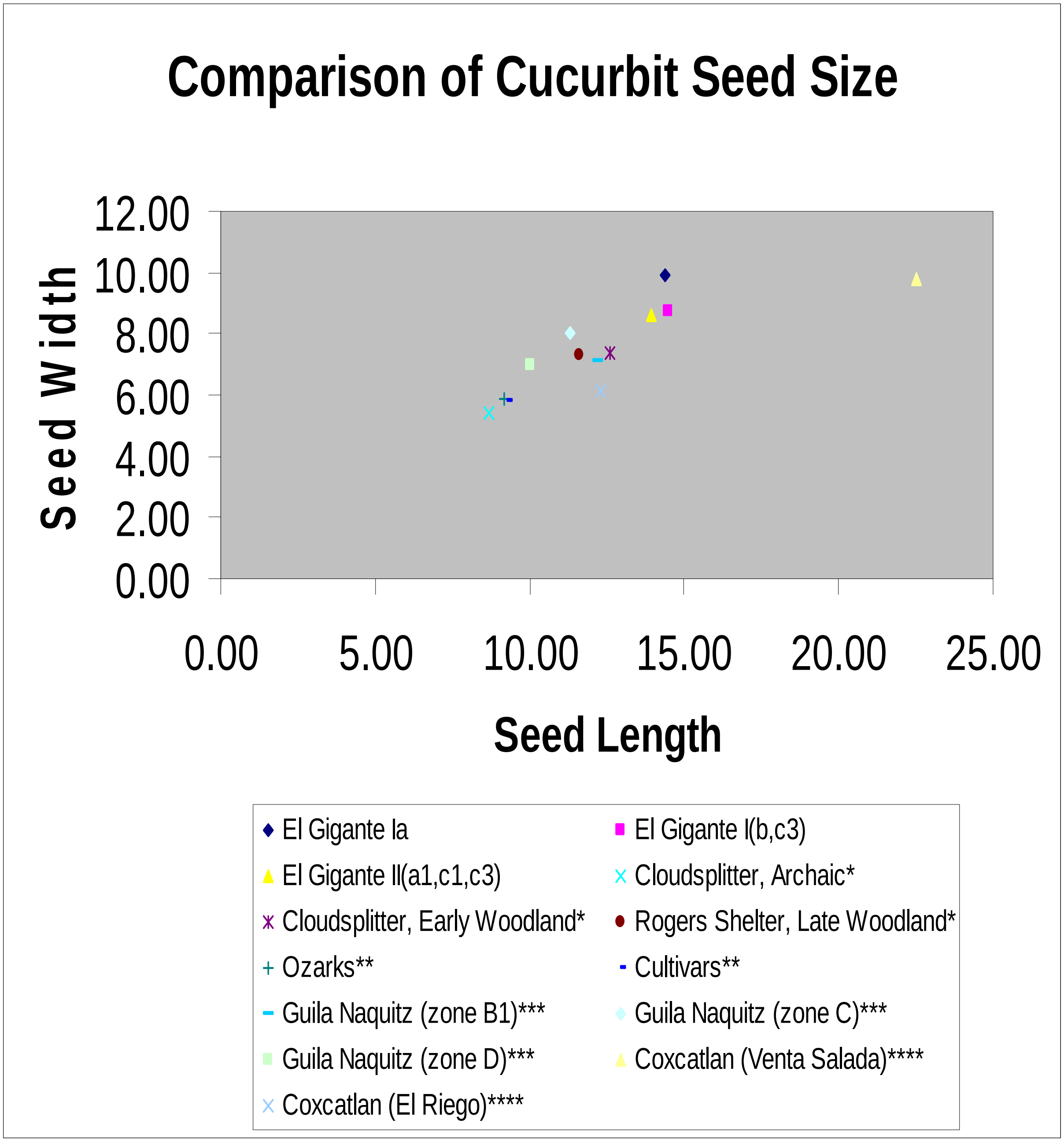
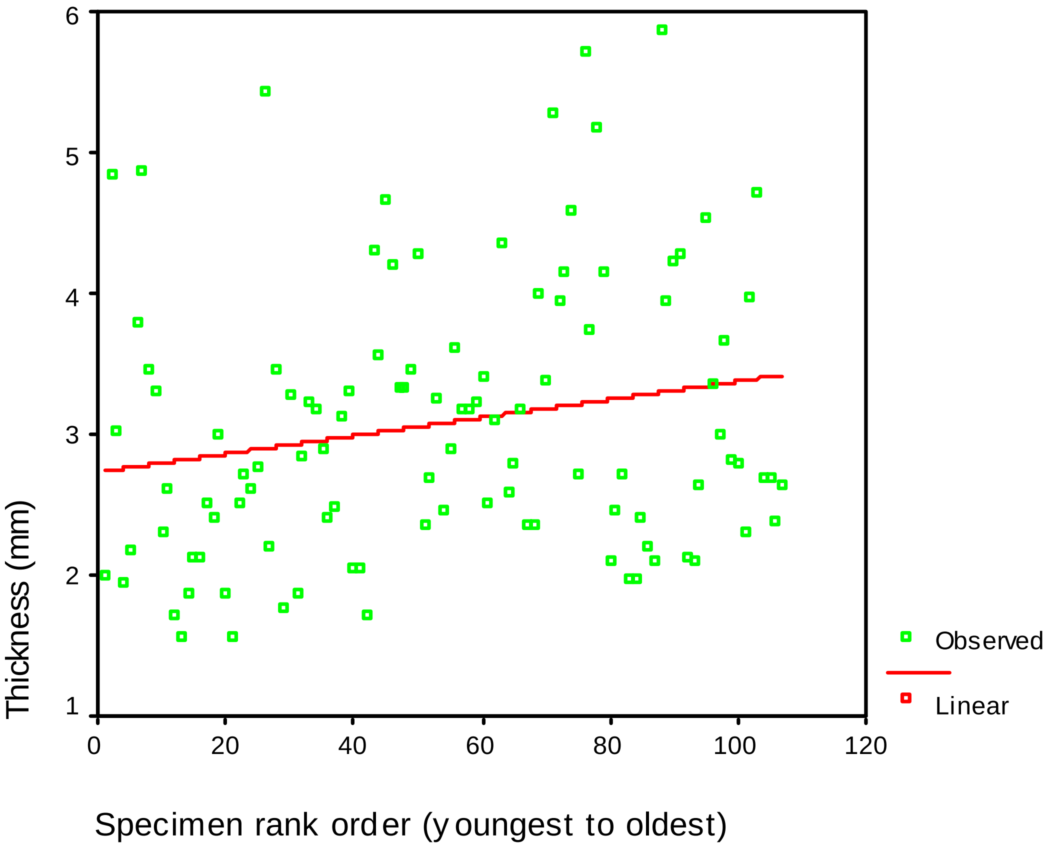


Figure 42 Gourd (*Lagenaria*) fruit/rind wall thickness (mm) and best fit regression line.



Rsquare = .042, Significance (p) = .034
Total number of specimens = 107
Strata Ia-c (n=81), IIa-d (n=20), IIIc-d (n=6)

Figure 43 Whole maize cob lengths (mm) by stratum.

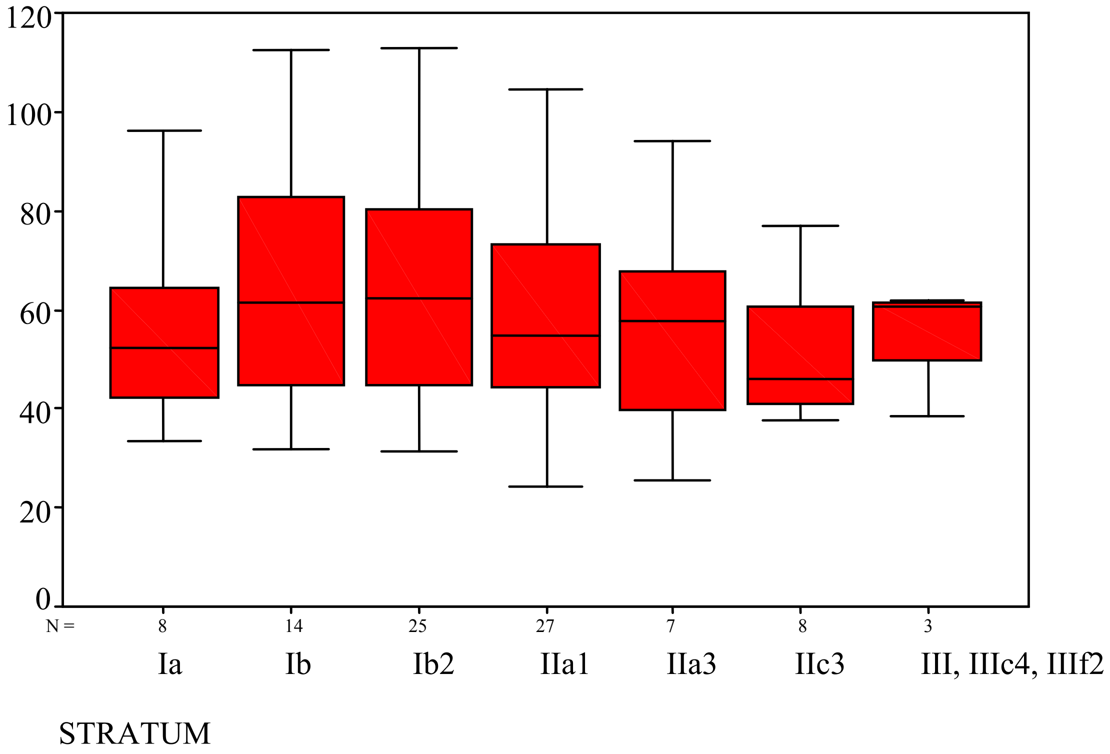


Figure 44 Maize cob diameter at mid-section (mm) by stratum

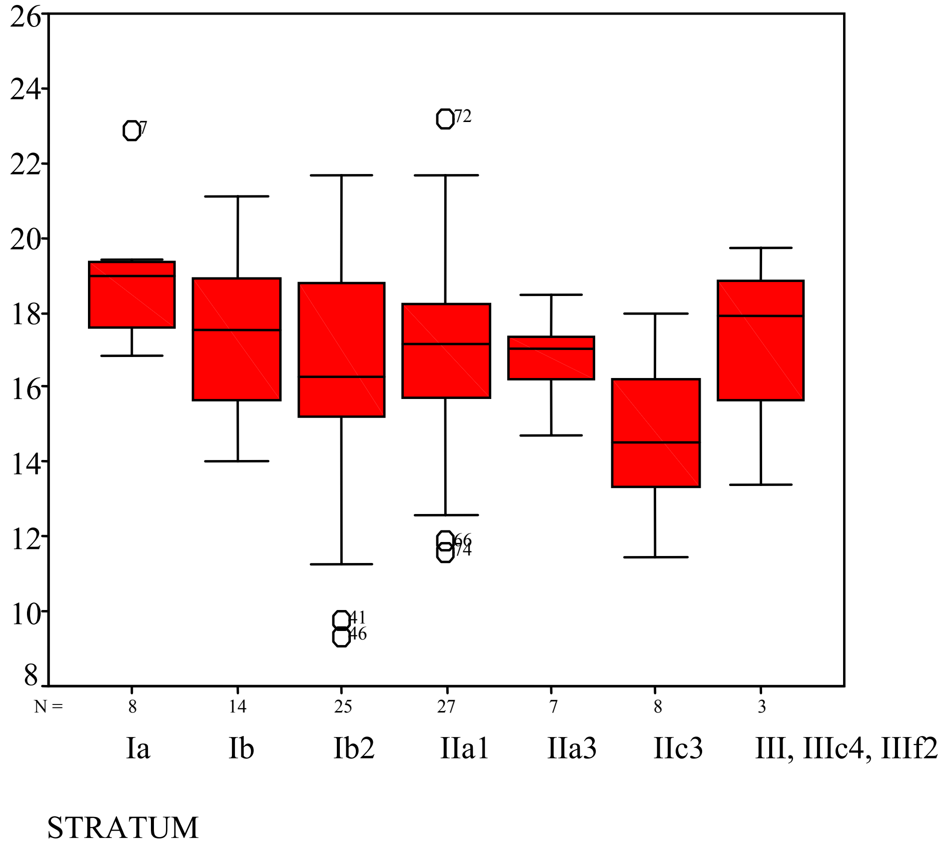


Figure 45 Whole maize cob row #'s by stratum.

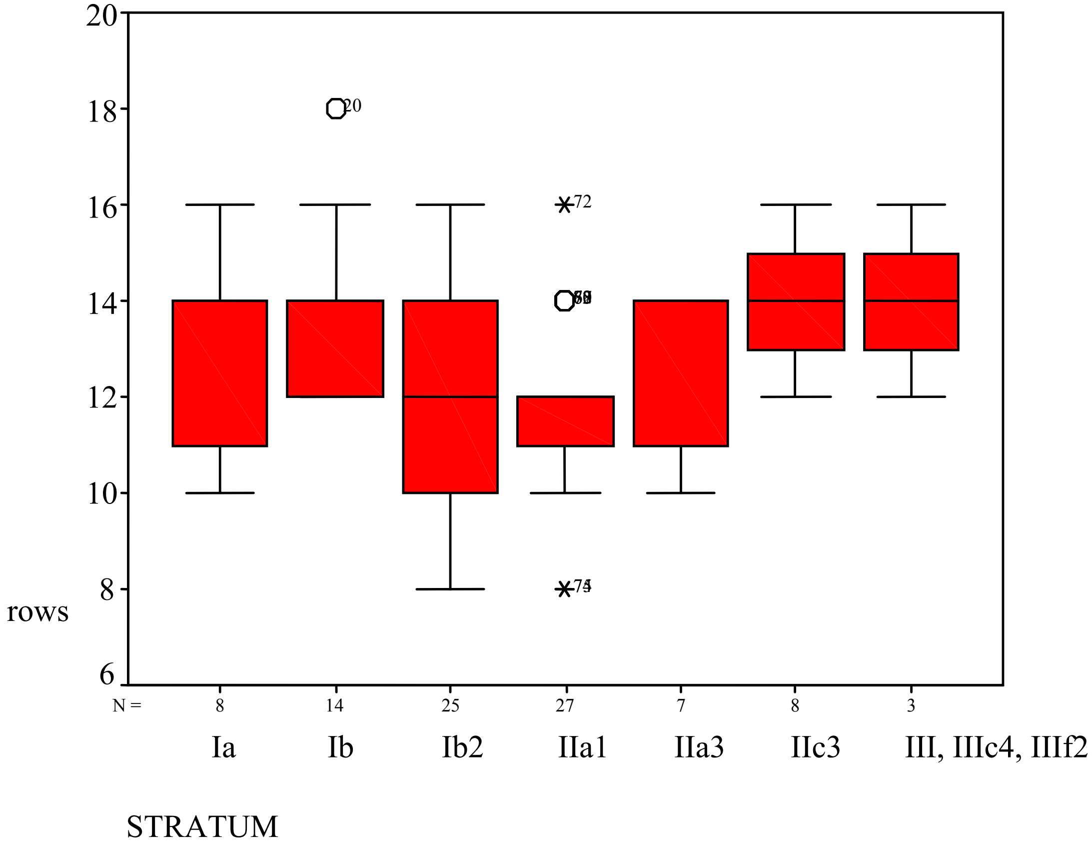
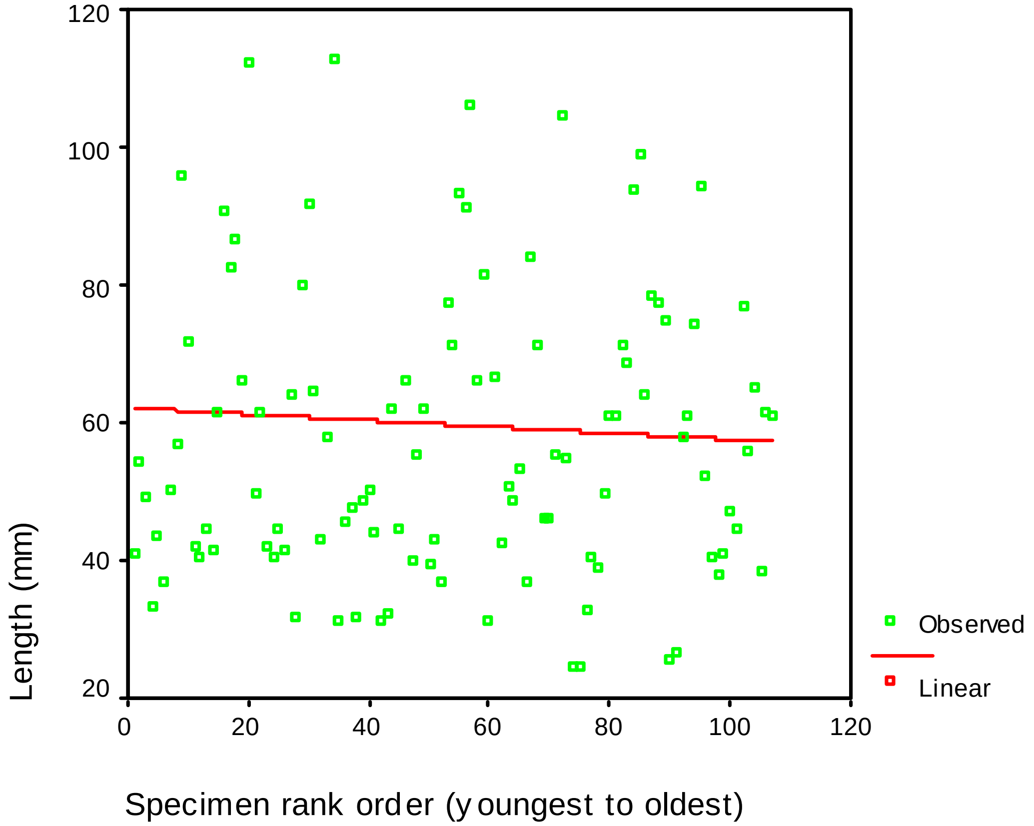


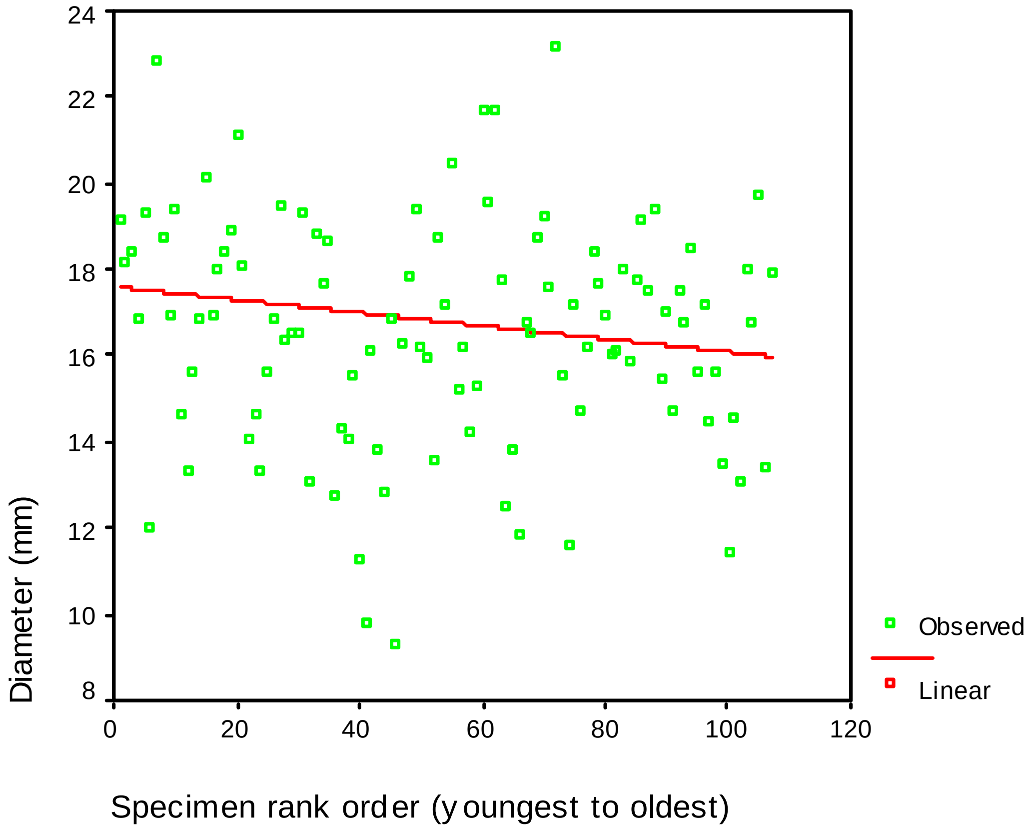
Figure 46 Length of cobs (mm) and best fit regression line.



Total number of specimens = 107
Strata Ia (n=10), Ib (n=18), Ib2 (n=33), IIa (n=28), IIa3 (n=7), IIc3 (n=8), IIIc-f (n=3)

ANOVA Results:
R-square = .005, Signif. (p)= .523

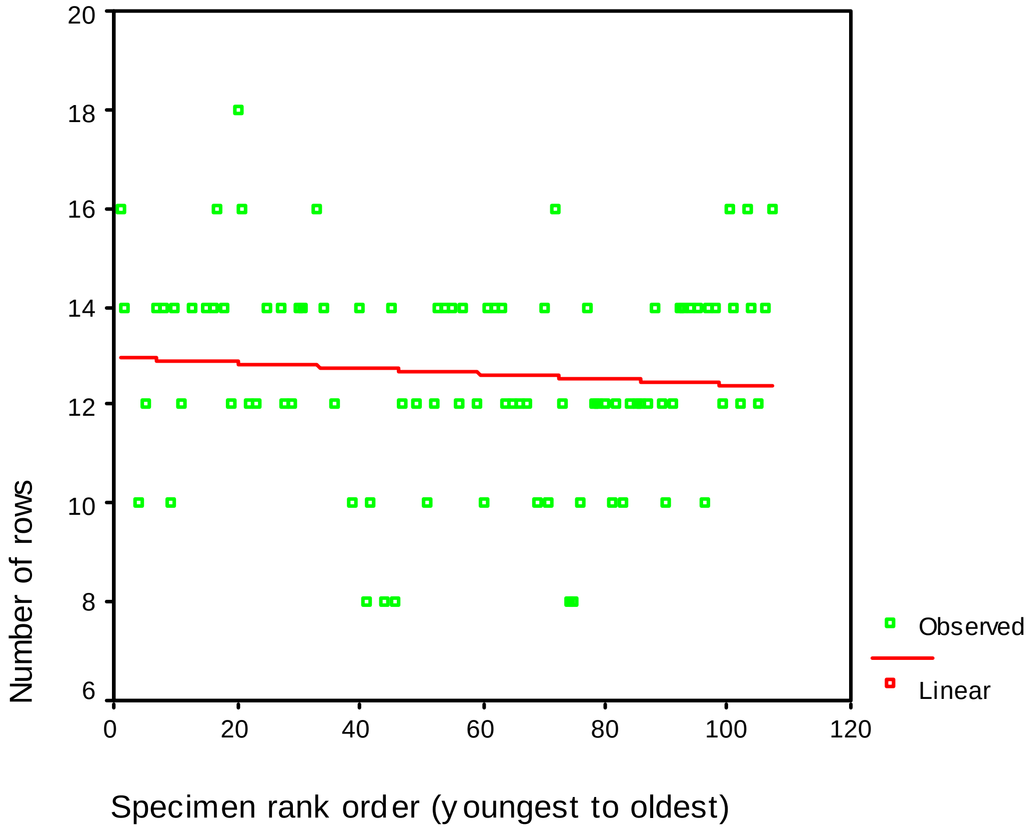
Figure 47 Diameter of cobs (mm) and best fit regression line.



Total number of specimens = 107
Strata Ia (n=10), Ib (n=18), Ib2 (n=33), IIa (n=28), IIa3 (n=7), IIc3 (n=8), IIIc-f (n=3)

ANOVA Results:
R-square = .031, Signif. (p) = .094

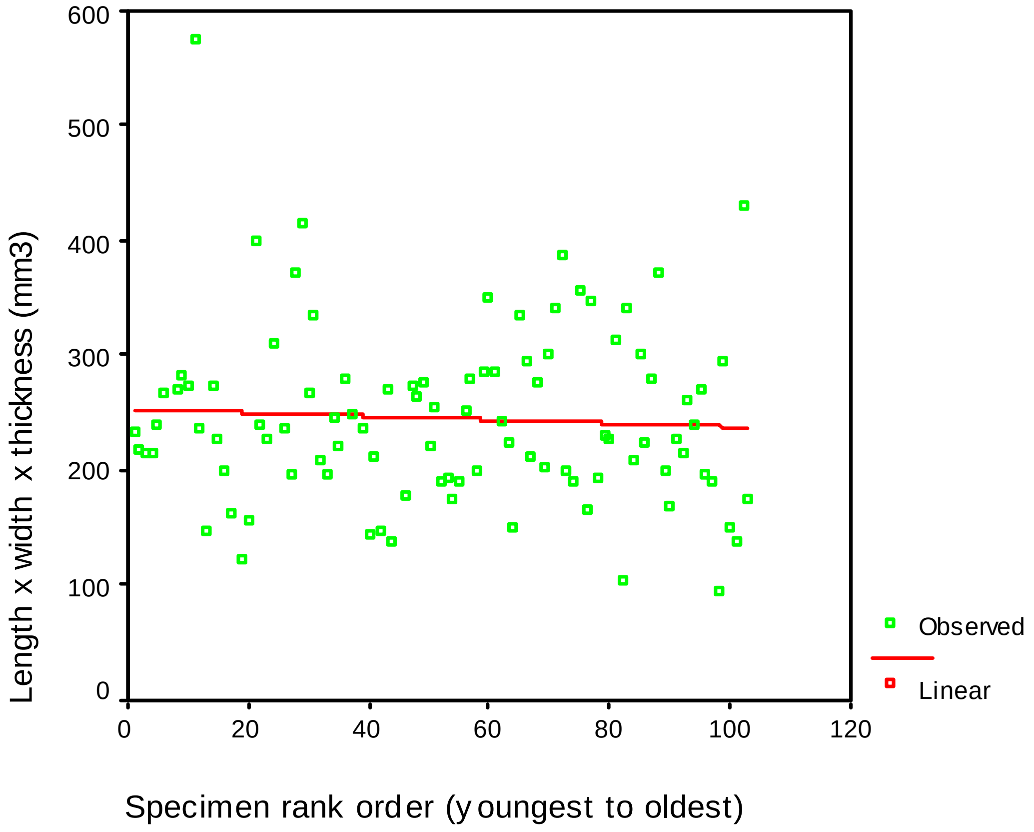
Figure 48 Row number for cobs and best fit regression line.



Total number of specimens = 107
Strata Ia (n=10), Ib (n=18), Ib2 (n=33), IIa (n=28), IIa3 (n=7), IIc3 (n=8), IIIc-f (n=3)

ANOVA Results:
R-square = .007, Signif. (p) = .433

Figure 49 Bean (assumed *Phaseolus* sp.) sizes (mm3) and best fit regression line.



Rsquare = .004, Significance (P) = .553
Total number of specimens = 103
Strata Ia-c (n=36), IIa-d (n=67)

Figure 50 Graph of botanical assemblage species richness by stratum (assuming representative categories)

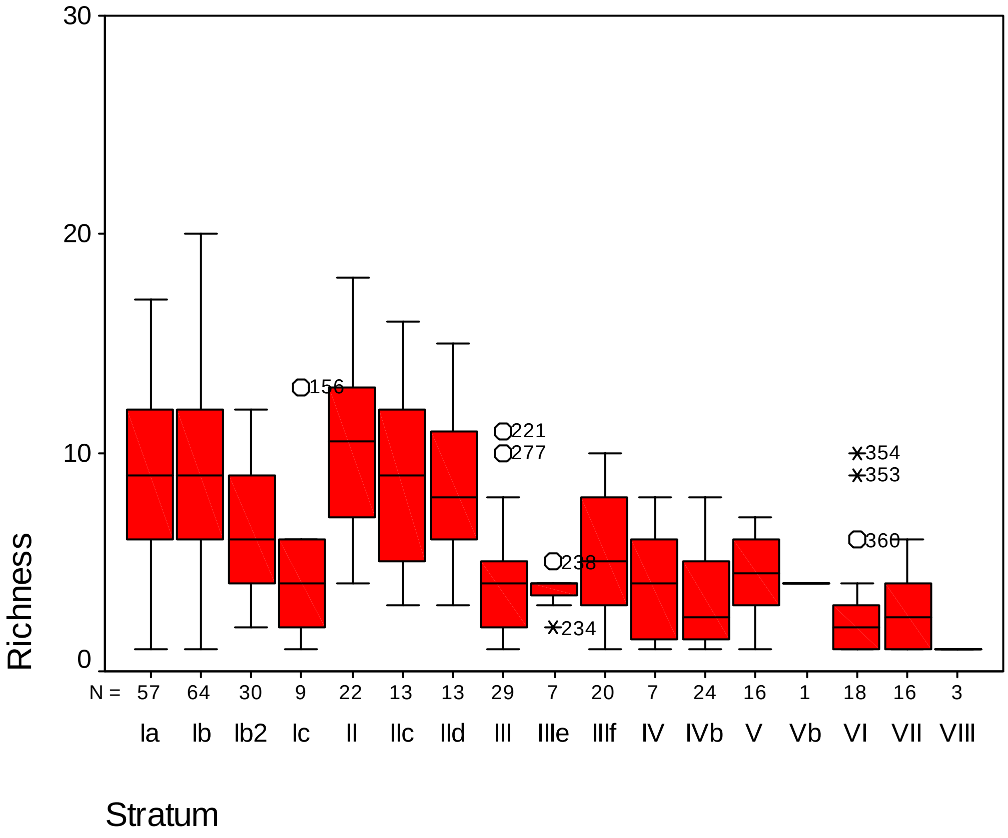


Figure 51 Graph of the Shannon Weaver Index of diversity by stratum (assuming representative categories).

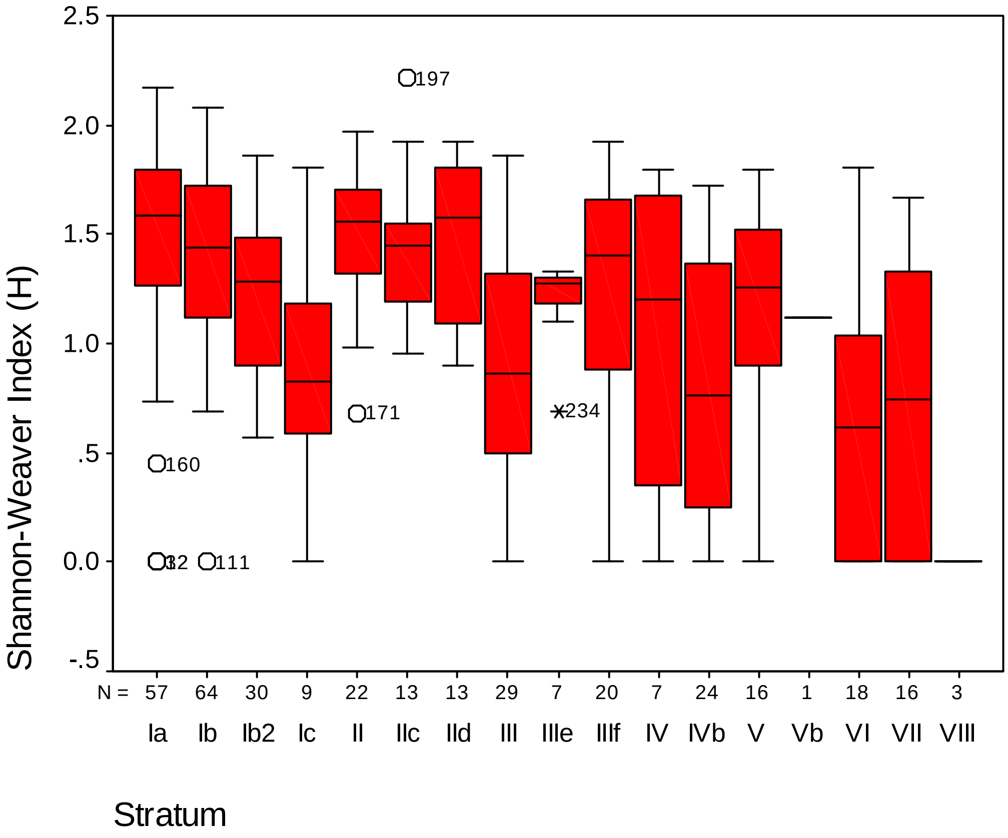


Figure 52 Graph of the Simpson's Index of diversity by stratum (assuming representative categories).

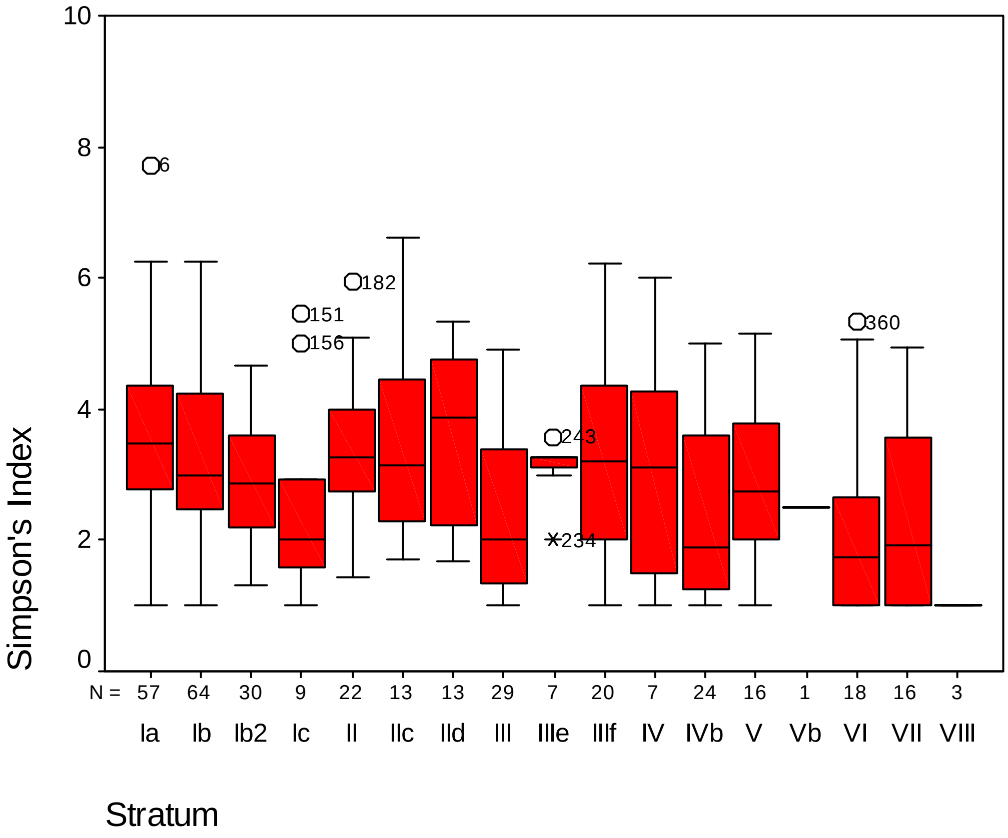


Photo 43 Quid, (dated material from Unit 3, Level 28: Stratum VI).

Photo 44 Agave plant parts

Photo 45 Hog plum, hairy and skeletal specimens

Photo 46 *Manilkara* sp. or *Sideroxylon* sp.

Photo 47 Avocado rind

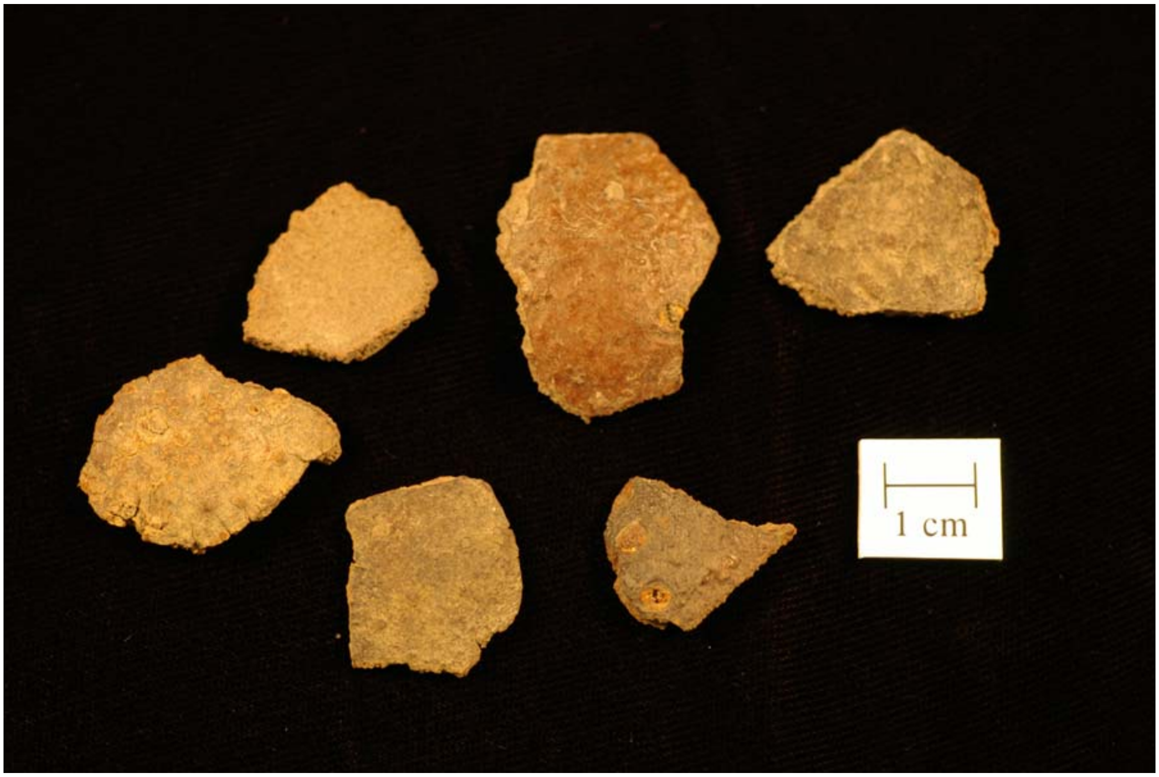


Photo 48 Avocado pit

Photo 49 Palm remains

Photo 50 *Pouteria* sp. remains

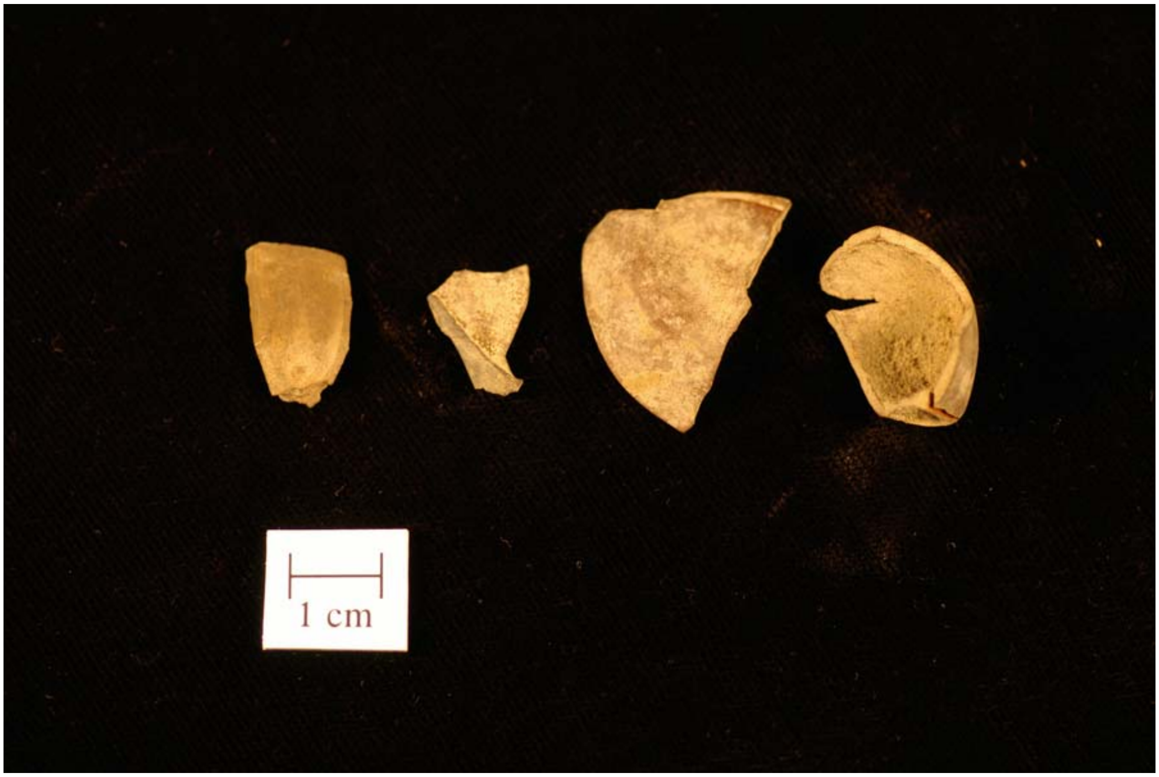


Photo 51 Wild bean pods

Photo 52 Acorns

Photo 53 Rind 10

Photo 54 Large seed 2

Photo 55 Large seed 3

Photo 56 Large seed 5

Photo 57 Squash (cf. *C. pepo*) rind 4

Photo 58 Squash (cf. *C. pepo*) seeds

Photo 59 Bottle gourd rind

Photo 60 Bottle gourd seeds

Photo 61 Custard apple

Photo 62 Hackberry

Photo 63 Rind 5

Photo 64 Medium seed 3

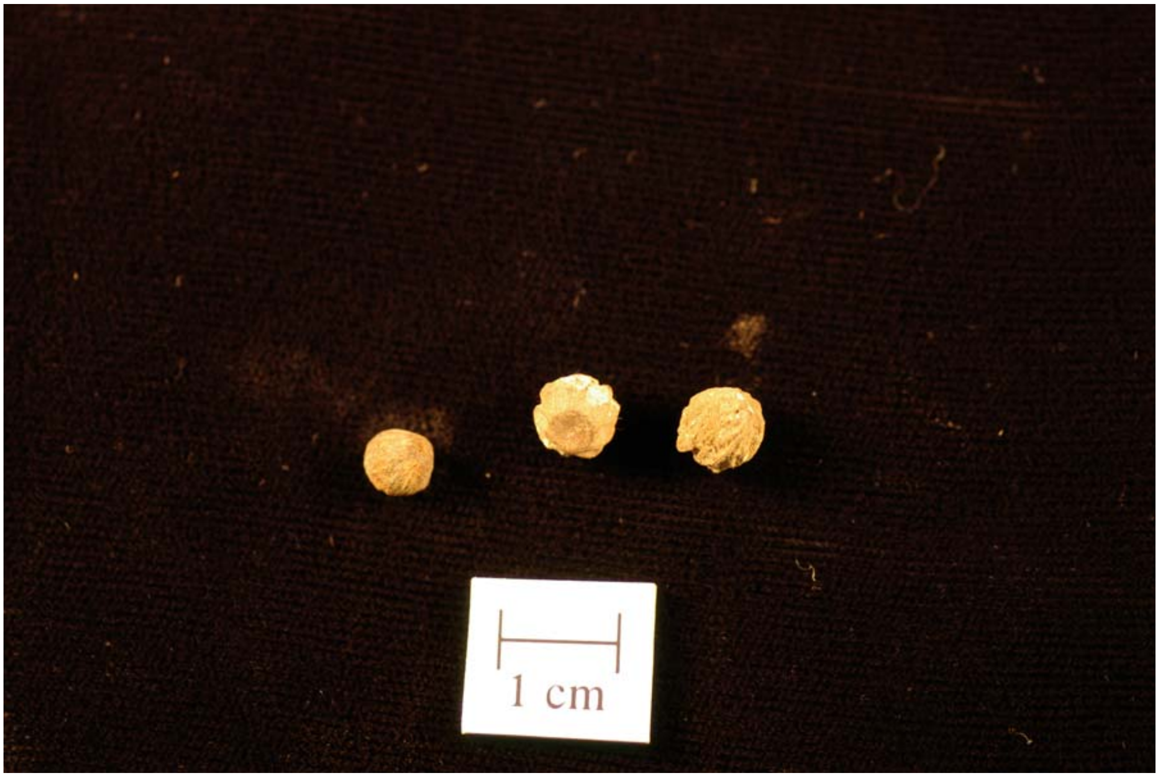


Photo 65 Medium seed 12

Photo 66 Medium seed 19

Photo 67 Large seed 12

Photo 68 Common bean (cf. *P. vulgaris*)

Photo 69 Cacao (?)

Photo 70 Arboreal legumes

Photo 71 Rind 7

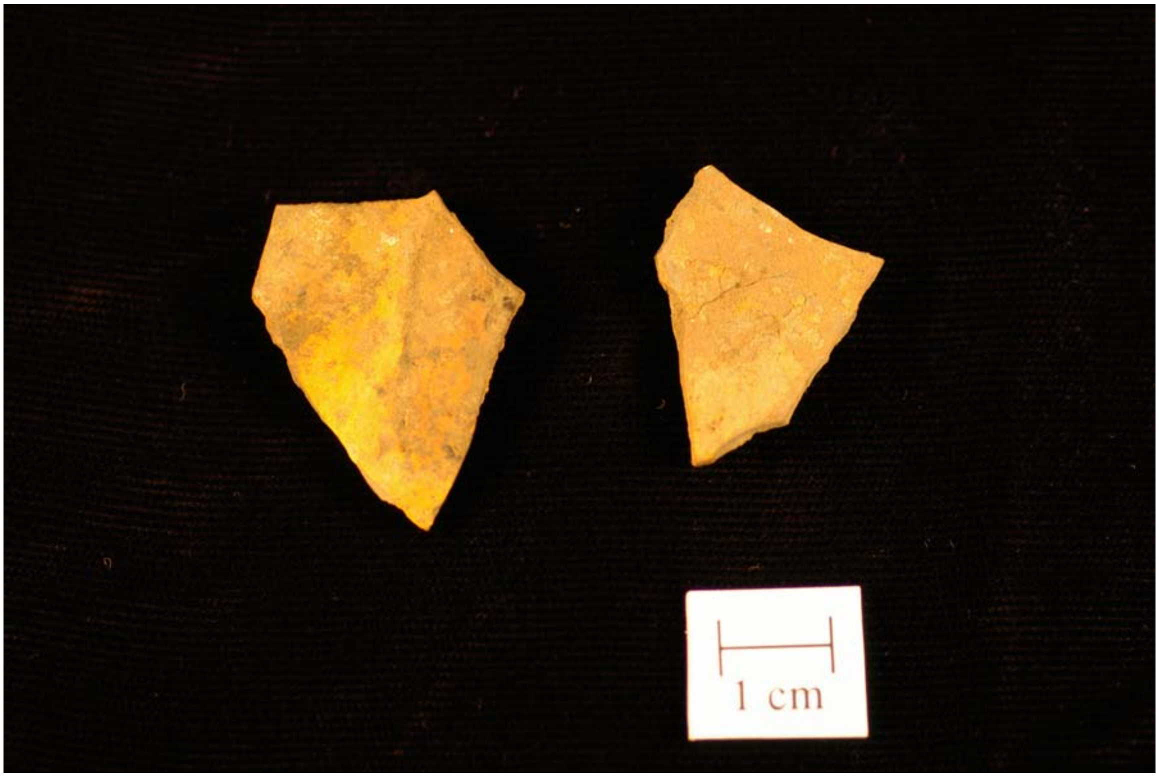


Photo 72 Small seed 1

Photo 73 Small seed 4

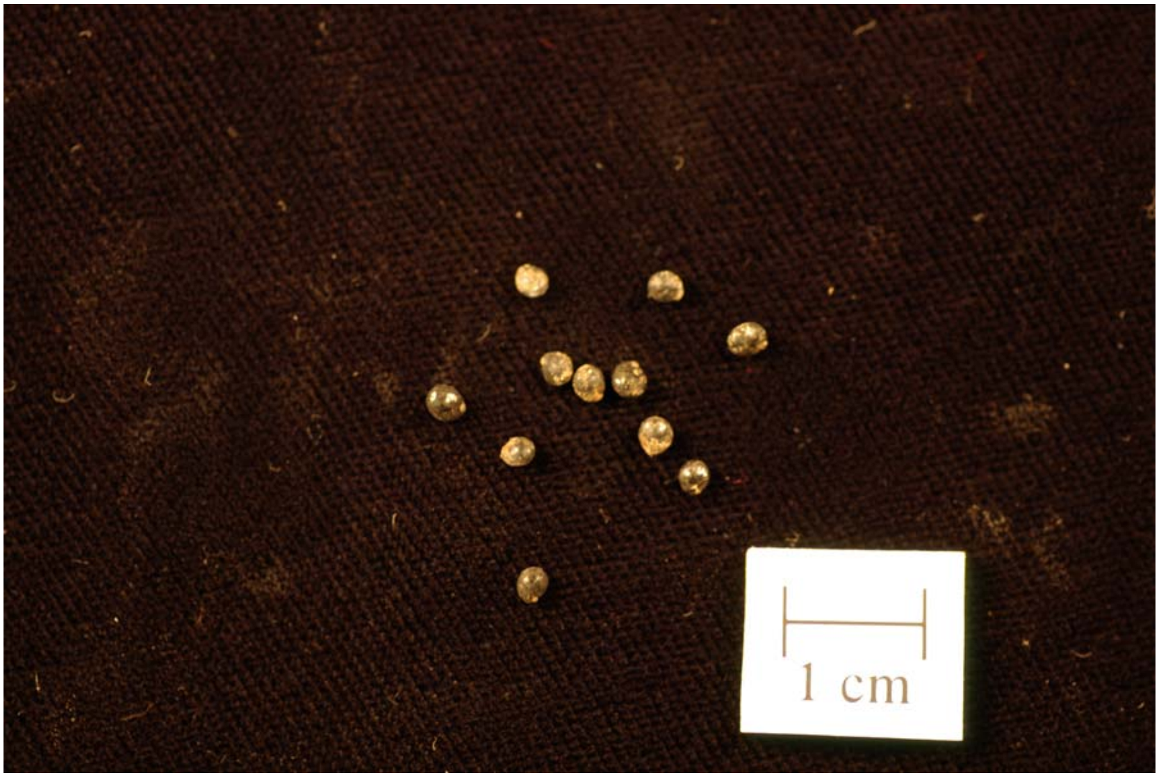


Photo 74 Medium seed 7

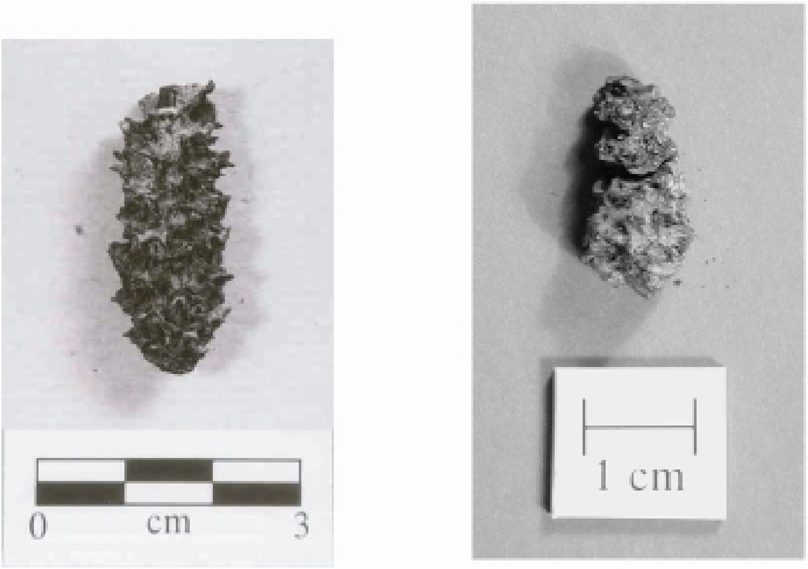
Photo 75 Medium seed 11

Photo 76 Medium seed 9

Photo 77 Medium seed 17

Photo 78 Large seed 10

Photo 79 Dated cob (*Zea mays*) fragments



Cob 2-14b
400 - 350 BC and 310 - 210 BC
(2-sigma calibrated AMS date)

Cob 18-20
100 BC - AD 70
(2-sigma calibrated AMS date)

Photo 80 "T" seed, *Manihot* sp. or *Jatropha* sp.

CHAPTER 7: DISCUSSION AND CONCLUSIONS

The purpose of the current work at El Gigante was to document the age and character of the material remains recovered from excavations carried out by the author in 2001. This, and a definition of the contexts in which these remains were found, are the first necessary steps in a broader anthropological examination of socio-cultural change at El Gigante and its broader region. A major focus of this dissertation has been the examination of the plant remains and how they reflected subsistence practices and local processes of plant domestication.

Prehistoric domestication was a function of random genetic mutation acted upon by human and natural selection leading to the differentiation of a single species into two genotypically and phenotypically distinct populations. Because this Darwinian process played out gradually, the focus of this study was not on the identification of domesticates, *per se*, but on quantifying measurable morphological effects of human selection on plants that were used by prehistoric populations over thousands of years. Of course, natural selection also continues to affect individuals in these populations, however, we assume for the purpose of the thesis that that the dominant selective force originates from human facility.

The El Gigante site presents a case in which human behavior and thus, the appearance of domesticates like maize, beans and squash, were conditioned by scheduling requirements, biogeography, and demographic pressures. This concluding chapter first outlines a number of comparative examples (ethnographic and archaeological) in which a particular plant's reproduction and genetic potential are assumed to have been manipulated by humans for many generations *without* a resulting morphological change, nor accompanied by the loss of the plant's ability to survive in a "wild" state. Thus, I argue that a whole class of undomesticated (*sensu* Smith 1995:19) plants were used prehistorically, that nevertheless were manipulated for the purpose of directing more energy toward human consumption. This constitutes neither pure foraging (if there ever was such a thing), nor formal farming, but a middle ground that seems to have been a successful strategy at El Gigante for millennia. The remaining discussion in this chapter concerns the subsistence trends observed and inferred from the El Gigante material by archaeological phase. In particular, three general models are applied to the El Gigante case. Dyson-Hudson and Smith's (1978) model of economic defensibility and territoriality is brought to bear on the possible dynamics of land use and tenure in the Archaic. Binfordian (1980 and 2001) predictions based on measured environmental parameters and assumed past parameters are compared with the archaeological data sets. Finally, I consider the possibility that a successful arboreal and extensive home garden-based subsistence mode in El Gigante's highland context forestalled the establishment of agro-ecosystems like those found in adjacent lowland contexts.

Variability in Food Production Systems

The El Gigante rock shelter is one of very few sites in Mesoamerica with a lengthy archaeological sequence that is appropriate for the investigation of long term cultural-ecological adaptation. The early culture history for this peripheral region of Mesoamerica is largely unexplored, and this study was first designed to answer fundamental questions of how a local, hunter-gatherer population of the Archaic period capitalized on the variable environmental possibilities presented to them throughout more than nine thousand years of environmental change. In order to do this I documented as best as was possible (given limited radiocarbon dates) the chronological development of specific cultigens, from their first appearance (in some cases since the Paleoindian period) through the Formative period.

The transition to a sedentary agricultural economy marked a significant turning point in the history of human relationships with the environment. This change heralded the almost complete domination of the natural landscape by humans. The domestication of plants and animals effectively expanded the carrying capacity of our environment and affected our fitness as a biological species. Human fitness and domesticates' fitness are linked, since by definition, domesticates cannot survive on their own (Smith 1995:19; Piperno and Pearsall 1998:6). The relationship between human groups and plants that were neither fully “wild” nor "domesticated," but whose survival was encouraged by foraging humans, is difficult to map (Terrell *et al.* 2003). Archaeologists must be particularly careful not to ignore the potential influence of behaviors that leave no archaeological trace, nor let definitions guide the research where they should be serving its progress.

In terms of permanent, field-based intensive strategies El Gigante was likely a marginal area. On the basis of the available evidence, the complete shift to an agro-economy based on maize, beans and squash (which were adopted and/or domesticated separately over a broad timespan) was relatively late at El Gigante. There is, though, a stratigraphic gap in the sequence that may render this impression false.

El Gigante serves as a test case for many formulations concerning the “origins of agriculture.” For example, Zvelebil (1994, 1995, 1996) proposes that in marginal environments a “substitution phase,” exists between the “availability” and “consolidation” of agricultural practices, and that generally this phase proceeds rapidly. Because of the diversity and number of potential “crops” both annual and perennial available in Mesoamerica, Zvelebil’s model may be more appropriate at describing the adoption of individual crop plants in this case but, not an entire subsistence strategies. El Gigante also provides a case that exemplifies the strength of a similar, local and particularistic perspectives, such as is employed by Zeder (1994) in the context of Old World adoption of domesticated animals (see below)

The situation at El Gigante fits well with the formulations of Harris (1978, 1989, 1996) in which multiple food procurement systems operate but, are not mutually exclusive. The entire subsistence regime can only be understood with reference to all procurement systems and how they worked together. The El Gigante sequence shows how the core plant diet evolved from Paleoindian times by the elaboration of some systems (tree crops), the retention of others (*maguey* harvesting), and the adoption or innovation of yet more (squash and other domesticated resources). These are termed “plant using traditions” by Zvelebil (1996). Individual systems of plant exploitation must be examined independently before sense can be made of their articulation into a coherent system of food production.

A myriad of horticultural and cultivation practices preceded and continued to be used in addition to permanent or shifting field farming of keystone domesticates. Some of these food production systems incorporated species unfamiliar to New World colonists and have been neglected in favor of an emphasis on systems (*i.e.,* grain production) more familiar to western agricultural practices (Leach 1997). Whether or not this is the result of ethnocentric bias is debatable but, the trend is noted by Drennan (1996). The often implicit assumption that the appearance of maize will "spark major changes in subsistence and social organization" is regrettable but has a "momentum" which leads to a "focus largely on the spatial patterning of the earliest dates for different cultivars, especially maize, without really attempting to deal with the subsistence dynamics of any region" (Drennan 1996:104).

It would not be accurate to describe the Archaic as a period of simple hunting and gathering, lacking the sophisticated or planned food *production* activities found during the Formative. Instead, the Archaic peoples should be considered in their capacities as landscape managers, gardeners and horticulturalists, who skillfully manipulate and produce food with a goal of increasing or producing a more reliable harvest. In essence they are “domesticators” without the benefit of domesticates. These goals and strategies have been until recently, prominent in many surviving or ethnohistorically documented traditional cultures around the world. The Kumeyaay of California (Shipek 1981), Nukak (Politis 1996, 2001), Kayapó, Guaja, Kaapor (Balee 1989, 1992, 1994), and Hotí of Amazonia (Zent and Zent 2002), the Malukan islanders (Latinis 2000), Nuaulu (Ellen 1988) and other groups in Southeast Asia and Near Oceania (Yen 1985, Lepofsky 1992, Kirch 1989) are some examples in which the edges of the home garden are difficult to discern from the beginnings of the plantation.

Food production strategies cannot be fully appreciated if we adhere to a simple dichotomy of domesticate versus non-domesticate. For example, O'Connell *et al.* (1983) describe Australian aborigines who, when collecting *Dioscorea* sp. tubers, replace a portion of the plant in the ground so that it will regenerate the following season. While no phenotypic selection occurs, the harvested tuber population is given a relative reproductive advantage over those tubers eaten by non-human predators. Perhaps one of the best documented instances of wild food augmentation and management are the California Kumeyaay. Florence Shipek (1981) describes them as having altered their landscape on a massive scale. For example, the Kumeyaay planted oak groves (an "undomesticated" tree) to boost the annual acorn mast (Basgall 1987). Another example is the Great Basin Paiute who irrigated piñon pine stands to increase the reliability of that resource (Steward 1934).

In all of these instances humans have promoted an environmental context that is deliberately altered and more productive than "the wild" landscape. Evidence for this type of behavior in Honduras is available in Ephraim Squier's 1855 account of the indigenous people of Honduras and El Salvador, where he comments that:

> ". . . much lower in civilization. . . termed wild Indians. . . they wander to and fro as they list, making plantations which, in the course of a certain number of moons, they revisit to gather the fruit." (Squier 1855:205)

Although Squier does not specify what types of fruits they planted (and he may well have been referring to maize), we might infer a mix of low labor annuals and perennials similar to what is evident archaeologically at El Gigante. While these types of transient behaviors do not constitute agriculture, neither were prehistoric foragers wholly reliant on "wild" foods. Many "foragers" are in fact "food producers" in the sense that they (often consciously) effect changes in the landscape including the distribution and density of foods that make them more abundant and accessible (if not "domesticated"). Humans are active participants in shaping their surroundings' productive potential and sometimes in the diversity of the ecological communities that make up the landscape (*cf.* Zent and Zent

2002).

The difficulties in describing and comparing food production economies that are neither fully foraging, nor fully farming-based are exemplified in archaeological cases across the globe. Similar patterns of variability in the "bearing and pace" (Zeder 1994) of subsistence evolution are evident archaeologically in regions as far removed from El Gigante as Colombia, Eastern North America, Northern Europe, and Northern Mesopotamia.

Research in Colombia has revealed evidence of 10,000 years of human modification of the landscape (Gnecco 1998). The evaluation of pollen cores from Sauzalito, Colima, and at San Isidro, Valle de Popayan, reveal the presence of disturbance-adapted vegetation and the dominance of fire regimes. These open forest vegetation communities likely have no modern analog (Gnecco 1998:50). Among other species, palm fruits are a central component of the subsistence system and species such as the *coyol* palm are thought to have been artificially concentrated in the area.

Gnecco (1998) does not argue that this sort of landscape modification implies domestication or agriculture but, neither does he exclude the possibility. Pollen and fire data are not the only lines of evidence that Gnecco uses to formulate his hypothesis. He notes the presence of domesticated avocado and bottle gourd together with specialized stone axe forms and ground stone technology which indicates a focus on forest clearing and the processing of rhizomal plants such as arrowroot (*Maranta arundinaceae*). This adaptation goes back as far as the Pleistocene-Holocene boundary at Colombian sites (Gnecco 1998:54). Gnecco suggests that the ultimate adoption of maize would have been impossible without an *existing* environmental and forest management system within which the novel species could be efficiently integrated (Gnecco 1998:55). A complementary scenario is presented for foraging groups of the La Plata Basin in Uruguay (Iriarte *et al.* 2004). Early cultivars were adopted here during a dry phase of the mid-Holocene, and sedentism is evident at the mound complex site of Los Ajos as early as 4,190 radiocarbon years BP (*ibid.*).

In Eastern North America, the foundations for food production systems that included domesticated native crop plants were established in the Archaic as well (Fritz 1990:391). By 4000 B.P., sumpweed or, marshelder (*Iva annua* var. *annua*) fruits found in archaeological sites had become larger on average than the wild phenotype (Fritz 1990:391). By the Early Woodland times, four seed plants had been brought under domestication, squash (*Cucurbita pepo*), chenopod (*Chenopodium berlandieri*), marshelder (*Iva annua*) and sunflower (*Helianthus annuus*) (Smith 2001:224). There are however questions concerning a "companion set of eastern seed plant species" that do not show signs of morphological change necessary to be included as domesticates but were of clear economic importance (Smith 2001:225). These include erect knotweed (*Polygonum erectum*), little barley (*Hordeum pusillum*), and maygrass (*Phalaris caroliniana*). Fritz (1990) found that:

> "Cave and rock shelter sites in central and eastern Kentucky have yielded unequivocal evidence for diets high in seeds of the native crop group by 2500 BP [550 B.C.], primarily sunflower, sumpweed, chenopod, and pepo squash. . ."

The systematic use of flotation methods, increasing AMS dating, and genetic studies have fostered the importance of the domesticated native seed component in the Eastern Agricultural Complex. By highlighting regional differences in eastern North America, Fritz (1990) rejects the idea that maize-focused agricultural systems were the catalysts to the rise of Mississippian chiefdoms. For example, at the site of Fort Ancient, in the Ohio River Valley, she notes that the seed component of the diet was minor and that maize consumption was substancial. She contrasts this with the near absence of maize south of 34 degrees latitude (south of northern Alabama). The Poverty Point site in the Lower Mississippi Valley was once thought to have had an agricultural base (*ibid.*) as early as 2050 B.C. Upon reevaluation, domesticates did not seem to become important until much later (Fritz 1990). In the southeast region in particular, subsistence systems might have been significantly invested in wild and managed stands of nut bearing trees, especially acorn bearing oaks (Fritz 1990:418). These, in addition to the companion non-domesticates maygrass and little barley, were important components in the complex of domesticated and non-domesticated plants that comprise the subsistence system. The variation and unique combinations of resources both locally derived and received, domesticated and non-domesticated create dynamic “multiple regional mosaics” (Smith 2001:202) of the transition to food production.

A call for re-examination of subsistence variability in the archaeological record has come from Gremillion and Sobolik (1996). Instead of using the conventional long-term analytical framework which emphasizes the transition from foraging to farming, they examined coprolite data from Salts Cave and Mammoth Cave in Kentucky for evidence of short-term and seasonal variation. The paleofecal analysis suggests that around 3,000 BP there was a consistent use of crops as well as a consistent range of crop species in the dietary sample. These crops include not only sumpweed, sunflower, goosefoot or lambsquarters, but also hickory nuts and other tree species. All were storable thus could have their abundance extended beyond the season in which they were harvested.

Likewise, the transition from foraging to farming in Europe is hard to date and was not a straightforward process. Price and Gebauer (1992) suggest a four-stage scheme for the period from Ertebølle to Funeral Beaker traditions in Southern Scandinavia (*c.* 6,000 - 5,000 B.C.). In this region, the hunting and gathering lifestyle continued for 1,000 years longer than in other areas of southern Europe. This is particularly important because the lag at El Gigante may be due to similar driving forces. Price and Gebauer credit the extremely rich terrestrial and marine fauna of the region for the subsistence specialization that certain human groups developed in adapting to unique ecological niches. More interestingly, they suggest that foragers "pursued a pattern of economic exploitation and a degree of sedentism that extended the capacity of the environment" (Price and Gebauer 1992:107). This implies that these hunter-gatherers were *producing* food, not living off of a "wild" landscape. This is one of many possible "adaptive pathways" (Yen 1985) towards domestication and here is implied to have begun long before threshold domestication events of the Neolithic.

The site of Umm Qseir in Northern Mesopotamia provides my last example of the ambiguous character of early food production strategies. There is no doubt that a major subsistence shift took place after the Mesolithic. This change is not necessarily consistent with, or easily characterized by a simple, gradual or, linear transition from forager to farmer. Instead,

> “. . . the Neolithic revolution is marked, in all instances, by a departure from food procurement strategies to subsistence economies driven by an underlying definition of food resources as reproducible commodities." (Zeder 1994:121)

Zeder's explicit separation of the subsistence economy from the study of the

(Marxist) mode of production parallels the distinction I have tried to convey between domestication and agriculture. While subsistence may be described by listing the plants used, the behaviors under examination are only meaningful in the context of their interaction and integration in a more holistic system. Zeder arrives at her conclusion after a reexamination of Umm Qseir, a 5,000 - 6,000 year old site, outside the Halafian tradition. Based on faunal remains, which included both domesticated animals (sheep, pig, and goat) and wild game (gazelle, onager, cattle, and deer), Zeder demonstrates that hunted game was increasingly relied upon through 1,000 years of occupation. During this time, domesticated animal remains never exceed even half of the sample.

Previous interpretations of the site inferred a transitional pastoral occupation of an environmentally marginal habitat. In other words, it was described as a site of struggling “domesticators.” In contrast, Zeder interprets the pattern as one of successful pioneering forager-farmers. The occupants were still highly reliant on predictable hunting and did not intend to replace their adaptive strategy with known domesticated alternatives. She concludes that the more unpredictable (and/or marginal) the environment, the more eclectic the diet may become. This situation does not arise from the necessities of farming but, by choice, within the context of a flexible subsistence repertoire. The people of Umm Qseir were "expanding their resource base to include both produced and procured resources--in effect tailoring their subsistence economies in extremely individualistic ways to meet highly localized needs" (Zeder 1994:120). Zeder compares the Umm Qseir site, which received less than 250 mm of rain per year, to other Halafian sites of the time period where rainfall is greater than 300 mm/yr and where there is a consistently greater proportion of domesticated animals in the faunal assemblages. This situation may be relevant to El Gigante which can also be considered marginal in terms of arable land (see Chapter 3).

A Summary of Subsistence Activities at El Gigante

Esperanza Phase (9,220 B.C. - 8,300 B.C.)

C. Vance Haynes established the minimum acceptable criteria for a *bona fide* Paleoindian occupation (1969:714). This includes undeniable human activity, undisturbed geologic context, and unquestioned dates. El Gigante satisfies each requirement, with Paleoindian occupation evident on multiple grounds. Multiple dates from secure contexts on artifactually associated charcoal, and AMS dates on cultural material define the earliest occupation. Early occupation ranges from 9,210 - 9,600 radiocarbon years before the present. This calibrates to a two-sigma (95% certainty) corrected date as far back as 11,170 BP.

I use these dates as a working range of the probable Paleoindian habitation. The radiocarbon method relies on calibration to arrive at a calendar date and it is vulnerable to perturbations in atmospheric carbon over time. The terminal Pleistocene was particularly variable and frought with perturbations, which were especially large between 12,500 and 10,000 years BP (Fiedel 1999). These conditions mean that accuracy on the order of 500 years or so may have to suffice during this time period (*ibid.*)

Paleoindian subsistence economies are difficult to characterize because of preservational biases. These biases extend to the stereotypical (Paleoindian) Clovis site, the mammoth kill location. These sites invite inferences of a specialized big game adaptation (Walker *et al.* 2001). More recent research into Paleoindian occupations across the American continent has revealed this to be a false impression (see below) and has shown that Paleoindian economies, including those of Clovis, were often structured much more generally. Grayson and Meltzer (2002) report that of the 76 Clovis sites they review, only 14 actually have evidence of mastodon (2 sites) or mammoth kills (12 sites). At El Gigante, evidence was found for the exploitation of a wide variety of plants and small animals including waterfowl and aquatic fauna. The only three recent examples of similar findings include Monte Verde, Chile (Dillehay *et al.* 1989), Monte Allegre, Brazil (Roosevelt 1996) and Dust Cave, Alabama (Walker *et al.* 2001). Based on this investigation, it is likely that El Gigante Paleoindians hunted intensively and were somewhat technologically specialized (*e.g.*, their use of large projectile points) for this pursuit. However, they also foraged broadly to supplement their diet and maintained flexibility with respect to mobility (*sensu* Tankersley 1998).

The remains of game most often recovered at El Gigante was deer, although other large Pleistocene fauna were identified. The bovid teeth from very early contexts (see chapter 5) provide evidence of possible alternatives, though the preliminary examination of the faunal remains reported here provides no indication of butchered megafauna.

In Paleoindian times (>10,000 BP) El Gigante was sporatically occupied by small hunting and gathering micro-bands. Bullen and Plowden (1963) have proposed that the region was prime megafaunal habitat for early hunters. Even this early, humans were probably manipulating and changing the local ecology with fire (Sauer 1952, Redman 1999). The loss of specialized large game hunting equipment, particularly large bifacial projectile points at the end of the Esperanza phase at El Gigante probably signals a transition to Archaic adaptations. Several patterns in the lithic material indicate a similar shift in the economy. These include a flaked stone to ground stone ratio which is disproportionately high in the Paleoindian period (upwards of 500 flakes to 1 piece of ground stone, see Fig. 28). The fall-off in debitage density is also dramatic from earliest to later deposits. Throughout the sequence there seems to have been a consistent supply of obsidian. Future research should include mineralogical sourcing analysis to examine the extent and structure of regional exchange systems. Likewise, detailed technological analysis would help differentiate between alternate resource procurement strategies for lithic resources.

From a seasonal perspective, Paleoindian resources (those that were recovered and identified, see Chapter 6) would have reached a wet-season peak in richness during September. The optimum window for occupation of this site during the Paleoindian period may have begun in early July. Paleoindian camps might have remained together throughout the Fall, perhaps into October. Migrations would be timed with the resource declines brought about at the onset of the dry season.

Marcala Phase (6,410 B.C. - 4,850 B.C.)

According to Binford (1968), highly scheduled foraging practices characterized the subsistence adaptations of the Archaic people in the New. This broad hypothesis is supported at El Gigante by the increasing trend toward a higher density and regularity of archaeological features. This transition took place over several thousand years, during which experimentation with new ways coexisted with older traditions (Bousman *et al.* 2002).

By 5,000 B.C., El Gigante had become a seasonal camp, perhaps used as a hunting and collecting base for parts of the year, some more intensive occupations may have established small seasonal garden plots very near the rock shelter . El Gigante may have been a regular but temporary camp on a transhumant migration route for people from as far as the Pacific coast. While occupation of the site was less intense in the dry-season it probably was not depopulated completely during this part of the year. Some of the group may have resided year round in the area, shifting to a more mobile hunting strategy suited to the seasonal conditions and perhaps tending a small mixed plot of selective plants. Following the wet season (from June to September), many species found archaeologically at El Gigante would have been ready to harvest, including hog plum (*ciruela*), avocado, and various agave. In other areas of Honduras other gatherable foods including palm fruits and wild seeds (*e.g.*, Poaceae and Chenopodiaceae) were relied upon during this season (*e.g.,* Lentz, *et al.* 1997). These small seeds, in particular *Setaria* sp., may have comprised an important dietary component. In fact these species do appear in the bulk soil samples from El Gigante during this period (see Chapter 6, Table 28). Year-round, Archaic age settlement of the Basin of Mexico has been documented by Niederberger (1979) where *Zea mexicana* (non-domesticated teosinte) was found. Wild grasses were considered a potentially significant resource that may have enabled sedentism there. Micro- and macro-band size groups probably inhabited the area on a regular basis, becoming more familiar with the landscape as the same locations were visited and revisited on an annual basis. I hypothesize that some of these locations were subsequently transformed by human use, including broad regional modifications intended to augment or create wild food stands.

Even a heavily modified landscape (as discussed above) might not have provided year-round sustenance for macro-band sized groups. Food resources would be limited during the dry season, and game would be depleted quickly around a permanent camp. This would have forced a shift in tactics. The least cost solution to this problem would have been to move. This decision would be conditioned in part on how much labor had been invested in the maintenance and creation of gardens and other "food infrastructure," as well as a calculation of the risk involved in leaving it unattended.

Archaeological reconnaissance in 1998 revealed that many caves in the El Gigante region continue to be used as permanent residential sites by contemporary agricultural people. Although modern cave dwellings used as permanent homes all had post holes and other modifications, no such features were identified at El Gigante. Extended habitation of El Gigante (on the order of perhaps a couple months) does not appear to be common until the late Archaic, when several multi-component features were identified in that zone (see Chapter 4, in particular Features 3, 4, and 7).

The scheduled occupation of locations like El Gigante would have been linked to the seasonal hunting of migratory fowl or deer, or to the collection of plant seeds and fruits. To the extent that the data are reliable, there appear to be significant changes in faunal exploitation through time at El Gigante. The proportion of large game (deer) in the assemblage declines sharply through the Archaic. Conversely, there are marked increases in abundance of smaller prey including armadillos, crabs, snails and birds. The species identification and habitat preferences of the crab and snail remains are tentative, but they are assumed to be aquatic species. I believe they indicate the expansion and/or intensification of aquatic and circum-riverine resource usage during the Archaic.

With regard to the abandonment of the site in the dry season, occupations were flexible and linked to the extractive potential of the area. The availability of faunal resources and the availability of several ripening plant resources (both annual and perennial types) coincide at El Gigante and thus provides a prime location for settlement. Increasingly complex risk-management and successfully organized logistic behavior surely enabled some substantial population growth over the long term (*cf.* Cohen 1975, Binford 1968). There is very little evidence from El Gigante or the larger highland region of Honduras to directly address issues of population size or growth.

In this critical and extended Marcala phase, El Gigante would have been an ideal camp in the late summer when the arboreal resources were at their peak. The rock shelter could also have been inhabited in the dry season, perhaps as a temporary hunting base. Gatherable fruiting tree species were utilized and probably cared for during the longer wet season stays as Squier (1855) described above. The extent to which these species were a central focus of the economy cannot be determined until a more complete review of the possible small seed component of the diet is carried out. Perhaps macro-band sized populations inhabited the area on a regular basis, becoming increasingly familiar with the landscape as the same locations were repeatedly visited. As has been described for the Amazonian Nukak (Politis 1996, 2001), the productivity of these locations were likely enhanced by human action through tending, tilling, transplanting and sowing as suggested by Ford (1985). Although this dissertation does not resolve whether the area was permanently inhabited, the evidence for substantial and prolonged fires in El Gigante, as well as features including multiple-use hearths, indicate at least semi-permanent residence at El Gigante by the mid-Archaic. Macroscopic wood charcoal fragments visually quantified during the excavation increase in density in the Archaic strata, and this pattern was repeated in laboratory studies of the carbon content in a sedimentary column (see Chapter 4).

Perhaps because the area was marginal with respect to field-based production, early intensification resulted in the elaboration of extant food systems, rather than early farming. In this period there is possible evidence for the directed selection of both avocado and bottle gourd. At El Gigante avocados seem to have been under the influences of selection since Paleoindian times.

Were people using El Gigante briefly on a seasonal basis, or was the site a stable, sedentary base from which people engaged in the exploitation of local resources through scheduled movements of small task groups? This would depend in part on how the inhabitants conceptualized the land and its resources in terms of use by other forager groups. If population was growing throughout the highlands, then longer stays at El Gigante may have facilitated the defense and exclusive use of seasonal resources.

Dyson-Hudson and Smith (1978) formulated the classic model of territoriality. This is an ecologically-based model that predicts the level of territoriality based on the twin factors of resource predictability and resource density/abundance. The model is based on the concept of economic defensibility, whereby the decision to defend a territory is conditioned by weighing the cost and benfit of defending a resource for exclusive use. If the resource is highly predictable, it is more likely to be defended because the benefits are guaranteed. If the resource is densely packed on the landscape it also is more likely to be defended since the cost to defend discrete patches is lower than that of defending diffuse or widely spaced scatterings. These two observations lead to a four-cell matrix of possible outcomes. High predictability and high density lead to territorial systems. Low predictability and low density result in increased dispersion and mobility in order to capitalize on the resource which is not worth defending; it is "cheaper" to either share the patch or keep moving and find another. Low predictability and high density (as well as high predictability and low density) resource situations are likely to encourage systems of spacio-temporal territoriality. This is because once a patch is located, it is worth the effort of keeping other users out (at least for the period within which the patch is productive).

El Gigante appears to represent the mixed case of high resource predictability and low or medium resource density. Important resources in the tropical highlands follow the cycle of the wet and dry seasons and predictably yield food at certain times of year. The density of past “wild” resources is hard to judge, especially given the possibility that they may have been augmented and made more dense and/or predictable through human manipulation. The kinds of low labor modifications that can dramatically affect production are invisible archaeologically (Peters 2000). Given the absence of other indications of territoriality (*i.e.,* weaponry, physical defenses, or other indications of competition or warfare between groups), a "home-range" pattern of spatial organization is, in my opinion, most likely. The characteristics of this pattern are a low to medium level of mobility, limited territorial behavior, and large home ranges with some overlap between groups (Dyson-Hudson and Smith 1978:25-26). An overlap in home-ranges between groups can actually benefit the groups by providing opportunities for social interaction, marriage and other reciprocal relations.

Home ranges almost certainly changed over time, depending on fluctuations in group size and on the particular resources being exploited. For example, a highly productive stand of trees, or a particularly robust fawning season might lead a band-sized group to be more aggressive in the defense of its territory (Dyson-Hudson and Smith 1978:37). Alternatively, periods of climatic instability (*e.g.*, El Niño events) may result in periods of lower predictability in which foragers choose to share information and food with others and reduce territoriality. As we gain more climate and local paleoecological information from El Gigante, we can assess the home-range conclusion further. Research into "residential campsites" (*sensu* Binford 1982) along an elevation gradient through El Salvador would be particularly informative in this regard.

We have yet to determine if changes in subsistence practices between the Archaic and the Formative periods correlate with changes in environment. Correlating environmental changes with changes in subsistence seems a straightforward task. However, a fine-grained paleoenvironmental record specific to this region does not exist. Regional reviews of paleoclimate indicate changing habitats during the occupation of El Gigante (Hodell *et al.* 2000). These include a shrinking of the once extensive pine-oak zones throughout the early Holocene, which may have exerted pressure on foragers exploiting this habitat to intensify their activities in a dwindling space. A significantly wetter period between 5,000 - 7,000 years BP (Bradbury *et al.* 1981) is congruent with the hypothesized Marcala phase expansion of tree harvesting. Later intensification of El Niño events and droughts at El Gigante could have created more unpredictable and riskier conditions for those tree yields as well as more prospicious conditions for annual plant forms.

“The annual growth form should have the greatest fitness in situations where the probablility that a seed will establish an adult plant exceeds the probability that the adult plant will survive to another year." (Barbour *et al.* 1987:84). Barbour goes on to note that "situations that reduce adult survival and therefore favor the annual life cycle . . . may be related to disturbance and existence of temporary habitats" and also include droughts, high temperature or other extreme conditions. Therefore, under conditions of increasing El Niño and drought prone seasonal variation at this scale, the annual growth form is conferred increasing fitness relative to perennials. Annual species that are specialy adapted to respond to this type of annual variation are known as ephemerals and thrive in environments of temporal and special variability (*ibid.*:85). They grow in dense stands, germinating all at once and can be observed, tended and defended easily. This type of annual plant would have capitalized on increasing human disturbance of later archaeological periods as well, certain plants might have formed relationships with humans that represent self replicating feedback between the two. An increasingly seasonal environment might have led to an increasing reliance on (or the initial use and incorporation of) annuals, possibly domesticates, with better short term prospects for a predictable harvest.

Louis Binford has spent decades seeking to account for hunter gatherer variation in universalist terms. From his materialist and environmentalist perspective, Binford has shown that some patterns of behavior can be predicted on the basis of very limited environmental information. In a 1980 paper he demonstrated significant correlations between the proportion of hunting contributing to the diet, settlement mobility, and storage strategies with a single environmental statistic called effective temperature (ET). Others (Kelley 1995) have since refined this predictive model to include other environmental variables such as net primary productivity (PP). Since 1980, Binford has written an entire book outlining dozens of quantifiable environmental parameters that combine to form a model of the "exclusively terrestrial hunter-gatherer who responds to variability in directly accessible food" (Binford 2001:187).

A simple version of this type of modeling as presented by Kelley (1995) can be applied to El Gigante with heuristic value. Kelley (1995: 70-71) uses a sample of hunter gatherer groups described largely by Murdock (1967), to generate a multi-linear regression formula in which ET and PP are independent variables, predicting the percent dependence on hunting:

$$\%Hunting = 113.45 + ET(-4.906) + PP(0.01032)$$

$$(R = 0.604, R\ Square\ 0.365, ANOVA\ Significance = 0.000)$$

Today's ET for the El Gigante site is 16.3 degrees C, and an estimate of PP for a sub-tropical forest ecosystem is about 1525 g/m^2/yr (Ricklefs and Miller 2000:192). This results in a prediction of 49.22% dependence on hunting for this area given the modern climatic setting. By manipulating the model, an interesting pattern emerges which parallels our conclusions concerning changing diets. By adjusting ET and PP for the Pleistocene (when we know it was much cooler and more temperate, *e.g.*, ET = 9.3 C and PP = 1250 g/m2/yr) the proportion of predicted hunting jumps to 80.72%. Likewise, if we adjust the ET and PP values to conform to the humid warm interval of the mid-Archaic from five to seven thousand years ago (19.3 C and 1800 g/m2/yr) the predicted amount of hunting drops to 37.3%. These are very general predictions, yet they provide concise and testable propositions to guide future research. Binford (2001) has called these estimates "frames of reference" in the scientific process.

Estanzuela Phase (2,430 B.C. - A.D. 230)

In the Formative Period of Central Honduras (2,500 BC to 300 AD), complex political organizations developed (Hirth *et al*. 1989) and El Gigante's occupants may have been influenced by larger, fully agricultural and settled valley-bottom communities located nearby (see below). Drennan (1996:101) notes that reciprocity between foragers and farmers can raise the carrying capacity of the region. Such an exchange might have occurred at El Gigante.

The two most significant changes in the archaeological record of the Formative period are the appearance of maize and the introduction of ceramic technology. Maize, along with ceramic technology, likely arrived at El Gigante around 2,010 - 3,100 radiocarbon years before present (cal, 2-sigma, 1,400 B.C. - A.D.70). Unfortunately, this range is tenuous given the large temporal gap and increased mixing evident between the Archaic and Formative occupation levels. The earliest directly dated maize cobs date to the advent of the Common Era and the present a set of new questions to address.

There is no morphological evidence of early maize domestication at El Gigante. The rate of change and direction of selection of maize is statistically distinguishable in only one of the measured traits, the cob diameter. However, this region may have played a role in the regional adaptive radiation and differentiation of domesticated varieties of maize. While it may be possible to establish cultural connections to other parts of Mesoamerica through a more detailed analysis of the maize assemblage and identification of the race(s) present, such an analysis was beyond the scope of this dissertation.

If the addition of maize cultivation was compatible with the preexisting scheduling and space requirements of Archaic food production strategies, then Optimal

Foraging Theory predicts that its addition to the repertoire would not have occurred without increasing (or maintaining) the overall efficiency of the subsistence system. The delayed acceptance of maize at El Gigante could have been due to the investment that valley inhabitants had in an extant, well-functioning subsistence system that was only later subject to population pressure.

Maize may have come from the Comayagua Valley to the north, where complex formative chiefdoms existed at large sites like Yarumela (Joesink-Mandeville 1993, Dixon *et al.* 1994). External population growth may have ultimately become a source of pressure on the less populated highlands. Other potential sources of diffusion lie to the south and include important centers like Chalchuapa, Quelepa, and others in the Zapotitan Valley of El Salvador.

Previous studies of Formative subsistence practices have been carried out in fertile alluvial valleys or flood plains. For example, the La Venta complex in Veracruz, Mexico, is located at lower elevation where warmer temperatures, more humid conditions, and suitable geography enabled agricultural success (Rust and Leyden 1994). It is in these rich lowland environments that we find the beginnings of settled life, monumental architecture, and evidence of complex chieftainship in Honduras (Joyce and Henderson 2001). In comparison, it is likely that the El Gigante region was only lightly populated during the Formative period and the small groups scattered across the region probably practiced a mixed subsistence economy consisting of agriculture, seasonal collecting, and hunting. Agro-ecosystems (*sensu* Rindos 1984) were not yet established as evidenced circumstantially by the continued use of the varied tree products. There may have been a small horticultural hamlet with relatively intensive gardens established in the valley bottom by this time. Activities may have been based from El Gigante during the rainy season (June - September). People living there year-round would probably have relied on stored surpluses of maize, squash seeds, and later, common beans during the dry season. Storable resources are difficult to detect, and there is little physical evidence for extensive storage practices at El Gigante. Nevertheless, storage probably would have been important during the dry season from December through April. Ceramic technology would have aided in this strategy. If employed on a sufficient scale the combination of a surplus producing crop (maize) and the means to store it (in ceramic vessels), might have enabled year round occupation of the site for the first time

Interaction between El Gigante and more advanced agricultural settlements in the Central Honduran Highlands (Lentz, *et al.* 1997, Dixon *et al.* 1994, Joesink-Mandeville 1993) would have been feasible. Because excavation methods paid only minor attention to small seed recovery, it is probably premature to argue for a heavy contribution of tree species to the diet relative to small seeded annuals. However, this difference could reflect a different subsistence focus between highland and lowland areas throughout Honduras. Given a physical geography that limits agricultural land in the highlands, and my preliminary findings at El Gigante with respect to tree fruit ubiquity, in my opinion it is a valid distinction to explore further.

The function of a hinterland rock shelter would change dramatically with the establishment of local valley-floor hamlets. Archaeological and ethnographic research suggests two primary uses for caves during the Formative: as sites of ritual importance for the communities (Brady 1995), and as temporary camps used by mobile foraging parties (Flannery 1976). The ritual role of caves in Mesoamerica is reflected in their use as burial locations at early Formative sites like Gordon's Cave #3 at Copan (Brady 1995). The symbolism and place of the "cave cult" in the Maya area is well known (Stone 1995) and its importance appears to extend into non-Maya areas such as at Talgua the "Cave of the Glowing Skulls" (Brady *et al.* 1997, Dixon *et al.* 1998).

El Gigante might have been both a ritual site and a practical resource in the Formative period. It is not a deep, dark, cavern, as are many famous religious shrine sites of Guatemala or Belize (Stone 1995). Nevertheless, El Gigante could have been perceived as a symbolic portal to the underworld by prehistoric inhabitants. Flannery (1986) outlines a functional shift in cave utilization in the Valley of Oaxaca and in the Tehuacan Valley of Mexico. In both instances, seasonal collecting remained an important component of the subsistence economy even after the establishment of agricultural subsistence systems. He suggests that caves and rock shelters were used as temporary base camps by foragers and farmers alike. At El Gigante, fields may have been close enough that the large rock shelter could have continued as a residential base or store-house for several extended families.

Low-level food production strategies operating at El Gigante (*i.e.,* Smith 2001b) were sustained for as many as two millennia, longer than at Guilá Naquitz. Was it low population density alone that enabled this stability? How and why did population remain low? The appearance of new domesticates and the surpluses they offered catalyzed cultural and demographic change as has been shown by Santley and Rose (1979) in the Valley of Mexico. Using fine grained population and subsistence data, they demonstrate how demographic changes are affected by various forces, including diet and the nutritional value of specific subsistence regimes.

I think it is likely that humans were engaged in low-level manipulation of the environment for millennia before the adoption of agriculture It would have required very low-cost investments to augment stands of many of the food items (such as the agave, *ciruela*, avocado and others) recovered from early Archaic contexts. However, it was the acceptance and inclusion of domesticates into this regime that pushed the human-environment system to new thresholds in Central Honduras. This is evidenced by the more intensive activity in the rock shelter in the Formative period which I believe is attributable to the efficiency of the maize-beans-squash triad. The timing and existence of a domesticated landscape is not easy to establish. The modern vegetation surveys are of limited utility to prehistoric retrodiction, since very few of the species found archaeologically were encountered in the existing vegetation community.

Population dynamics have also been at the center of the agricultural origin debate for several decades. Some models, alluded to above, conceive of a finite landscape filling up with people to the point where emigration became an non-viable strategy for dealing with environmental stress (Cohen 1975). Support for this hypothesis has been observed in different areas by the development of regionalism in tool kits, the broadening of diets to lower trophic levels (so called broad spectrum adaptations), the increased reliance on storage, and the diversification in foraging and logistic collection strategies (Kelly and Todd 1988). There is evidence at El Gigante for the broadening and diversification of diets. The faunal assemblage, for example, shows increasing diversification. This blanket statement, however, needs some modification. Even the earliest botanical assemblages (measured in terms of species richness) are diverse. Increasing diversity through time may well be due to improved preservation in younger samples rather than a result of the addition of new species to the diet.

As the mobility required for successful open foraging was restricted, foragers (given local ecological circumstances and a finite ability to interact peacefully with others), may have been pushed toward increased logistic collecting (Binford 1980). This, in theory, gave selective advantage to those groups that had efficient storage capabilities. A relatively higher level of predictability would be afforded by those able to take advantage of temporarily abundant foodstuffs and make them last into lean periods. This scenario is advocated by Binford at the local level and by Cohen at a global scale. This "territorial packing" is seen as the impetus for people to increasingly augment wild foods with cultivated ones. These models rely on inherent and accelerating population growth after the Pleistocene. This assumption is not challenged here, and is the main untested weakness in the current argument. Population densities are hard to quantify at both the site and regional levels.

In part to sidestep this issue, Winterhalder and Goland (1997) focus on the local, and what they call intensive variables, rather than the extensive, or population level consequences of evolving agricultural practices (Winterhalder and Goland 1997:156). Their interpretations encompass the non-normative properties of a variable (resource choice *via* the diet breadth model from optimal foraging theory), rather than the identification of a prime mover. In this way, they demonstrate the similar evolutionary functions that field dispersal and inter-group sharing serve. Both strategies are choices that mitigate risk, common to non-industrial farmers and foragers alike.

In the Formative period social incentives may have also played an increasing role in motivating the added investments in labor required of an agricultural economy. Some have hypothesized that social pressures were of primary importance in the origins of agriculture. For example, Barbara Bender (1978) emphasized the necessity of surplus production among tribal level societies, suggesting that the maintenance and growth of exchange systems were the root cause of farming economies. In the same vein, Brian Hayden (1990, 1995) advocates a socially-based impetus for change as well. Instead of exchange, he points to competitive feasting and social aggrandizement as reasons to stimulate increased production. Hayden notes that many of the first domesticates were in fact "party foods." Although these arguments are unconvincing for agriculture as a whole, they may be valid for individual items and along some local adaptive pathways. Here again is a reason for archaeologists to evaluate agricultural adaptations and transitions on a case-by-case, and species-by-species basis.

The Forest and the Garden: an Archaic mixed subsistence strategy

Alternative hypotheses have been proposed emphasizing the production of forest tree species for subsistence use among the Maya many emphasizing the practice of "dooryard orchards" or other in-field gardens utilizing a mix of tree species (Lentz 1999:12). The "*Ramón* hypothesis" (Puleston 1982; Thompson 1930) has been downplayed by more recent discoveries and investigations. Specifically, in Belize, at the site of Cobweb swamp, Jones (1994) reports that pollen counts from dated cores (as old as 2,500 BC) do not fit with a situation in which large numbers of the this tree were propagated as a staple crop. On the other hand, the species' life history characteristics have been studied at Tikal, Guatemala with very interesting results. The population of *ramón* there (presumably selected, planted and managed prehistorically) fruit twice and sometimes three times per year, as opposed to wild populations which fruit only once annually (Peters 2000). Although Puleston's emphasis on a single species may have been misdirected, it underscores the fact that swidden farming was not the sole food production strategy responsible for the rise of the Classic Maya.

Puleston demonstrated how productive an arboreal based food system could be in terms of calories. Some rough calculations based on the caloric and nutritional value of *ramón* and the very low labor requirements of the techniques necessary to maintain a harvest, show that a similar level of caloric gain can be had from *ramón* with 60 - 90 hours of work per year, compared to the 2,000 - 3,000 minimal man hours required to produce maize in a slash and burn system of agriculture (1982:362). These high pay-off, low labor, and abundant species like *ramón* are common in the archaeological record. The processing costs, however, can be very high – the main reason why modern Maya use the nut only as a starvation food. In addition, like many tree species, yields are variable from year to year, making it difficult for effective human alteration of the species. For this reason a mix of several tree crops (as is evident at El Gigante) would be preferable, so that failure of one crop wouldn't result in total loss.

A significant dependence of the Classic Maya on tree-crops is shown in another case at Wild Cane Cay, Belize. There, McKillop (1994) describes a system operating in the context of an island ecosystem with limited in arable land. In this case, combined with the exploitation of abundant marine resources, ten species of tree-crops are identified, including three palm species that served a particularly central role. One of these species, the *coyol* palm (cf. *Acrocomia* sp.), or similar species of palm tree is abundant at El Gigante from the earliest time periods.

At El Gigante we found palm nut, agave, avocado, and hog plum remains that date to Paleoindian times. These could have been managed in much the same way that Puleston envisioned for the *ramón*. The major drawback of this type of system is that it takes years or decades to establish and is easily replaced by more intensive swidden or permanent field agriculture (Peters 2000). A landscape heavily devoted to a single tree species or a mixes of arboreal taxa should be detectable in pollen cores. This remains a tantilizing avenue of study for the future.

A dependence on tree crops has several drawbacks which contribute to the fact that in Formative Mesoamerica, while many were important adjuncts to the diet and encouraged in the wild, "none were really domesticated" (Lentz 2000:107). In particular, tree crops are much less flexible in terms of short term manipulation. While long-lived perennial species can need decades to respond to climatic variation home gardens planted with annual crops can be adjusted at each sowing to the current conditions (by timing and planting more or less when conditions are optimal). Also, given annuals' *r*-selected reproductive strategies they can be expected to produce surpluses per area, far beyond the capacity of a perennial species (Hayden 1995). Small home gardens with their adaptive capacity for flexible structure and function (Rico-Grey *et al.* 1990) may have emerged in the face of increasing variability, due either to climate, polulation pressures or other causes of higher subsistence risks. One must wait ten years for a single maguey plant to mature that will yield enough calories for 1 - 2 people for a day (Fish *et al.* 1985); this would be an inefficient strategy without large-scale plantations.

One advantage of tree crops and perennials is that many of these plants are naturally adapted to the local environment, growing without much, if any, special care.

This means that they can be a good subsistence adjunct for a forager as well as horticulturalists living on uncircumscribed land. Another advantage is that typically, hundreds of individual plants in different stages of growth are available in the wild during any given year. In contrast, while a family subsisting on an annual intercropped harvest of maize, beans and squash, needs only one hectare of land to sustain itself a particularly harsh drought may impact all of the plants the farmer was counting on to get through the rest of the year.

How can we detect the presence of a managed forest system in the prehistoric record given the predominance in the archaeological assemblage of plant species no longer present on the modern landscape? Silvicultural activities can include whole areas, if not corridors, of territory that can range from mountain to sea. When these areas are abandoned or not maintained for a period of time, they are left to the successional pressures of the forest around them (Peters 2000). Alternatively, they are settled by groups that put the land to new uses. This leaves archaeologists with little choice but to use comparative data from ethnographic contexts to augment the interpretation of the material record.

Historical ecological circumstances, influenced by the action of humans, define the suite of species that fill the landscape around the site of El Gigante. Any remnants of a prehistorically managed forest in this heavily populated region of Central America probably have been obliterated by modern cattle ranching and fire regimes (George Pilz, *pers. comm.*). A prehistoric management regime can be as simple as the casual but regular dispersal of seed into a plot or garden that is visited occasionally and tended seasonally. Or, it can be as complex as the propagation of small plants and their careful transplanting in pre-selected and prepared groves (Peters 2000). Depending on the phenology of the plant and the level to which humans intervene, plant distributions and abundance can be enhanced as a result of bringing them into a home garden where soil and water conditions are optimal. Home gardens contain a high diversity of plants of all types (Rico-Grey *et al.* 1990). This is what Puleston was suggesting with the *ramón*. This sort of artificial density of useful species also has been documented with *Spondias mombin* (Balee 1994). *Ciruela*, as well as the avocado and the palm, are significant components of the archaeological assemblage at El Gigante, but are essentially absent in the modern vegetation surveys.

I propose that subsistence changes at El Gigante throughout the early- and mid-Archaic (8,000-5,000 BC) were the result of intimate, long-term interactions of mobile, yet seasonally sedentary peoples traveling between augmented and managed microhabitats and modified "domesticated landscapes." This may be particularly true of the narrow isthmian region of lower Central America, where environmental heterogeneity was pronounced. The movements of microbands (Steward 1955) from their home-bases, and regular formation of macrobands assembling from different geographical areas, may have resulted in extremely complex and dynamic manipulations of plant species from far and wide. These interactions could have contributed to the pace with which domesticates diffused into North, Central, and South America. Evidence of this intense interaction in later periods is clear from botanical and genetic studies on the origins of modern maize (Iltis 2000, Sanchez 1994).

The Human-Environment Nexus

The landscape surrounding El Gigante today is an artifact of modern cultivation practices including the production of cash crops (coffee), subsistence farming, and cattle ranching. I believe it was similarly affected by the actions of humans in the past. If grain and legume crops were not adopted early on (though given our recovery bias we cannot yet say with finality that they were not), it seems clear that certain useful trees (e.g. *ciruela*, avocado, sweet- and sour- sop) and perhaps succulent plants (*maguey*) were used intensively from an early stage. The reason that these species were never domesticated is because the specific biology of the plants was not susceptible to domestication. This does not mean that selective propagation or other behaviors analogous to agricultural techniques were not operating. *Ciruela*, *maguey*, avocado, and other tree fruits, in combination with (possibly also managed) faunal resources sustained populations for millennia. Subsistence in the pre-ceramic Estanzuela Valley can be called an "era of incipient cultivation" (Mangelsdorf *et al.* 1964, Mangelsdorf 1974, Smith 1997) or a low level food producing society (Smith 2001b) in which many of the available plants were not domesticated, *per se* (as defined by morphological change and dependence on humans). Thus, the human population was propelled along an alternate adaptive path, slower to incorporate higher levels of sociocultural integration until the arrival of hyper-productive, storable grain producing domesticates from the outside.

Abel (1998) describes good anthropology as a "science of the integration of parts," as opposed to the reductionist and narrowly disciplinary "science of parts" more familiar to disciplines such as molecular biology or physics. Good anthropology is always the former: interdisciplinary, integrative, historical, analytical, comparative and experimental at the appropriate scale (*ibid.*). I have attempted to integrate multiple lines of evidence in this study to illustrate how the emergence of agriculture is a historically contingent process dependent on the interaction of perceived human needs within a specific environment. Pre-industrial agriculture should not be placed in opposition to foraging, but rather as a qualitative extension of it. The scope and scale of domestication should be measured in terms of human-plant interaction and commensalisms, and integration within the existing economy, as a dynamic and unending process. I believe a more useful definition of agriculture (that is, a richer understanding of human cultural evolution) is achieved if we abandon the conventional notion that ties it to morphological change and the inability to survive in a "wild" state (Smith 1998). Instead, I favor a definition provided by Mathew Spriggs (1996:525) that restricts the term agriculture to "the creation of agro-ecosystems that limit subsistence choice because of environmental transformation or labour demands". This definition brings the focus back to human behavior and culture process rather than deflecting it toward what can be stochastic and historically dependant idiosyncrasies of individual plants. It avoids the trap of searching for the first domesticate and seeks the integrated and systematic understanding of how suites of resources combine to produce specific subsistence behavior.

Reliance on specialized agricultural systems changed our relationship with the environment as well as with other humans. The conservative, long-term strategies of early prehistoric subsistence production were superseded by shorter-term goals of maximization, prompted perhaps by an increasingly seasonal environment. Subsistence production became linked to strategies of social aggrandizement, food became a commodity and a source of social status as well as a source of calories (*cf.* Zeder 1994).

The relationship of humans with the environment requires evaluation, especially in the twenty-first century because humans can now prepare, predict, and manipulate the environment with enormous capacity (Redman 1999). The process of creating "human-centered trophic webs" (Lentz 2000) is relevant globally and will affect human institutions. These include political, religious, and trade relationships between nations and also the potential development of unsustainable environmental degradation and species extinctions at a scale the earth has only before witnessed as a consequence of geologic or extraterrestrial forces. Estimates of the proportion of land altered or degraded by human actions fall between 39 - 50%, and these figures do not take into account the effect that habitat fragmentation has on species composition and functioning (Vitousek *et al.* 1997). Research into the evolutionary history of our subsistence base is required in order to develop a rational ecological "vision" for the future (Kareiva, Watts, McDonald and Boucher 2007).

Bibliography

Abel, T.

1998 Complex Adaptive Systems, Evolutionism, and Ecology within Anthropology: Interdisciplinary Reasearch for Understanding Cultural Ecological Dynamics. *Georgia Journal of Ecological Anthropology* 2:6-29.

Acuna C., V. J.

1985 Un Petroglifo de la Cuenca Media del Reventazon, Costa Rica: Su analisis. *Vinculos* 11(1-2):47-56.

Adams, K. R.

1994 A regional synthesis of *Zea mays* in the prehistoric American Southwest. In *Corn and Culture in the Prehistoric Ne World*, edited by S. Johannessen and C. A. Hastorf, pp. 273-302. Westview Press, Boulder, CO.

Adams, R. E. W.

1975 Stratigraphy. In *Field methods in Archaeology*, edited by T. R. Hester, R. F. Heizer and J. A. Graham, pp. 147-162. 6 ed. Mayfield Publishing Co., Palo Alto.

Adler, G. H. and K. A. Kielpinski

2000 Reproductive Phenology of a Tropical Canopy Tree, Spondius mombin. *Biotropica* 32(4a):686-692.

Adovasio, J., R. Donahue and R. Stuckenrath

1990 Meadowcroft Rockshelter radiocarbon chronology. *American Antiquity* 55(2):348-354.

Alcorn, J. B.

1984 *Huastec Mayan Ethnobotany*. University of Texas Press, Austin.

Ames, K. M.

2004 Supposing Hunter-Gatherer Variability. *American Antiquity* 69(2):364-374.

Ammerman, A. J.

1975 Late Pleistocene Population Dynamics: An Alternative view. *Human Ecology* 3(4):219-233.

Anderson, A. B. and D. A. Posey

1985 Manejo de cerrado pelos indios Kayapo. *Boletin Museu Paraense Emilio Goeldi* 2(1):77-98.

Anderson, E.

1952 *Plants, Man and Life*. Little, Brown, Boston.

Anderson, P. M., et al.
1988 Climatic Changes of the Last 18,000 Years: Observations and Model Simulations. *Science* 241:1043-1052.

Aoyama, K., T. Tashiro and M. Glascock
1999 A Pre-Colombian Obsidian Source in San Luis, Honduras: Implications for the relationship between Late Classic Maya political boundaries and the boundaries of obsidian exchange networks. *Ancient Mesoamerica* 10:237-249.

Baden, W. W. and C. S. Beekman
2001 Culture and Agriculture: A Comment on Sissel Schroeder, *Maize Productivity in the Eastern Woodlands and Great Plains of North America*. *American Antiquity* 66(3):505-515.

Bailey, G. N.
1981 Concepts of Resource Exploitation: Continuity and Discontinuity in Palaeoeconomy. *World Archaeology* 13(1):1-15.

Baker, P. T. and W. T. Sander
1972 Demographic Studies in Anthropology. *Annual Review of Anthropology* 1:151-178.

Balee, W.
1989 The Culture of Amazonian Rainforests. *Advances in Economic Botany* 7:1-21.

1992 People of the Fallow: A Historical Ecology of Foraging in Lowland South America. In *Conservation of Neotropical Forests: Building on Traditional Resource Use*, edited by K. H. Redford and C. Padoch. Columbia University Press, New York.

1993 Histoire, histoires. *L'Homme* XXXIII((2-4)):231-254.

1994 *Footprints on the Forest*. Columbia University Press, New York.

Balick, M. J.
1984 Ethnobotany of Palms in the Neotropics. *Advances in Economic Botany* 1:9-23.

Barbour, M. G., J. H. Burk and W. D. Pitts
1987 *Terrestrial Plant Ecology*. 2nd ed. The Benjamin/Cummings Publishing Co., Inc., Menlo Park, CA.

Barlow, R. K.
2002 Predicting Maize Agriculture Among the Fremont: An Economic Comparison of Farming and Foraging in the American Southwest. *American Antiquity* 67(1):65-88.

Basgall, M. E.
1987 Resource Intensification Among Hunter-Gatherers: Acorn Economies in Prehistoric California. *Research in Economic Anthropology* 9:21-52.

Baudez, C. F. and P. Becquelin
1976 Los Naranjos, Lago de Yojoa, Honduras. *Vinculos* 2(1):5-14.

Bayham, F. E.
1979 Factors Influencing the Archaic Pattern of Animal Explotiation. *The Kiva* 44(2-3):219-235.

Beadle, G. W.
1939 Teosinte and the Origin of maize. *The Journal of Heredity* 30:245-247.

Bell, R. E.
1960 Evidence of a Fluted Point Tradition in Ecuador. *American Antiquity* 26:102-106.

Bender, B.
1978 Gatherer-Hunter to Farmer: A Social Perspective. *World Archaeology* 10(2):204-222.

Bennetzen, J., E. Buckler, V. Chandler, J. Doebley, J. Dorweiler, B. Gaut, M. Freeling, S. Hake, E. Kellogg, R. S. Poethig, V. Walbot and S. Wessler
2001 Genetic Evidence and the Origin of Maize. *Latin American Antiquity* 12(1):84-86.

Benz, B. F.
1994 Reconstructing the Racial Phylogeny of Mexican Maize: Where do We Stand? In *Corn and Culture in the New World*, edited by S. Johannessen and C. A. Hastorf, pp. 157-179. Westview Press, Boulder.

Benz, B. F. and A. Long
2000 Prehistoric Maize Evolution in the Tehuacan Valley. *Current Anthropology* 41(3):459-465.

Bettinger, R.
1991 *Hunter-Gatherers, Archaeological and Evolutionary Theory*. Plenum Press, New York.

Binford, L. R.

1968 Post-Pliestocene Adaptations. In *New Perspectives in Archaeology*, edited by S. R. Binford and L. R. Binford, pp. 313-341. Aldine Publishing Company, Chicago.

1971 Mortuary Practices: Their Study andTheir Potential. In *Approaches to Mortuary Practices*, pp. 6-29. vol. Memior No. 25.

1980 Willow Smoke and Dogs Tails. *American Antiquity* 45(1):4-20.

1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1:5-31.

2001 *Constructing Frames of Reference, An Analytical Method for Archaeological Theory Building Using Ethnographic Data Sets*. University of California Press, Berkeley.

Bird, J. B.

1969 Comparison of South Chilean and Ecuadorian "Fishtail" Projectile Points. *The Kroeber Anthropological Society Papers* 40:52-71.

Bird, R. M.

1984 South American Maize in Central America? In *Pre-Columbian Plant Migration*, edited by D. Stone, pp. 39-65. vol. 44th International Congress of Americanists. Peabody Museum of Archaeology and Ethnology, Harvard University Press, Cambridge, MA.

Bird, R. M.

1994 Manual for the Measurement of Maize Cobs. In *Corn and Culture in the Prehistoric New World*, edited by S. Johannessen and C. A. Hastorf, pp. 5-22. Westview Press, Boulder.

Blake, M., B. S. Chrisholm, J. E. Clark and K. Mudar

1992 Non-Agricultural Staples and Agricultural Supplements: Early Formative Subsistence in the Soconusco Region, Mexico. In *Transitions to Agriculture in Prehistory*, edited by A. B. Gebauer and T. D. Price, pp. 133-151. Mongraphs in World Archaeology #4. Prehistory Press, Madison.

Blott, S. J. and K. Pye

2001 Gradistat: A Grain Size Distribution and Statistics Package for the Analysis of Unconsolidated sediments. *Earth Surfaces Processes and Landforms* 26:1237-1248.

Blumler, M. A.

1996 Ecology, Evolutionary Theory and Agricultural Origins. In *Origins and Spread of Agriculture and Pastoralism in Eurasia*, edited by D. R. Harris, pp. 25-50. Smithsonian Institution Press, Washington, D.C.

Boggs, S. J.

1987 *Principles of Sedimentology and Stratigraphy*. Macmillan Publishing Co., New York.

Bogucki, P.

1995 Prelude to Agriculture in North-Central Europe. In *Before Farming" Hunter-Gatherer Society and Subsistence*, edited by D. Campana, pp. 105-116. MASCA Research Papers in Science and Archaeology. vol. 12 (supplement). University of Pennsylvania Museum of Archaeology and Anthropology, Philidelphia.

Boone, J. L. and E. A. Smith

1998 Is it Evolution Yet? A Critique of Evolutionary Archaeology. *Current Anthropology* 39:s141-s173.

Bousman, C. B., M. B. Collins, P. Goldberg, T. Stafford, J. Guy, B. W. Baker, D. G. Steele, m. Kay, A. Kerr, G. Fredlund, P. Dering, V. Holliday, D. Wilson, W. Gose, S. Dial, P. Takac, R. Balinsky, M. Masson and J. F. Powell

2002 The Paleoindian-Archaic transition in North America: new evidence from Texas. *Antiquity* 76(294):980-990.

Boyd, R. and P. J. Richerson

1985 *Culture and the Evolutionary Process*. University of Chicago Press, Chicago.

Bradbury, J. P., B. W. Leyden, M. Salgado-Labouriau, W. M. Lewis, Jr., C. Schubert, M. W. Binford, D. G. Frey, D. R. Whitehead and F. H. Weibezahn

1981 Late Quaternary Environmental History of Lake Valencia, Venezuela. *Science* 214(4527):1299-1305.

Brady, J. E.

1995 A Reassesment of the Chronology and Function of Gordon's Cave #3, Copan, Honduras. *Ancient Mesoamerica* 6:29-38.

Brady, J. E., G. Hasemann and J. Fogarty

1997 La Cueva del Rio Talgua: El cementerio mas antiguo de honduras. *Yaxkin* 16(1-2):49-56.

Brown, J. A.
1981 The Search for Rank in Prehistoric Burials. In *The Archaeology of Death*, edited by R. Chapman, I. Kinnes and K. Randsborg, pp. 25-37. Cambridge University Press, Cambridge.

Bullen, R. P. and W. W. J. Plowden
1963 Preceramic Sites in the Highlands of Honduras. *American Antiquity* 28(3):382-385.

Bush, M. B. and P. A. Colinvaux
1990 A pollen record of a complete glacial cycle from lowland Panama. *Vegetation Science* 1:105-118.

Byers, D. S. (editor)
1967 *The Prehistory of the Tehuacan Valley; Volume 1: Environment and Subsistence*. 1. 5 vols. Published for the Robert S. Peabody Foundation Phillips Academy Andover [Mass. by the] University of Texas Press, Austin.

Byrd, J. E.
1997 The Analysis of Diversity in Archaeological Faunal Assemblages: Complexity and Subsistence Strategies in the Southeast during the Middle Woodland Period. *Journal of Anthropological Archaeology* 16:49-72.

Callen, E. O.
1965 Food Habits of Some Pre-Columbian Mexican Indians. *Economic Botany* 19(4):335-343.

1967 Analysis of the Tehuacan Coprolites. In *The Prehistory of the Tehuacan Valley; Volume 1: Environment and Subsistence*, edited by D. Byers. vol. 1. 5 vols. Published for the Robert S. Peabody Foundation Phillips Academy Andover [Mass. by the] University of Texas Press, Austin.

1967 The First New World Cereal. *American Antiquity* 32(4):535-538.

Callen, E. O.
1973 Dietary Patterns in Mexico Between 6500 B.C. and 1580 A.D. In *Man and His Foods: Studies in the Ethnobotany of Nutrition- Contemporary, Primitive, and Prehistoric Non-European Diets*, edited by C. E. J. Smith, pp. 29-49. Papers Presented at the Eleventh International Botanical Congress. University of Alabama Press.

Callen, E. O. and P. S. Martin
1969 Plant Remains in Some Coprolites from Utah. *American Antiquity* 34(3):329-331.

Carr, P. J.
1994 Technological Organization and Prehistoric Hunter-Gatherer Mobility. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies*, edited by P. J. Carr, pp. 35-44. Archaeological Series, International Monographs in Prehistory. vol. 7, Ann Arbor.

Casteel, R. W.
1972 Two static maximum population-density models for hunter-gatherers: a first approximation. *World Archaeology* 4:19-40.

Castellanos, V., C. S. Summons and K. P. Rodgers
1962 Mapa Parcial de Honduras Clasificacion de Tierras. Organizacion de los Estados Americanos, Dept. de Suelos del Ministerio de Recursos Naturales.

Castetter, E. F., W. H. Bell and A. R. Grove
1938 The Early Utilization and the Distribution of *Agave* in the American Southwest. *University of New Mexico Bulletin, Biological Series* 5:1-92.

Chapman, R. and K. Randsborg
1981 Approaches to the Archaeology of Death. In *The Archaeology of Death*, edited by R. Chapman, I. Kinnes and K. Randsborg, pp. 1-24. Cambridge University Press, Cambridge.

Childe, V. G.
1926 *The Most Ancient East*. Routledge and Kegen Paul, London.

Clark, J. E. and M. Blake
1994 The power of prestige: Competitive generosityand the emergence of rank societies in lowland Mesoamerica. In *Factional Competition and Political Development in the New World*, edited by E. Brumfiel and J. Fox, pp. 17-30. Cambridge University Press, Cambridge.

Clark, J. E. and D. D. Bryant
1997 A Technological Typology of Prismatic Blades and Debitage from Ojo de Agua, Chiapas, Mexico. *Ancient Mesoamerica* (8):111-136.

Cohen, M. N.
1975 Archaeological Evidence for Population Pressure in Pre-Agricultural Societies. *American Antiquity* 40(4):471-475.

Collcutt, S. N.
1979 The Analysis of Quaternary Cave Sediments. *World Archaeology* 10(3):290-301.

Collins, M. B.
1991 Rock Shelters and the Early Archaeological Record in the Americas. In *The First Americans: Search and Research*, edited by T. D. Dillihay and D. J. Meltzer, pp. 157-182. CRC Press, Boca Raton.

Cowan, C. W.
1997 Evolutionary changes associated with the domestication of *Cucurbita pepo*: evidence from eastern Kentucky. In *People, Plants and Landscapes: Studies in paleoethnobotany*, edited by K. J. Gremillion, pp. 63-85. University of Alabama Press, Tuscaloosa.

Cowan, C. W. and B. D. Smith
1993 New perspectives on a wild gourd in eastern North America. *Journal of Ethnobiology* 13(1):17-54.

Cowan, C. W. and P. J. Watson (editors)
1992 *The Origins of Agriculture: An international perspective*. Smithsonian Institution Press, Washington.

Cowgill, G. L.
1989 The concept of diversity in archaeological theory. In *Quantifying Diversity in Archaeology*, edited by R. D. Leonard and G. T. Jones, pp. 131-141. Cambridge University Press, Cambridge.

Cruxent, J. M.
1956 A Lithic Industry of Paleo-Indian Type in Venezuela. *American Antiquity* 22:172-179.

Cruz-Uribe, K.
1988 The Use and Meaning of Species Diversity and Richness in Archaeological Faunas. *Journal of Archaeological Science* 15:179-196.

Cuevas, J. A.
1994 Spanish Plum, red mombin (Spondias purpurea). In *Neglected Crops: 1492 from a different perspective*, edited by J. E. H. Bermejo and J. Leon, pp. 111-122. FAO Plant Production and Protection Series. vol. 26. Food and Agriculture Organization of the United Nations, Rome.

Cutler, H. C. and T. W. Whittaker
1967 Cucurbits from the Tehuacan Caves. In *The Prehistory of the Tehuacan Valley; Volume 1: Environment and Subsistence*, edited by D. Byers, pp. 212-219. vol. 1. 5 vols. Published for the Robert S. Peabody Foundation Phillips Academy Andover [Mass. by the] University of Texas Press, Austin.

Daniel, R. I., Jr.

2001 Stone Raw Material Availability and Early Archaic Settlement in the Southeastern United States. *American Antiquity* 66(2):237-265.

Debouke, D. G.

1994 Beans (Phaseolus spp.). In *Neglected Crops: 1492 from a different perspective*, edited by J. E. H. Bermejo and J. Leon, pp. 47-62. FAO Plant production and protection Series. vol. 26. Food and Agriculture Organization of the United Nations, Rome.

Decker, D. S. and L. A. Newsom

1988 Numerical analysis of archaeological *Cucurbita pepo* seeds from Hontoon Is., Florida. *Journal of Ethnobiology* 8:35-44.

Demir, F., H. Dogan, M. Ozcan and H. Haciseferogullari

2002 Nutritional and physical properties of hackberry (*Celtis australis* L.). *Journal of Food Engineering* 54:241-247.

Dering, P.

1999 Earth-Oven Plant Processing in Archaic Period Economies: An Example from a Semi-Arid Savannah in South-Central North America. *American Antiquity* 64(4):659-.

Dillihay, T. D.

1989 *Monte Verde: A Late Pliestocene Settlement in Chile.* Smithsonian Institution Press, Washington, D.C.

2000 *The Settlement of the Americas*. Basic Books, New York.

Dinerstein, E., D. M. Olsen, D. J. Graham, A. L. Webster, S. A. Primm, M. P. Bookbinder and G. Ledec

1995 A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean. *World Bank - Documents and Reports* (14996).

Dixon, B.

1994 *Preliminary Technical Report-El Gigante Analysis*. B.P. Bishop Museum.

Dixon, B., G. Hasemann, J. Gomez, J. E. Brady and M. Beaudry-Corbett

1998 Multiethnicity or Multienigma: Archaeological survey and cave exploration in the Rio Talgua drainage, Honduras. *Ancient Mesoamerica* 9(2):327-340.

Dixon, B., L. Joesink-Mandeville, N. Hasebe, M. Mucio, W. Vincent, D. James and K. Peterson

1994 Formative Period Architecture at the Site of Yarumela, Central Honduras. *Latin American Antiquity* 5(1):70-87.

Doebley, J.

2004 The Genetics of Maize Evolution. *Annual Review of Genetics* 38:37-59.

Doran, G. H., D. N. Dickel and L. A. Newsom

1990 A 7,290-year-old bottle gourd from the Windover site, Florida. *American Antiquity* 55(2):354-360.

Drennan, R. D.

1996 Betwixt and Between in the Intermediate Area. *Journal of Archaeological Research* 4(2):95-132.

Dunnell, R. C.

1989 Diversity in archaeology: a group of measures in search of application? In *Quantifying Diversity in Archaeology*, edited by R. D. Leonard and G. T. Jones, pp. 142-149. Cambridge University Press, Cambridge.

1996 Evolutionary Archaeology: An Introduction. In *Evolutionary Archaeology: Theory and Application*, edited by M. O'Brien, pp. 1-15. University of Utah Press, Salt Lake City.

Dyson-Hudson, R. and E. A. Smith

1978 Human Territoriality: An Ecological Reassesment. *American Anthropologist* 80(1):21-41.

Ebeling, W.

1986 *Handbook of Indian Foods and Fibers of Arid America*. University of California Press, Berkeley, CA.

Ellen, R.

1988 Foraging, starch extraction and the sedentary lifestyle in the lowland rainforest of central Seram. In *Hunters and Gatherers 1, History Evolution and Social Change*, edited by T. Ingold, D. Riches and J. Woodburn, pp. 117-133. BERG, New York.

Emery, K. F. (editor)

2004 *Maya Zooarchaeology: New Directions in Method and Theory*. Monograph 51. Cotsen Institute of Archaeology at UCLA, Los Angeles.

Eubanks, M. W.

2001 The Origin of maize: Evidence for *Tripsacum* Ancestry. *Plant Breeding Reviews* 20:15-66.

2001 An Interdisciplinary Perspective on the Origin of Maize. *Latin American Antiquity* 12(1):91-98.

Evans, S. T.

1990 The Productivity of Maguey Terrace Agriculture in Central Mexico During the Aztec Period. *Latin American Antiquity* 1(2):117-132.

Farnsworth, P.

1985 A re-evaluation of the isotopic and archaeological reconstructions of diet in the Tehuacan valley. *American Antiquity* 50:102-116.

Farrand, W. R.

1985 Rockshelter and Cave Sediments. In *Archaeological Sediments in Context*, edited by J. K. Stein and W. R. Farrand, pp. 21-39. University of Maine, Orono.

2001 Sediments and Stratigraphy in Rockshelters and Caves: A Personal Perspective on Principles and Pragmatics. *Geoarchaeology* 16(5):537-557.

Fiedel, S. J.

1999 Older Than We Thought: Implications of correctred dates for Paleoindians. *American Antiquity* 64(1):95-115.

Fish, S. K., P. R. Fish, C. H. Miksicek and J. Madsen

1985 Prehistoric Agave Cultivation in Southern Arizona. *Desert Plants* 7(2):100-112.

Flannery, K. V.

1965 The Ecology of Early Food Production in Mesopotamia. *Science* 147(3663):1247-1256.

Flannery, K. V.

1968(a) Archaeological Systems Theory and Early Mesoamerica. In *Anthropological Archaeology in the Americas*, edited by B. J. Meggers, pp. 67-87.

1968(b) The Olmec and the Valley of Oaxaca: A Model for Inter-Regional Interaction in Formative Times. In *Dumbarton Oaks Conference on the Olmec, Oct. 28,29, 1967*, edited by E. P. Benson, pp. 79-117. Dumbarton Oaks Research Library and Collection Trustees for Harvard University, Washington D.C.

1972 The Cultural Evolution of Civilizations, pp. 399-426.

1976 *The Early Mesoamerican Village*. Academic Press, New York.

1986 *Guila Naquitz, Archaic Foraging and Early Agriculture in Oaxaca, Mexico*. Academic Press, inc., Orlando.

Flannery, K. V. and R. I. Ford
1972 A productivity study of teosinte (*Zea mexicana*), Nov. 22-25, 1971. In *Manuscript on file, Museum of Anthropology, University of Michigan*, Ann Arbor.

Ford, R. I.
1985 The Processes of Plant Food Production in Prehistoric North America. In *Prehistoric Food Production in North America*, edited by R. I. Ford, pp. 1-18. vol. Anthropological Papers, No. 75. Museum of Anthropology, University of Michigan, Ann Arbor.

Freitas, F. O., G. Bendel, R. G. Allaby and T. A. Brown
2003 DNA from primitive maize landraces and archaeological remains: implications for the domestication of maize and its expansion into South America. *Journal of Archaeological Science* 30:901-908.

Fried, M. H.
1967 *The Evolution of Political Society: An essay in political anthropology*. Random House, Ney York.

Fritz, G. J.
1990 Multiple Pathways to Farming in Precontact Eastern North America. *Journal of World Prehistory* 4(4):387-435.

Fritz, G. J.
1994 Reply (On the Emergence of Agriculture in the New World). *Current Anthropology* 35(5):639-643.

Fritz, G. J. and B. D. Smith
1988 Old collections and new technology: Documenting the domestication of *Chenopodium* in eastern North America. *Midcontinental Journal of Archaeology* 13:3-27.

Galinat, W. C.
1995 El Origen del Maiz: El Grano de la Humanidad. *Economic Botany* 49(1):3-12.

Gasche, H. and O. Tunca
1983 Guide to Archaeostratigraphic Classification and Terminology: Definitions and Principles. *Journal of Field Archaeology* 10(3):325-335.

Gentry, H. S.
1982 *Agaves of Continental North America*. The University of Arizona Press, Tucson, AZ.

Gil, A. F.
2003 Zea mays on the South American Periphery: Chronology and Dietary Importance. *Current Anthropology* 44(2):295-300.

Gnecco, C.
1998 Paisajes Antropogenicas en el Pleistoceno Final y Holoceno Temprano en Colombia. *Revista de Antropologia y Arqueologia* 10(1):45-61.

Goette, S., S. Johannessen, C. A. Hastorf and M. Williams
1994 Toward reconstructing ancient maize: experiments in processing and charring. *Journal of Ethnobiology* 14(1):1-21.

Gomez-Pompa, A., J. S. Flores and M. A. Fernandez
1990 The Sacred Cacao Groves of the Maya. *Latin American Antiquity* 1(3):247-257.

Gonzalez-Soberanis, C. and A. Casas
2004 Traditional management and domestication of tempesquistle, Sideroxylon palmeri (Sapotaceae) in the Tehuacan-Cuicatlan Valley, Mexico. *Journal of Arid Envirnoments* 59:245-258.

Grayson, D. K. and D. J. Meltzer
2002 Clovis Hunting and Large Mammal Extinction: A Critical Review of the Evidence. *Journal of World Prehistory* 16(4):313-359.

Gremillion, K. J. and K. D. Sobolik
1996 Dietary variability among prehistoric forager-farmers of eastern North America. *Current Anthropology* 37(3):529-539.

Gruhn, R.
1977 Los Tapiales: a paleo-indian campsite in the Guatemalan highlands. *Proceedings of the American Philosophical Society* 121(3):235-273.

Haaland, R.
1995 Sedentism, Cultivation and Plant Domestication in the Holocene Middle Nile Region. *Journal of Field Archaeology* 22:157-174.

Halperin, R. H.
1989 Ecological Versus Economic Anthropology: Changing "Place" vs. Changing "Hands". In *Research in Economic Anthropology*, edited by B. Isaac, pp. 15-41. vol. 11. JAI Press, Inc., Greenwich.

Halstead, P.

1989 The Economy Has a Normal Surpluss: Economic Stability and Social Change Among Early Farming Communities of Thessaly, Greece. In *Bad Year Economics*, edited by P. Halstead and J. O'Shea, pp. 68-80. Cambridge University Press, Cambridge.

Halstead, P. and J. O'Shea

1989 Introduction: Cultural responces to Risk and Uncertainty. In *Bad Year Economics*, edited by P. Halstead and J. O'Shea, pp. 1-7. Cambridge University Press, Cambridge.

Hammond, N. and C. H. Miksicek

1981 Ecology and Economy of a Formative Maya Site at Cuello, Belize. *Journal of Field Archaeology* 8(3):259-269.

Hansen, R. D., S. Bozarth, J. Jacob, D. Wahl and T. Schreiner

2002 Climatic and Environmental Variability in the Rise of Maya Civilization, A preliminary perspective from northern Peten. *Ancient Mesoamerica* 13:273-295.

Harlan, J. R.

1971 Agricultural Origins: Centers and Noncenters. *Science* 174:468-474.

Harpending, H. and H. Davis

1977 Some Implications for Hunter-Gatherer Ecology Derived from the Spacial Structure of Resources. *World Archaeology* 8(3):275-286.

Harris, D. R.

1978 The Agricultural Foundations of Lowland Maya Civilization: A Critique. In *Pre-Hispanic Maya Agriculture*, edited by P. D. Harrison and B. L. Turner II, pp. 301-323. University of New Mexico Press, Albuquerque.

1989 An evolutionary continuum of people-plant interaction. In *Foraging and Farming, the evolution of plant exploitation*, edited by D. R. Harris and G. C. Hillman, pp. 11-26. Unwin Hyman Publ., Boston.

1996 Domesticatory Relationships of People, Plants and Animals. In *Redefining Nature, Ecology, Culture and Domestication*, edited by R. Ellen and K. Fukui, pp. 437-463. BERG, Oxford.

Hart, J. P., D. L. Asche, C. M. Scarry and G. W. Crawford

2002 The age of the common bean (Phaseolus vulgaris L.) in the northern Eastern Woodlands of North America. *American Antiquity* 76:377-385.

Hasemann, G., G. Lara-Pinto and F. C. Sandoval
1996 *Los Indios de Centroamerica*. Fundacion MAPFRE America (Talleres de Graficas Lormo, S.A.), Madrid.

Hasenrath, S.
1967 Rainfall Distribution and Regime in Central America. *Archiv Meteor. Geophys. Bioklim.* Ser. B 15:201-241.

Hastorf, C. A.

1999 Recent Research in Paleoethnobotany. *Journal of Archaeological Research* 7(1):55-103.

Haug, G. H., D. Gunther, L. C. Peterson, D. M. Sigman, K. A. Hughen and B. Aeschlimann
2003 Climate and the Collapse of Maya Civilization. *Science* 299:1731-1735.

Hayden, B.
1990 Nimrods, Piscators, Pluckers and Planters: The Emergence of Food Production. *Journal of Anthropological Archaeology* 9:31-69.

Hayden, B.
1995 A New Overview of Domestication. In *Last Hunters-First Farmers: New Prespectives on the Prehistoric Transition to Agriculture*, edited by T. D. Price and A. B. Gebauer, pp. 273-299. School of American Research Press, Santa Fe.

Haynes, C. V. J.
1969 The Earliest Americans. *Science* 166(3906):709-715.

Healy, P. F.
1990 Ancient and Modern Maya Exploitation of the '*jute*' snail (*Pachychilus*). *Latin American Antiquity*:170-83.

Heider, K. G.
1969 Visiting Trade Institutions. *American Anthropologist* 71:462-471.

Heiser, C. B. J.
1979 *The Gourd Book*. University of Oklahoma Press, Norman.

Henderson, J. S. and R. Joyce
2004 Human Use of Animals in Prehispanic Honduras, a Preliminary Report from the Lower Ulua Valley. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery, pp. 223-236. vol. Monograph 51. Cotsen Institute of Archaeology at UCLA, Los Angeles.

Hester, T. R.

1986 On the Misuse of Projectile Point Typology in Mesoamerica. *American Antiquity* 51(2):412-414.

Heun, M., R. Schafer-Pregl, D. Klawan, R. Castagna, A. Monica, B. Borghi and F. Salamini

1997 Site of Einkorn Wheat Domestication Identified by DNA Fingerprinting. *Science* 278:1312-1314.

Hirth, K. G. and D. Cosken

1989 Geography, Geology and Natural Resource Availability. In *Archaeological Research in the El Cajon Region*, edited by K. G. Hirth, G. Lara-Pinto and G. Hasemann, pp. 19-40. University of Pittsburgh, Pittsburgh.

Hirth, K. G., G. Lara-Pinto and G. Hasemann (editors)

1989 *Archaeological Research in the El Cajon Region*. 1. University of Pittsburgh, Pittsburgh.

Hodell, D. A., M. Brenner and J. H. Curtis

2000 Climate Change in the Northern American Tropics and Subtropics Since the Last Ice Age: Implications for environment and culture. In *Imperfect Balance: Landscape transformations in the Precolombian Americas*, edited by D. Lentz, pp. 13-38. Columbia University Press, New York.

Holdridge, L. R.

1962 Mapa Ecologico de honduras. Organization of American States, Washington, D.C.

Hoopes, J. W.

1994 The Tronadora Complex: Early Formative Ceramics in Northwestern Costa Rica. *Latin American Antiquity* 5(1):3-30.

Howell, T. R.

1969 A Pleistocene Vertebrate Fauna from Nicaragua. *Special Papers of the Geological Society of America* 121:143-144.

Iltis, H. H.

2000 Homeotic Sexual Translocation and the Origin of Maize (*Zea Maize*, Poceae): A New look at an Old Problem. *Economic Botany* 54(1):7-42.

Iriarte, J., I. Holst, O. Marozzi, C. Listopad, E. Alonso, A. Rinderknecht and J. Montana

2004 Evidence for cultivar adoption and emerging complexity during the mid-Holocene in the La Plata basin. *Nature* 432:614-617.

Isleby, G. A., H. Hooghiemstra, M. Brenner, J. H. Curtis and D. A. Hodell
1996 A Holocene Vegetation History from Lowland Guatemala. *Holocene* 6(3):265-271.

Jackson, J. A.
1997 *Glossary of Geology*. 4th ed. American Geological Institute, Alexandria, Va.

Jaenicke-Despres, V., E. Buckler, B. D. Smith, M. T. P. Gilbert, A. Cooper, J. Doebley and S. Paabo
2003 Early Allelic Selection in Maize as Revealed by Ancient DNA. *Science* 302:1206-1208.

Jennings, J. D.
1957 *Danger Cave*. Anthropological Papers (University of Utah) #27. University of Utah, Salt Lake City.

Jochim, M. A.
1981 *Strategies for Survival: Cultural behavior in ecological context*. Academic Press, New York.

Joesink-Mandeville, L.
1987 The Ethnological Significance of the Copan Archaic. In *The Periphery of the Southeastern Classic Maya Realm*, edited by G. W. Pahl, pp. 3-26. vol. 61. UCLA Latin American Center Publicatins, Los Angeles.

1993 Comayagua Valley. In *Pottery of Prehistoric Honduras: Regional classification and Analysis*, pp. 234-247. vol. #35. Institute of Archaeology UCLA, Los Angeles.

Johnson, A. W. and T. Earle
2000 *The Evolution of Human Societies: From Foraging Group to Agrarian State*. 2nd ed. Stanford University Press, Stanford, CA.

Jones, G. T., C. Beck, E. E. Jones and R. E. Hughes
2003 Lithic Source Use and Paleoarchaic Foraging Territories in the Great Basin. *American Antiquity* 68(1):5-38.

Jones, G. T. and R. D. Leonard
1989 The concept of diversity: an introduction. In *Quantifying Diversity in Archaeology*, edited by R. D. Leonard and G. T. Jones, pp. 1-3. University of Cambridge Press, Cambridge.

Jones, J. G.
1994 Pollen Evidence for Early Settlement for Early Settlement and Agriculture in Northern Belize. *Palynology* 18:205-211.

Joyce, R. and J. A. Henderson

2001 Begginings of Village Life in Eastern Mesoamerica. *Latin American Antiquity* 12(1):5-24.

Kaiser, T. and B. Voytek

1983 Sedentism and Economic Change in the Balkan Neolithic. *Journal of Anthropological Archaeology* 2:323-353.

Kaplan, L.

1967 Archaeological *Phaseolus* from Tehuacan. In *The Prehistory of the Tehuacan Valley; Volume 1: Environment and Subsistence*, edited by D. Byers, pp. 201-211. vol. 1. 5 vols. Published for the Robert S. Peabody Foundation Phillips Academy Andover [Mass. by the] University of Texas Press, Austin.

Kaplan, L.

1986 Preceramic Phaseolus from Guila Naquitz. In *Guila Naquitz, Archaic Foraging and Early Agriculture in Oaxaca, Mexico*, edited by K. V. Flannery, pp. 281-284. Academic Press, inc., Orlando.

Kaplan, L. and L. N. Kaplan

1992 Beans of the Americas. In *Chilies to Chocolate: Food the Americas gave the world*, edited by N. Foster and L. S. Cordell, pp. 61-79. University of Arizona Press, Tucson.

Kaplan, L. and T. F. Lynch

1999 Phaseolus (Fabaceae) in Archaeology: AMS Radiocarbon Dates and Their Significance for Pre-Colombian Agriculture. *Economic Botany* 53(3):261-272.

Kareiva, P., S. Watts, R. McDonald and T. Boucher

2007 Domesticated Nature: Shaping Landscapes and Ecosystems for Human Welfare. *Science* 316:1866-1869.

Kelly, R. L.

1995 *The Foraging Spectrum*. Smithsonian Institution Press, Washington.

Kelly, R. L. and L. C. Todd

1988 Coming Into the Country: Early Paleoindian hunting and mobility. *American Antiquity* 53(2):231-244.

Kennedy, W. J.

1976 Prehistory of the Reventazon River Drainage Area, Costa Rica. *Vinculos* 2(1):87-100.

King, F. B.
1987 *Prehistoric Maize in Eastern North America: An evolutionary evaluation*. Doctoral Thesis. University of Illinois at Urbana-Champaign, Urbana.

Kintigh, K. W.
1989 Sample size, significance and measures of diversity. In *Quantifying Diversity in Archaeology*, edited by R. D. Leonard and G. T. Jones, pp. 25-36. Cambridge University Press, Cambridge.

Kirch, P. V.
1989 Second Millennium B.C. Arboriculture in Melanesia: Archaeological Evidence from the Mussau Islands. *Economic Botany* 43(2):225-240.

Kirch, P. V.
2000 *On the Road of the Winds: An Archaeological History of the Pacific Islands before European Contact*. University of California Press, Berkeley.

Kirchoff, P.
1952 Mesoamerica: Its geographic limits, ethnic composition and cultural characteristics. In *Heritage of Conquest*, edited by S. Tax. Glencoe, Illinois.

Kislev, M. E., A. Hartmann and O. Bar-Yosef
2006 Early Domesticated Fig and the Jordan Valley. *Science* 312:1372-1374.

Kittleman, L. R.
1979 Geologic Methods in Studies of Quaternary Tephra. In *Volcanic Activity and Human Ecology*, pp. 49-82. Academic Press, New York.

Kozuch, M. J.
1991 Mapa Geologico de Honduras. Instituto Geografico Nacional (Secretaria de Comunicaciones Obras Publicas y Transporte.

Kuhn, T. S.
1970 *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago.

Langdon, R.
1996 The Soapberry, A Neglected Clue to Polynesia's Prehistoric Past. *Journal of the Polynesian Society* 105(2):185-200.

Lange, F. W. and D. Z. Stone (editors)
1984 *The Archaeology of Lower Central America*. University of New Mexico Press, Albuquerque.

Lara-Hasemann, G.

2000 Rock Shelters of Central Honduras: The Setting of a Prehistoric Landscape. Paper presented at the Society for American Archaeology, Philadelphia.

Lathrap, D. W.

1977 Our father the cayman, our mother the gourd: Spinden revisited, or a unitary model for the emergence of agriculture in the new world. In *Origins of agriculture*, pp. 713-752. The Hague : Mouton ; Chicago : Aldine, c1977.

Lathrap, D. W. and D. W. a. J. D. Lathrap, eds.

1973 Gifts of the Cayman: some thoughts on the subsistence basis of Chavin. In *Variation in anthropology*, pp. 91-105. Urbana, 1973.

Latinis, K.

2000 The development of subsistence system models for Island Southeast Asia and Near Oceania: the nature and role of arboriculture and arboreal-based economies. *World Archaeology* 32(1):41-67.

Laville, H., J. P. Rigaud and J. Sackett

1980 *Rock Shelters of the Perigord : Geological Stratigraphy and Archaeological Succession*. Studies in Archaeology. Academic Press, New York, N.Y.

Lee, R. B. and I. DeVore (editors)

1966 *Man the Hunter*. Aldine, New York.

Lentz, D.

1989 Contemporary Plant Communities in the El Cajon Region. In *Archaeological Research in the El Cajon Region*, edited by K. G. Hirth, G. Lara-Hasemann and G. Hasemann, pp. 59-94. vol. 1. University of Pittsburgh, Pittsburgh.

1999 Plant Resources of the Ancient Maya. In *Reconstructing Maya Diet*, edited by C. White, pp. 3-19. The University of Utah Press, Salt Lake City.

2000 Anthropocentric Food Webs in the Precolumbian Americas. In *Imperfect Balance*, edited by D. Lentz, pp. 89-119. Columbia University Press, New York.

Lentz, D., M. D. Pohl and K. O. Pope

2005 Domesticated Plants and Cultural Connections in Early Mesoamerica: Formative Period Paleoethnobotanical Evidence from Belize, Mexico, and Honduras. In *New Perspectives on Formative Mesoamerican Cultures*, edited by T. G. Powis, pp. 121-126. BAR international series; 1377. Archaeopress, Oxford.

Lentz, D., C. R. Ramirez and V. W. Grisholm
1997 Formative-Period Subsistence and Forest-Product Extraction at the Yarumela Site, Honduras. *Ancient Mesoamerica* 8(1):63-74.

Leopofsky, D.
1992 Arboriculture in the Mussau Islands, Bismark Archipelago. *Economic Botany* 46(2):192-211.

Leyden, B. W., M. Brenner, D. A. Hodell and J. H. Curtis
1993 Late Pleistocene climate in the Central American Lowlands. In *Climate Change in Continental Isotopic Records*, edited by P. K. Swart, K. C. Lohman, J. McKenzie and S. Savin. American Geophysical Union, Washington, D.C.

Lieberman, D. E.
1993 The Rise of Seasonal Mobility among Hunter-Gatherers, The Case of the Southern Levant. *Current Anthropology* 34(5):599-614.

Linares, O. F., P. D. Sheets and E. J. Rosenthal
1975 Prehistoric Agriculture in Tropical Highlands: Settlement Patterns in Western Panama Reflect Variations in Subsitence Adaptations to the Tropics. *Science* 187:137-145.

Lindsey, A. A.
1955 Testing the line-strip method against full tallies in diverse foreset types. *Ecology* 36:485-495.

Long, A., B. F. Benz, J. Donahue, A. Jull and L. Toolin
1989 First Direct Radiocarbon Dates on Early Maize from Tehuacan, Mexico. *Radiocarbon* 31(3):1035-1040.

Long, A. and G. J. Fritz
2001 Validity of AMS Dates on Maize from the Tehuacan Valley: A Comment on MacNeish and Eubanks. *Latin American Antiquity* 12(1):87-90.

Lucas, S. G. and G. E. Alvarado
1991 El Hallazgo Mas Austral de un *Mammut Americanum*: El Caso del Mastodonte de San Pedro Sula, Honduras. *Revista Geologica de America Central* 13:85-89.

Lucas, S. G., G. E. Alvarado and E. Vega
1997 The Pleistocene Mammals of Costa Rica. *Jounal of Vetebrate Paleontology* 17:413-427.

Mabberley, D. J.
1997 *The Plant Book*. Cambridge University Press, Cambridge.

Macia, M. J. and A. Barford

2000 Economic Botany of *Spondias purpurea* (Anacardiaceae) in Ecuador. *Economic Botany* 54(4):449-458.

MacNeish, R. S.

1967a A Summary of the Subsistence. In *The Prehistory of the Tehuacan Valley; Volume 1: Environment and Subsistence*, edited by D. Byers, pp. 290-310. vol. 1. 5 vols. Published for the Robert S. Peabody Foundation Phillips Academy Andover [Mass. by the] University of Texas Press, Austin.

1976 Early man in the New World. *American Scientist* 64(3):316-327.

1986 The Preceramic of Middle America. In *Advances in World Archaeology*, edited by F. Wendorf and A. E. Close, pp. 93-129. vol. 5. Academic Press, Inc., Orlando.

1992 *The Origins of Agriculture and Settled Life*. University of Oklahoma Press, Norman.

MacNeish, R. S.

2001 A Response to Long's Radiocarbon Determinations that Attempt to put Acceptable Chronology on the Fritz. *Latin American Antiquity* 12(1):99-104.

MacNeish, R. S. and M. W. Eubanks

2000 Comparative Analysis of the Rio Balsas and Tehuacan Models for the Origin of Maize. *Latin American Antiquity* 11(1):3-20.

MacNeish, R. S. and A. Nelken-Turner

1983 Preceramic of Mesoamerica. *Journal of Field Archaeology* 10:71-84.

MacNeish, R. S., A. Nelken-Turner and I. W. Johnson

1967 *The Prehistory of the Tehuacan Valley, Volume II: The Nonceramic artifacts*. University of Texas Press, Austin.

Madrigal, C. T. and J. Z. Holt

2002 White-Tailed Deer Meat and Marrow Return Rates and their Application to Eastern Woodlands Archaeology. *American Antiquity* 67(4):745-759.

Mahdeem, H.

1994 Custard Apples (Annona spp.). In *Neglected Crops: 1492 from a different perspective*, edited by J. E. H. Bermejo and J. Leon, pp. 85-101. FAO Plant Production and Protection Series. vol. 26. Food and Agriculture Organization of the United Nations, Rome.

Mangelsdorf, P. C.
1974 *Corn: Its Origin Evolution and Improvement*. Harvard University Press, Cambridge.

Mangelsdorf, P. C., R. S. MacNeish and G. R. Willey
1964 Origins of Agriculture in Middle America. In *Natural Environment and Early Cultures*, edited by R. C. West, pp. 427-445. Handbook of Middle American Indians. vol. 1, R. Wauchope, general editor. University of Texas Press, Austin.

Mangelsdorf, P. C. and R. G. Reevey
1959 The origins of Indian corn and its relatives. *Texas Agricultural Experimentation Station Bulletin* (574).

Martin, F. W., C. W. Campbell and R. M. Rubert
1987 *Perennial Edible Fruits of the Tropics: An inventory*. U.S. Dept. of Agriculture, Agricultural Research Service, Washington, D.C.

Matsuoka, Y., Y. Vigouroux, M. M. Goodman, J. Sanchez G., E. Buckler and J. Doebley
2002 A single domestication for maize shown by multilocus microsatellite genotyping. *Proceedings of the National Academy of Sciences* 99(9):6080-6084.

McClung de Tapia, E.
1992 The Origins of Agriculture in Mesoamerica and Central America. In *The Origins of Agriculture, an International Perspective*, edited by W. C. Cohen and P. J. Watson, pp. 143-171. Smithsonian Institution Press, Washington, D.C.

McCorristen, J. and F. Hole
1991 The Ecology of Seasonal Stress and the Origins of Agriculture in the Near East. *American Anthropologist* 93:46-69.

McKillop, H.
1994 Ancient Maya Tree Cropping: A viable subsitence adaptation for the island Maya. *Ancient Mesoamerica* 5:129-140.

Meltzer, D. J., R. D. Leonard and S. K. Stratton
1992 The Relationship Between Sample Size and Diversity in Archaeological Assemblages. *Journal of Archaeological Science* 19:375-387.

Messenger Jr., L. C.
1990 Ancient Winds of Change: Climatic Settings and Prehistoric Social Complexity in Mesoamerica. *Ancient Mesoamerica* 1:21-40.

Miller, A. and B. Schaal

2005 Domestication of a Mesoamerican cultivated fruit tree, Spondias purpurea. Proceedings of the National Academy of Sciences 102(36):12801-12806.

2006 Domestication and the distribution of genetic variation in wild and cultivated populations of the mesoamerican fruit tree Spondias purpurea L. (Anacardiaceae). Molecular Ecology 15:1467-1480.

Minnis, P. E.

1992 Earliest plant cultivation in the desert borderlands of North America. In *The Origins of Agriculture: An International Perspective*, edited by C. W. Cowan and P. J. Watson, pp. 121-142. Smithsonian Institution Press, Washington, D.C.

Mora, C. A. L.

1988 Los Proboscideos Fosiles de Costa Rica y su Contexto en la America Central. *Vinculos* 14:29-58.

Morcote-Rios, G. and B. Rodrigo

2001 Remains of Palms (Palmae) at Archaeological Sites in the New World: A Review. *The Botanical Review* 67(3):309-350.

Morera, J. A.

1994 Sapote (Pouteria sapote). In *Neglected Crops: 1492 from a different perspective*, edited by J. E. H. Bermejo and J. Leon, pp. 103-109. FAO Plant Production and Proctection Series. vol. 26. Food and Agriculture Organization of the United Nations, Rome.

Morris, D. H.

1990 Changes in Groundstone Following the Introduction of Maize into the American Southwest. *Journal of Anthropological Research* 46(2):177-194.

Morton, J. F.

1987 *Fruits of Warm Climates*. Creative Resource Systems, Winterville, N.C.

Moseley, M. E.

1992 Maritime Foundations and Multilinear Evolution: Retrospect and Prospect. *Andean Past* 3:5-42.

Nichols, D. L.

1987 Risk and Agricultural Intensification During the Formative Period in the Northern Basin of Mexico. *American Anthropologist* 89:596-616.

Niederberger, C.

1979 Early Sedentary Economy in the Basin of Mexico. *Science* 203(4376):131-142.

O'Connell, J. F., P. K. Latz and P. Barnett
1983 Traditional and Modern Use Among the Alyawara of Central Australia. *Economic Botany* 37(1):80-109.

Odum, E. P.
1977 Emergence of Ecology as a New Integrative Discipline. *Science* 195(4284):1289-1293.

Paine, R. R. and A. Freter
1996 Environmental Degradation and the CLassic Maya Collapse at Copan, Honduras (A.D. 600-1250) Evidence from studies of household survival. *Ancient Mesoamerica* 7:37-47.

Parry, W. J.
1994 Prismatic Blade Technologies in North America. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies*, edited by P. J. Carr, pp. 87-98. International Monographs in Prehistory. vol. Archaeological Series 7. University of Michigan, Ann Arbor, MI.

2001 Production and Exchange of Obsidian Tools in Late Aztec City-States. *Ancient Mesoamerica* 12:101-111.

Parry, W. J. and R. L. Kelly
1987 Expedient Core Technology and Sedentism. In *The Organization of Core Technology*, edited by J. K. Johnson and C. A. Morrow. Westview Press, Boulder, CO.

Pearsall, D. M.
1988 *Paleoethnobotany, a handbook of procedures*. Academic Press, San Diego.

1995 Domestication and Agriculture in the New World Tropics. In *Last Hunters-First Farmers, New Perspectives on the Prehistoric Transition to Agriculture*, edited by T. D. Price and A. B. Gebauer, pp. 157-192. School of American Research Press, Santa Fe.

Pearson, G. A.
2002 *Pan-Continental Paleoindian Expansion s and Interactions as Viewed from the Earliest Lithic Industries of Lower Central America.* doctoral dissertation, University of Kansas.

Pearson, G. A.

2004 Pan-American Paleoindian Dispersals and the Origins of Fishtail Projectile Points as Seen through the Lithic Raw-Material Reduction Strategies and Tool-Manufacturing Techniques at the Guardiria Site, Turrialba Valley, Costa Rica. In *The Settlement of the American Continents, A Multidisciplinary Approach to Human Biogeography*, edited by M. Barton, G. A. Clark, D. R. Yesner and G. A. Pearson, pp. 85-102. University of Arizona Press.

Pearson, G. A. and R. G. Cooke

2002 The role of the Panamanian land bridge during the initial colonization of the Americas. *Antiquity* 76(294):931-932.

Perry, L., R. Dickau, S. Zarillo, I. Holst, D. M. Pearsall, D. R. Piperno, M. J. Berman, R. G. Cooke, K. Rademaker, A. J. Ranere, J. S. Raymond, D. H. Sandweiss, F. Scaramelli, K. Tarble and J. A. Zeidler

2007 Starch Fossils and the Domestication of Chili Peppers (*Capsicum* spp. L.) in the Americas. *Science* 315:986-988.

Perry, L., D. H. Sandweiss, D. R. Piperno, K. Rademaker, M. A. Malpass, A. Umire and P. de la Vera

2006 Early maize agriculture and interzonal interaction in southern Peru. *Nature* 440:76-79.

Peters, C. M.

2000 Precolumbian Siviculture and Indigenous Management of Neotropical Forests. In *Imperfect Balance: Landscape Transformations in the Precolumbian Americas*, edited by D. Lentz, pp. 203-223. Columbia University Press, New York.

Peterson, J. F.

1983 Fauna and Flora Imagry in Precolumbian Cultures: Iconography and Function. In *Flora and Fauna Imagry in Precolumbian Cultures: Iconography and Function*, edited by N. Hammond, pp. 1-5. vol. BAR International Series 171. International Congress of Americanists, Manchester.

Pianka, E. R.

2000 *Evolutionary Ecology, sixth edition*. Addison Wesley Educational Publishers, Inc., San Francisco.

Pickersgill, B. and C. B. J. Heiser

1977 Origins and Distribution of Plants Domesticated in the New World Tropics. In *Origins of Agriculture*, edited by C. A. Reed, pp. 803-835. Aldine, Chicago.

Piperno, D. R.

1984 A comparison and differentiation of phytoliths from maize and wild grasses: use of morphological criteria. *American Antiquity* 49(2):361-83.

Piperno, D. R. and K. V. Flannery

2001 The earliest archaeological maize (*Zea mays* L.) from highland Mexico: New accelerator mass spectrometry dates and their implications. *Proceedings of the National Academy of Sciences* 98(4):2101-2103.

Piperno, D. R. and D. M. Pearsal

1998 *The Origins of Agriculture in the Lowland Neotropics*. Academic Press, San Diego.

Piperno, D. R., A. J. Ranere, I. Holst and P. Hansell

2000 Starch Grains Reveal Early Root Crop Horticulture in the Panamanian Tropical Forest. *Nature* 407:894-897.

Piperno, D. R. and K. E. Strothert

2003 Phytolith Evidence for Early Holocene *Cucurbita* Domestication in Southwest Ecuador. *Science* 299:1054-1030.

Pohl, M. D., K. O. Pope, J. G. Jones, J. S. Jacob, D. R. Piperno, S. D. deFrance, D. Lentz, J. A. Gifford, M. E. Danforth and J. K. Josserand

1996 Early Agriculture in the Maya Lowlands. *Latin American Antiquity* 7(4):355-372.

Politis, G.

1996 Moving to produce: Nukak mobility and settlement patterns in Amazonia. *World Archaeology* 27(3):492-511.

2001 Foragers of the Amazon: The Last Survivors or the First to Succeed? In *Unknown Amazon*, edited by C. McEwan, C. Barreto and E. Neves. British Museum Press, London.

Pope, K. O., M. D. Pohl, J. G. Jones, D. Lentz, C. VonNagy, F. J. Vega and I. R. Quitmeyer

2001 Origin and Environmental Setting of Ancient Agriculture in Lowlands of Mesoamerica. *Science* (292):1370-1373.

Popenoe, W.

1920 *Manual of Tropical and Subtropical Fruits*. Hafner Press, New York.

Powis, T. G., F. J. Valdez, T. R. Hester, W. J. Hurst and S. M. Tarka

2002 Spouted Vessels and Cacao Use Among the Preclassic Maya. *Latin American Antiquity* 13(1):85-106.

Price, D. T. and J. A. Brown (editors)
1985 *Prehistoric Hunter-Gatherers, The Emergence of Cultural Complexity*. Academic Press, Inc., Orlando.

Price, D. T. and A. B. Gebauer
1992 The Final Frontier: Foragers to Farmers in Southern Scandinavia. In *Transitions to Agriculture in Prehistory*, edited by D. T. Price and A. B. Gebauer, pp. 97-116. Monographs in World Archaeology, No. 4. Prehistory Press, Madison, WI.

Price, N.
1983 *The Tropical Mixed Garden: An Agroforestry Component of the Small Farm*. Centro Agronomico Tropical de Investigacion y Ensenanza, Turrialba, Costa Rica.

Puleston, D. E.
1982 The Role of Ramon in Maya Subsistence. In *Maya Subsitence, Studies in Memory of Dennis E. Puleston*, edited by K. V. Flannery, pp. 353-366. Academic Press, New York.

Ranere, A. J. and R. G. Cooke
1996 Stone Tools and Cultural Boundaries in Prehistoric Panama, an Initial Assesment. In *Paths to Central American Prehistory*, edited by F. W. Lange, pp. 49-77. University Press of Colorado, Niwot.

Redding, R. W.
1988 A General Expanation of Subsistence Change: From Hunting and Gathering to Food Production. *Journal of Anthropological Archaeology* 7:56-97.

Redman, C. L.
1999 *Human Impact on Ancient Environments*. University of Arizona Press, Tucson.

Rehm, S. and G. Espig
1991 The cultivated plants of the tropics and subtropics: cultivation, economic value, utilization. Margraf, Weikersheim, Germany.

Renfrew, C.
1977 Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory*, edited by T. Earle and J. Ericson, pp. 71-90. Academic Press, New York.

Reyes-Mazzoni, R. R.
1976 Influencias mayas y mexicanas en los petroglifos de la quebrada de Santa Rosa Tenampua, Honduras. *Katunob* 9(3):38-51.

1977 Posibles Influencias Epi-Teotihuacanas en Petroglifos de Honduras. *Vinculos* 3(1-2):47-65.

Richerson, P. J., R. Boyd and R. L. Bettinger
2001 Was agriculture impossible during the Pleistocene but mandatory during the Holocene? A climate change hypothesis. *American Antiquity* 66(3):387-411.

Ricklefs, R. E. and G. L. Miller
2000 *Ecology*. 4th ed. W.H. Freeman and CO., New York.

Rico-Grey, V., J. G. Garcia-Franco, A. Chemas, A. Puch and P. Sima
1990 Species Composition, Similarity, and Structure of Mayan Homegardens in Tixpeual and Tixcacaltuyub, Yucatan, Mexico. *Economic Botany* 44(4):470-487.

Rindos, D.
1984 *The Origins of Agriculture: An Evolutionary Perspective*. Academic Press, Inc., Orlando.

1989 Darwinism and its role in the explanation of domestication. In *Foraging and Farming, the evolution of plant exploitation*, edited by D. R. Harris and G. C. Hillman, pp. 27-41. Unwin Hyman, Boston.

Roosevelt, A. C., M. Lima da Costa, L. C. Machado, M. Michab, N. Mercier, H. Valladas, J. Feathers, W. Barnett, M. Imazio da Silveira, A. Henderson, J. Silva, B. Chernoff, D. S. Reese, J. A. Holman, N. Toth and K. Schick
1996 Paleoindian Cave Dwellers in the Amazon: The Peopling of the Americas. *Science* 272:373-384.

Rose, W. I., F. M. Conway, C. R. Pullinger, A. Deino and W. C. McIntosh
1999 An improved age framework for late Quaternary silicic eruptions in northern Central America. *Bulletin of Volcanology* 61:106-120.

Rovner, I.
1999 Phytolith Analysis. *Science* 283(5401):487.

Rue, D.
1989 Archaic Middle American Agriculture and Settlement: Recent Pollen Data from Honduras. *Journal of Field Archaeology* 16:177-184.

Rue, D., A. Freter and D. A. Ballinger
1989 The Caverns of Copan Revisited: Preclassic Sites in the Sesesmil River Valley, Copan, Honduras. *Journal of Field Archaeology* 16:395-404.

Rue, D., D. Webster and A. Traverse
2002 Late Holocene Fire and Agriculture in the Copan Valley, Honduras. *Ancient Mesoamerica* 13:267-272.

Russ, J. C. and I. Rovner
1989 Stereological Identification of Opal Phytolith Populations from Wild and Cultivated Zea. *American Antiquity* 54(4):784-792.

Rust, W. F. and B. W. Leyden
1994 Evidence of maize Use at early and middle Preclassic La Venta Olmec Sites. In *Corn and Culture in the Prehistoric New World*, edited by S. Johannessen and C. A. Hastorf, pp. 181-201. Westview Press, Boulder.

Saade, L. R. and S. M. Hernandez
1994 Curcurbits (Curcurbita spp.). In *Neglected Crops: 1492 from a different perspective*, edited by J. E. H. Bermejo and J. Leon. FAO Plant Production and Protection Series. vol. 26. Food and Agriculture Organization of the United Nations, Rome.

Sahlins, M.
1972 *Stone Age Economics*. Aldine de Gruyter, New York.

Sanchez G., J. J.
1994 Modern Variability and Patterns of Maize Movement in Mesoamerica. In *Corn and Culture in the New World*, edited by S. Johannessen and C. A. Hastorf, pp. 135-156. Westview Press, Boulder.

Sanchez G., J. J., M. M. Goodman and J. O. Rawlings
1993 Appropriate Characters for Racial Classification in Maize. *Economic Botany* 47(1):44-51.

Sanchez, W. A. and J. E. Kutzbach
1974 Climate of the American Tropics in the 1960's and Possible Comparisons with Climatic Variations of the Last Millennium. *Quaternary Research* 4:128-135.

Sanders, W. T.
1976 The Agricultural History of the Basin of Mexico. In *The Valley of Mexico: Studies in Pre-hispanic Ecology and Society*, edited by E. R. Wolf, pp. 101-159. University of New Mexico Press, Albequerque.

Sanders, W. T. and B. J. Price
1968 *Mesoamerica: The Evolution of a Civilization*. Random house, New york.

Sanders, W. T. and R. S. Santley

1983 A Tale of Three Cities: Energetics and Urbanization in Pre-Hispanic Central Mexico. In *Prehistoric Settlement Patterns: Essays in Honor of Gordon R. Willey*, edited by E. Z. Vogt and R. M. Leventhal, pp. 243-291. University of New Mexico Press.

Santamaria, D.

1981 Preceramic Occupations at Los Grifos Rock Shelter, Ocozocoautla, Chiapas, Mexico. In *X Congresso Union Internacional de Ciencias Prehistoricas y Protohistoricas*, edited by J. Garcia-Barcena and F. Sanchez Martinez, pp. 63-83. UNESCO, Mexico, D.F.

Santley, R. S. and E. K. Rose

1979 Diet, nutrition and population dynamics in the Basin of Mexico. *World Archaeology* II(2):185-207.

Sauer, C. O.

1952 *Agricultural Origins and Dispersals*. The American Geographical Society, New York.

Saunders, N. J.

2001 A dark light: reflections on obsidian in Mesoamerica. *World Archaeology* 33(2):220-236.

Scheffler, T. E.

1998 *The Cave in Mesoamerica*. Masters Paper, Pennsylvania State University.

2001 Research Report on the Proyecto Cueva El Gigante 2000, La Paz, Honduras. *Mexicon* 23:115-123.

Scheffler, T. E.

in press Cuevas y Abrigos del Sur-Oeste de Honduras: Hallazgos y Inferencia del proyecto El Gigante, 1998. *Yaxkin*.

Schoenwetter, J.

1974 Pollen Record at Guila Naquitz Cave. *American Antiquity* 39(2):292-303.

Schoenwetter, J. and L. D. Smith

1986 Pollen Analysis of the Oaxaca Archaic. In *Guila Naquitz, Archaic Foraging and Early Agriculture in Oaxaca, Mexico*, edited by K. V. Flannery, pp. 179-238. Academic Press, inc., Orlando.

Schroeder, S.

1999 Maize Productivity in the Eastern Woodlands and Great Plains of North America. *American Antiquity* 64(2):499-516.

Schultes, R. E.

1984 Amazonian Cultigens and Their Northward and Westward Migration in Pre-Columbian Times. In *Pre-Columbian Plant Migration*, edited by D. Z. Stone, pp. 19-37. Papers presented at the Pre-Columbian Plant migration Symposium, 44th International Congress of Americanists. Harvard University Press, Cambridge, MA.

Service, E. R.

1962 *Primitive Social Organization: An Evolutionary Perspective*. Random House, New York.

Shannon, C. E. and W. Weaver

1949 *The Mathematical Theory of Communication*. University of Illinois Press, Urbana.

Sheehan, M. S.

2002 Dietary Responses to mid Holocene Climatic Change. *North American Archaeologist* 23(2):117-143.

Sheets, P. D.

1975 Behavioral Analysis and the Structure of a Prehistoric Industry. *Current Anthropology* 16(3):369-391.

1989 Resent Research on Obsidian in the Zapotitan Valley, El Salvador. In *Obsidiana en Mesoamerica*, pp. 419-425. Coleccion Cientifica. vol. 176. Instituto Nacional de Antropologia e Historia, Mexico, D.F.

Sheets, P. D., K. G. Hirth, F. W. Lange, F. Stross, F. Asaro and H. Michel

1990 Obsidian Sources and Elemental anaysis of Artifacts in Southern Mesoamerica and the Northern Intermediate Area. *American Antiquity* 55(1):144-158.

Shipek, F. C.

1981 A Native American Adaptation to Drought: The Kumeyaay as Seen in the San Diego Mission Records 1770-1798. *Ethnohistory* 28(4):295-312.

Shnirelman, V. A.

1992 Crisis and Economic Dynamics in Traditional Societies. *Journal of Anthropological Archaeology* 11:25-46.

Simms, S. R.

1985 Pine Nut Use in Three Great Basin Cases: Data, Theory, and a Fragmentary Material Record. *Journal of California and Great Basin Anthropology* 7(2):166-175.

Simpson, E. R.

1949 Measurement of Diversity. *Nature* 163:688-.

Sluyter, A. and G. Dominguez

2006 Early maize (*Zea mays* L.) cultivation in Mexico: Dating sedimentary pollen records and its implications. *Proceedings of the National Academy of Sciences* 103(4):1147-1151.

Smalley, J. and M. Blake

2003 Sweet Beginnings, Stalk Sugar and the Domestication of Maize. *Current Anthropology* 44(5):675-703.

Smith, B. D.

1989 Origins of Agriculture in Eastern North America. *Science* 246:1566-1571.

1995 *The Emergence of Agriculture*. W. H. Freeman Press.

1997 Reconsidering the Ocampo Caves and the Era of Incipient Cultivation in Mesoamerica. *Latin American Antiquity* 8(4):342-383.

Smith, B. D.

1997 The Initial Domestication of Curcurbita pepo in the Americas 10,000 Years Ago. *Science* 276:932-934.

2001(a) Documenting plant domestication: The consilience of biological and archaeological approaches. *Proceedings of the National Academy of Sciences* 98(4):1324-1326.

2001(b) Low-Level Food Production. *Journal of Archaeological Research* 9(1):1-43.

2005 Reassessing Coxcatlan Cave and the early history of domesticated plants in Mesoamerica. *Proceedings of the National Academy of Sciences* 102(27):9438-9445.

Smith, C. E. J.

1967 Plant Remains. In *The Prehistory of the Tehuacan Valley; Volume 1: Environment and Subsistence*, edited by D. Byers. vol. 1. 5 vols. Published for the Robert S. Peabody Foundation Phillips Academy Andover [Mass. by the] University of Texas Press, Austin.

1978 The Vegetational History of the Oaxaca Valley. In *Prehistory and Human Ecology of the Oaxaca Valley*, edited by K. V. Flannery and R. E. Blanton, pp. 9-30. vol. 5. University of Michigan Press, Ann Arbor, MI.

Smith, E. A.

1988 Risk and uncertainty in the 'original affluent society': evolutionary ecology of resource sharing and land tenure. In *Hunters and Gatherers 1, History, evolution and social change*, edited by t. Ingold, D. Riches and J. Woodburn, pp. 222-251. Explorations in Anthropology, J. Gledhill and B. Kapferer, general editor. BERG, Oxford.

Smith, E. A. and B. Winterhalder (editors)

1992 *Evolutionary Ecology and Human Behavior*. Walter de Gruyter, Inc., New York.

Smith, M. E.

1992 Braudel's Temporal Rhythms and Chronology Theory in Archaeology. In *Archaeology, Annals and Ethnohistory*, edited by A. Knapp, pp. 23-34. Cambridge University Press, Cambridge.

Snarskis, M. J.

1977 Turrialba (9-FG-T), un Sitio Paleoindio en el Este de Costa Rica. *Vinculos* 3(1-2):13-25.

Snarskis, M. J., M. Crump and C. E. Murillo

1975 Analysis de un Petroglyfo del Valle de Turrialba, Costa Rica. *Vinculos* 1(2):83-91.

Sorenson, J. and K. G. Hirth

1984 Minas Precolumbianas y Talleres de Obsidiana en La Esperanza, Depto. de Intibuca. *Yaxkin* 7(1):31-45.

Spence, M. W.

1984 Craft Production and polity in early Teotihuacan. In *Trade and exchange in early Mesoamerica*, edited by K. G. Hirth, pp. 87-114. University of New Mexico Press.

Speth, J. D. and S. L. Scott

1999 Horticulture and Large Mammal Hunting: The Role of Resource Depletion and the Constraints of Time and Labor. In *Farmers as Hunters: The Implications of Sedentism*, edited by S. Kent. New Directions in Archaeology. Cambridge University Press, Cambridge.

Spriggs, M.

1996 Early Agriculture and What Went Before in Island Melanesia: continuity or intrusion? In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, edited by D. R. Harris, pp. 524-537. UCL Press, London.

Squier, E. G.
1855 *Notes on Central America; particularly the states of Honduras and San Salvador: Their geography, climate, population, resources, productions, etc., etc. and the proposed Honduras Inter-Oceanic Railway*. AMS Press, New York.

Staller, J. E.
2003 An Examination of the Paleobotanical and Chronological Evidence for an Early Introduction of Maize (Zea Mays L.) into South America: A Response to Pearsall. *Journal of Archaeological Science* 30:373-380.

Staller, J. E. and R. G. Thompson
2002 A Multidisciplinary Approach to Understanding the Initial Introduction of Maize into Coastal Ecuador. *Journal of Archaeological Science* 29:33-50.

Steen-McIntyre, V.
1985 Tephrochronology and its Application to Archaeology. In *Archaeological Geology*, edited by G. J. Rapp and J. A. Gifford, pp. 265-302. Yale University Press, New Haven.

Stein, J. K.
1987 Deposits for Archaeologists. In *Advances in Archaeological Method and Theory*, edited by M. B. Schiffer, pp. 337-395. vol. 11.

Steward, J. H.
1934 Ethnography of the Owens Valley Paiute. In *American Archaeology and Ethnology*, edited by A. L. Kroeber, R. H. Lowie and R. L. Olson, pp. 233-350. vol. 23. University of California Press, Berkeley.

1955 *The Theory of Culture Change: The Methodology of Multilinear Evolution*. University of Illinois Press, Urbana.

Stirton, R. A. and W. K. Gealey
1943 Fossil Vertebrates from El Salvador. *Journal of Paleontoloty* 17:309.

1949 Reconnaissance Geology and Vertebrate Paleontology of El Salvador, Central America. *Bulletin of the Geological Society of America* 60:1731-1754.

Stone, A.
1995 *Images from the Underworld: Naj Tunich and the Tradition of Maya Cave Painting*. University of Texas Press, Austin.

Stone, D.
1963 The Northern Highland Tribes: The Lenca. In *Handbook of South American Indians*, edited by J. H. Steward, pp. 205-217. vol. 4. Cooper Square Publishers, Inc., New York.

Strauss, L. G.
1990 Underground Archaeology. In *Archaeological Method and Theory*, edited by M. B. Schiffer, pp. 255-304. vol. 2. University of Arizona Press, Tucson.

Stuiver, M., P. J. Reimer, E. Bard, J. W. Beck, G. S. Burr, K. A. Hughen, B. Kromer, G. McCormac, d. P. J. van and M. Spurk
1998 INTCAL98 radiocarbon age calibration, 24,000-0 calBP. *Radiocarbon* 40(3):1041-1083.

Tankersley, K. B.
1998 Variation in the Early Paleoindian Economies of Late Pleistocene Eastern North America. *American Antiquity* 63(1):7-20.

Tankersley, K. B. and B. L. Isaac
1990 Concluding Remarks on Paleoecology and Paleoeconomy. In *Research in Economic Anthropology*, edited by K. B. Tankersley and B. L. Isaac, pp. 337-355. vol. Supplement #5. JAI Press Inc.

Terrell, J.
1977 Biology, Biogeography and Man. *World Archaeology* 8(3):237-248.

Terrell, J., J. P. Hart, S. Barut, N. Cellinese, A. Curet, T. Denham, C. M. Kusimba, K. Latinis, R. Oka, J. Palka, M. D. Pohl, K. O. Pope, P. R. Williams, H. Haines and J. E. Staller
2003 Domesticated Landscapes: The Subsistence Ecology of Plant and Animal Domestication. *Journal of Archaeological Method and Theory* 10(4):323-368.

Testart, A.
1982 The Significance of Food Storage Among Hunter-Gatherers: Residence Patterns, Population Densities, and Social Inequalities. *Current Anthropology* 23(5):523-537.

Thompson, J. E. S.
1930 *Ethnology of the Maya of Southern and Central British Honduras*. Anthropology Series, Publ. 274 17(2). Field Museum of Natural History, Chicago.

Traverse, A.
2007 *Paleopalynology*. Springer, Dortrecht, Netherlands.

Tykot, R. H. and J. E. Staller
2002 The Importance of Early maize Agriculture in Coastal Ecuador: New Data from La Emerenciana. *Current Anthropology* 43(4):666-677.

Ugan, A.

2005 Does Size Matter? Body Size, Mass Collecting, and their Implications for Understanding Prehistoric Foraging Behavior. *American Antiquity* 70(1):75-89.

Vavilov, N. I.

1926 *Studies on the Origin of Cultivated Plants*. Institute of Applied Botany and Plant Breeding, Leningrad.

Vitousek, P. M., H. A. Mooney, j. Lubchenco and J. M. Melillo

1997 Human Domination of the Earth's Ecosystems. *Science* 277:494-499.

Walker, R. B., K. R. Detwiler, M. S. C. and B. N. Driskell

2001 Berries, Bones, and Blades: Reconstructing Late Paleoindian Subsistence Economy at Dust Cave, Alabama. *Midcontinental Journal of Archaeology* 26(2):169-197.

Waters, M. R.

1992 *Principles of Geoarchaeology, A North American Perspective*. University of Arizona Press, Tucson.

Waters, M. R. and T. W. J. Stafford

2007 Redefining the Age of CLovis: Implications for the Peopling of the Americas. *Science* 315:1122-1126.

Webb, S. D.

1991 Ecogeography and the Great American Faunal Interchange. *Paleobiology* 17:266-280.

1992 A Brief History of New World Proboscidea with Emphasis on Their Adaptations and Interactions with Man. In *Proboscidean and Paleoindian Interactions*, edited by C. J. Fox, C. B. Smith and K. T. Wilkins, pp. 15-34. Markham Press Fund of Baylor University Press, Waco.

1997 The Great Faunal Interchange. In *Central America: a Natural and Cultural History*, edited by A. G. Coates, pp. 97-122. Yale University Press, New Haven.

Webb, S. D. and S. C. Perrigo

1984 Late Cenozoic Vertebrates from Honduras and El Salvador. *The Journal of Vertebrate Paleontology* 4:237-254.

Webb, S. D. and D. Rindos
1997 The Mode and Tempo of the Initial Human Colonisation of Empty Landmasses: Evolutionary Theory and Archaeological Explanation. In *Archaeological Papers of the American Anthropological Association, No. 7*, edited by C. M. Barton and G. A. Clark, pp. 233-250. American Anthropological Association, Arlington.

Webster, D. R.
2002 *The fall of the ancient Maya: solving the mystery of the Maya collapse*. Thames & Hudson.

Webster, D. R., D. Rue, and A. Traverse
2005 Early Zea Cultivation in Honduras: Implications for the Iltis Hypothesis. *Economic Botany* 59:101-111.

Webster, G. S.
1986 Optimization Theory and Pre-Colombian Hunting in the Tehuacan Valley. *Human Ecology* 14(4):415-435.

White, L. A.
1959 *The Evolution of Culture*. McGraw-Hill Book Company, Inc., New York.

Whitley, D. S. and R. I. Dorn
1993 New Perspectives on the Clovis vs. Pre-Clovis Controversy. *American Antiquity* 58(4):626-647.

Whittaker, T. W. and H. C. Cutler
1986 Cucurbits from Preceramic Levels at Guila Naquitz. In *Guila Naquitz, Archaic Foraging and Early Agriculture in Oaxaca, Mexico*, edited by K. V. Flannery, pp. 275-280. Academic Press, inc., Orlando.

Williams, H. and A. R. McBirney
1969 *Volcanic History of Honduras*. University of California publications in geological sciences 85. University of California Press, Berkeley.

Wills, W. H.
1995 Archaic Foraging and the Beginning of Food Production in the American Southwest. In *Last Hunters-First Farmers: New Perspectives on the Prehistoric Transition to Agriculture*, edited by T. D. Price and A. B. Gebauer, pp. 215-242. School of American Research, Santa Fe.

Winterhalder, B.

1981 Foraging Strategies in the Boreal Forest: An Analysis of Cree Hunting and Gathering. In *Hunter-Gatherer Foraging Strategies*, edited by B. Winterhalder and E. A. Smith, pp. 66-98. University of Chicago Press, Chicago.

1986 Diet Choice, Risk, and Food Sharing in a Stochastic Environment. *Journal of Anthropological Archaeology* 5:369-392.

Winterhalder, B. and C. Goland

1997 An Evolutionary Ecology Perspective on Diet Choice, Risk and Plant Domestication. In *People, Plants, and Landscapes: Studies in paleoethnobotany*, edited by K. J. Gremillion, pp. 123-160. University of Alabama Press, Tuscaloosa.

Winterhalder, B. and E. A. Smith

2000 Analyzing Adaptive Strategies: Human Behavioral Ecology and Twenty-Five. *Evolutionary Anthropology* 9(2):51-72.

Wolf, E. R.

1982 *Europe and the people without history*. University of California Press.

Wright, K. I.

1994 Ground-Stone Tools and Hunter-Gatherer Subsistence in Southwest Asia: Implications for the Transistion to Farming. *American Antiquity* 59(2):238-263.

Yellen, J. and H. Harpending

1972 Hunter-Gatherer Populations and Archaeological Inference. *World Archaeology* 4(2):244-253.

Yen, D. E.

1985 Wild Plants and Domestication in the Pacific Islands. In *Recent Advances in Indo-Pacific Prehistory*, edited by V. N. Misra and P. Bellwood, pp. 315-326. Proceedings of the International Symposium. Oxford and IBH Publishing Co., New Delhi.

Yesner, D. R.

1981 Archaeological Applications of Optimal Foraging Theory: Harvest Strategies of Aleut Hunter-Gatherers. In *Hunter Gatherer Foraging Strategies*, edited by B. Winterhalder and E. A. Smith, pp. 148-170. The University of Chicago Press, Chicago.

Zeder, M. A.

1994 After the Revolution: Post-Neolithic Subsitence in Northern Mesopotamia. *American Anthropologist* 96(1):97-126.

Zeitlin, R. and J. Zeitlin

2000 The Paleoindian and Archaic Cultures of Mesoamerica. In *The Cambridge History of the Native Peoples of the Americas*, edited by R. E. W. Adams and M. J. McLeod, pp. 45-121. vol. 2, Mesoamerica. Cambridge University Press, Cambridge.

Zent, E. L. and S. Zent

2002 Impactos Ambientales Generadores de Biodiversidad: Conductas Ecologicas de los Hoti de la Sierra Maigualida, Amazonas Venezolano. *Interciencia* 27(1):9-20.

Zvelebil, M.

1994 Plant Use in the Mesolithic and its Role in the Transistion to Farming. *Proceedings of the Prehistoric Society* 60:35-74.

1995 Hunting, Gathering, or Husbandry? Management of food resources by the Late Mesolithic communities of temperate Europe. In *Before Farming: Hunter-Gatherer society and subsistence*, edited by D. Campana, pp. 79-104. MASCA Research Papers in Science and Archaeology. vol. 12 (supplement). University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia.

1996 The agricultural frontier and the transition to farming in the circum-Baltic region. In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, edited by D. R. Harris, pp. 323-345. Smithsonian Institution Press, Washington, D.C.

Appendix A

List 1 of 3, Summary botanical list organized phylogenetically (Tahktajan 1997)

DIVISION	**CLASS**	**SUB-CLASS**	**ORDER**	**FAMILY**	**SPECIES**
Coniferophyta	Pinopsida		Pinales	Cupresaceae	*Cupressus* L.
				Pinaceae	*Pinus L.*
					Pinus pseudostrobus Lindl.
Equisetophyta	Equisetopsida		Equisetales	Equisetaceae	*Equisetum giganteum* L.
Pteridophyta	Filicopsida		Polypodiales	Polypodaceae	*Polypodium aureum* L.
Magnoliophyta	Magnoliopsida	Magnoliidae	Magnoliales	Annonaceae	*Annona cherimolia* P. Hill
					Annona diversifolia Saff.
					Annona glabra L.
					Annona L.
					Annona reticulata L.
					Annona squamosa L.
			Laurales	Lauraceae	*Persea* P. Mill.
					Persea americana Mill. var. *americana*
					Persea americana Mill. var. *nubigena* (L.O. Williams) L.E. Kopp
					Persea americana Mill. var. *drymifolia* (Schltdl. & Cham.) S.F. Blake
		Caryophyllidae	Caryophyllales	Phytolaccaceae	*Petiveria alliacea L.*
				Cactaceae	*Carnegiea* Britt & Rose
					Opuntia P. Mill.
					Pachycereus (Berger) Britton & Rose
				Amaranthaceae	*Amaranthus* L.
				Chenopodaceae	*Chenopodium ambrosioides* L.
					Chenopodium berlandieri Moq.
			Polygonales	Polygonaceae	*Polygonum erectum* L.
		Hamamelidae	Hamamelidales	Hamamelidaceae	*Liquidambar styraciflua* L.
			Fagales	Fagaceae	*Quercus sapotifolia* Liebm.
					Quercus segoviensis Liebm.
			Myricales	Myricaceae	*Myrica cerifera* L.
		Dilleniidae	Theales	Theaceae	*Ternstroemia tepezapote* Schltdl. & Cham.
				Clusiaceae	*Clusia salvinii* Donn. Sm.
			Ericales	Clethraceae	*Clethra lanata* or *macrophylla* Mart. & Gal.
			Ebenales	Sapotaceae	*Manilkara achras* (Mill.) Fosberg (=*Achras sapota*)
					Manilkara Adans.
					Manilkara zapote (L.) van Royen
					Pouteria sapota (Jacq.) H.E. Moore & Stearn
					Sideroxylon L.
					Sideroxylon capiri (A.DC) Pittier subsp. *tempisque* (Pittier) T.D. Penn.
					*Sideroxylon palmeri (*Rose) T.D. Penn.
			Violales	Caricaceae	*Carica papaya* L.
				Cucurbitaceae	*Cucurbita argyrosperma* Huber
					Cucurbita ficifolia Bouche
					Cucurbita maxima Duchesne

(cont.) Summary botanical list organized phylogenetically (Takhtajan 1997)

DIVISION	CLASS	SUB-CLASS	ORDER	FAMILY	SPECIES
Magnoliophyta	Magnoliopsida	Dilleniidae	Violales	Cucurbitaceae	*Cucurbita moschata* Duchesne
					Cucurbita pepo L.
					Cucurbita pepo L. var. *ovifera* L. (Harz)
					Lagenaria siceraria (Molina) Standl.
			Capparales	Brassicaceae	*Lepidium virginicum* L.
			Cistales	Bixaceae	*Bixa orellana* L.
			Malvales	Sterculiaceae	*Theobroma cacao* L.
				Malvaceae	*Gossypium* L.
					Hibiscus rosa-sinensis L.
					Malvaviscus arboreus Cav. var. *arboreus*
					Sida rhombifolia L.F/*acuta* Burm.
			Urticales	Moraceae	*Ficus cotinifolia* var. *hondurensis* (St. & W.) Berg
					Brosimum alicastrum (Sw.) ssp. *Alicastrum*
				Cannabaceae	*Celtis* sp. L.
			Euphorbiales	Euphorbiaceae	*Manihot jatropha* L.
					Manihot P. Mill.
					Schinziophyton rautanenii Schinz
		Rosidae	Rosales	Crassulaceae	*(Bryophyllum) Kalanchoe* Adans.
				Rosaceae	*Prunus persica* (L.) Batch
					Rubus adenotrichus Schltdl.
			Myrtales	Melastomataceae	*Clidemia capitellata* (Bonpl.) D. Don
					Heterocentron hondurense Gleason
					Miconia albicans (Sw.) Triana
					Miconia theaezans (Bonpl.) Cogn.
					Tibouchina longifolia (Vahl) Baill.
				Onagraceae	*Hauya elegans* DC.
				Myrtaceae	*Calyptranthes hondurensis* Standl.
					Psidium guajava L.
					Psidium guajava L.
					Psidium guineense Sw.
					Syzygium jambos (L.) Alston
			Fabales	Fabaceae	*Calliandra grandiflora* (L'Hér.) Benth.
					Calliandra rubescens (Martens & Galeotti) Standl.
					Enterolobium cyclocarpum (Jacq.) Griseb.
					Harpalyce rupicola Donn. Sm.
					Inga P. Mill.
					Inga vera Willd. / *I. edulis* Mart.
					Lysiloma auritum (Schltdl.) Benth.
					Phaseolus acutifolius Grey
					Phaseolus coccineus L.

(cont.) Summary botanical list organized phylogenetically (Takhtajan 1997)

DIVISION	**CLASS**	**SUB-CLASS**	**ORDER**	**FAMILY**	**SPECIES**
Magnoliophyta	Magnoliopsida	Rosidae	Fabales	Fabaceae	*Phaseolus* L.
					Phaseolus lunatus L.
					Phaseolus polyanthus Greenman
					Phaseolus vulgaris L.
					Prosopis jutiflora (SW.) DC
					Prosopis L.
					Senna pallida (Vahl) Irwin & Barneby var.
			Sapindales	Sapindaceae	*Dodonaea viscosa* (L.) Jacq.
					Sapindus saponaria L.
				Rutaceae	*Citrus aurantifolia* Swindle
					Citrus L.
					Ruta chalepensis L.
				Anacardiaceae	*Anacardium occidentale* L.
					Mangifera L.
					Spondias mombim L.
					Spondias purpurea L.
			Geraniales	Geraniaceae	*Geranium* L.
			Vochysiales	Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth
					Heteropteris beecheyana Juss.
			Celastrales	Celastraceae	*Wimmeria acuminata* L.O. Williams
		Cornidae	Dipsacales	Caprifoliaceae	*Sambucus mexicana* Presl. ex. DC.
		Asteridae	Asterales	Asteraceae	*Ambrosia cumanensis* HBK.
					Calea zacatechichi Schltdl.
					Chromolaena glaberrima (DC.) King & Rob.
					Eupatorium laevigatum Lam.
					Helianthus annuus L.
					Iva annua L. var. *annua*
					Perymenium nacaraguense Blake
					Pluchea odorata (L.) Cass.
					Pluchea symphytifolia (Mill) Gill.
					Tagetes lucida Cav.
					Taraxacum officinale L.
		Lamiidae	Rubiales	Rubiaceae	*Anisomeris protracta* (Benth.) Standl.
					Cephalanthus salicifolius Bonpl.
					Coffea L.
					Galium L.
					Psychotria jinotegensis Nelson, Molina & Standl.
					Psychotria L.
			Solanales	Solanaceae	*Capsicum* L.

(cont.) Summary botanical list organized phylogenetically (Takhtajan 1997)

DIVISION	**CLASS**	**SUB-CLASS**	**ORDER**	**FAMILY**	**SPECIES**
Magnoliophyta	Magnoliopsida	Lamiidae	Solanales	Solanaceae	*Solanum* L.
					Solanum lycopersicum L.
			Boraginales	Boraginaceae	*Heliotropium indicum* L.
			Scrophulariales	Buddleiaceae	*Buddleia americana* L.
					Buddleia L.
			Plantaginales	Plantaginaceae	*Plantago major* L./*australis* Lam.
			Lamiales	Verbenaceae	*Lippia alba* N.E. Brown
					Lippia dulcis L.
				Verbenaceae	*Lippia graveolens* HBK.
					Lippia graveolens Kunth
				Lamiaceae	*Hyptis verticillata* Jacq.
					Mentha x *piperita L.*
					Ocimum micranthum Willd.
	Liliopsida	Liliidae	Amaryllidales	Alliaceae	*Allium* sp. L.
				Agavaceae	*Agave* L.
					Agave pachycentra Trelease
					Agave seemanniana Jacobi
					Agave wercklei Weber x Berger
			Asparagales	Aloaceae	*Aloe vera* L.
			Dioscoreales	Dioscoreaceae	*Disoscorea* sp. L.
		Commelinidae	Musales	Musaceae	*Musa* L.
			Zingiberales	Zingiberaceae	*Zingiber oficinales* Roscoe
			Cyperales	Cyperaceae	*Scleria* Berg
			Poales	Poaceae	*Hordeum pusillum* Nutt.
					Panicum L.
					Phalaris caroliniana Walter
					Poa L.
					Setaria Beauv.
					Tripsacum L.
					Vetiveria zizanioides Nash.
					Zea diploperennis Iltis and Doebl.
					Zea luxurians Iltis and Doebl.
					Zea mays ssp. mays Iltis and Doebl.
					Zea mays ssp. *mexicana* Iltis and Doebl.
					Zea mays ssp. *parviglumis* Iltis and Doebl.
					Zea mexicana Mangl. & Reeves
					Zea nicaraguensis Iltis and Doebl.
		Arecidae	Arecales	Aracaceae	*Acrocomia mexicana* Karw.
					Acrocomia aculeata (Jacq.) Lodd. Ex Mart.
					Astrocaryum Mart.
					Attalea Kunth
					Attalea cohune Mart.

(cont.) Summary botanical list organized phylogenetically (Takhtajan 1997)

DIVISION	**CLASS**	**SUB-CLASS**	**ORDER**	**FAMILY**	**SPECIES**
Magnoliophyta	Liliopsida	Arecidae	Arecales	Aracaceae	*Bactris* spp.
					Bactris gasipaes Kunth
					Brahea dulcis (Kunth.) Mart.
					Chamaedorea Willd.
					Elaeis Jacq.
					Euterpe oleracea Martius
					Lepidocaryum (?) *tenue* Martius
					Oenocarpus (?) *bacaba* Martius
					Roystonea spp. (O.F. Cook)
					Syagrus Mart.
		Triurididae	Typhales	Typhaceae	*Typha* L.

List 2 of 3, Summary botanical list by species with common name

SPECIES	**COMMON NAME**
Acrocomia aculeata (Jacq.) Lodd. Ex mart.	*coyol* palm
Acrocomia mexicana Karw.	*coyol* palm
Agave L.	*maguey*, agave
Agave pachycentra Trelease	agave var.
Agave seemanniana Jacobi	agave var.
Agave wercklei Weber x Berger	agave var.
Allium sp. L.	wild onion, garlic, leek
Aloe vera L.	*sabila,* aloe vera
Amaranthus L.	pigweed
Ambrosia cumanensis HBK.	*altamisa,* ragweed
Anacardium occidentale L.	*maranon,* cashew
Anisomeris protracta (Benth.) Standl.	no common name
Annona cherimolia P. Hill	*cherimoya*
Annona diversifolia Saff.	*iliama, anona blanca*
Annona glabra L.	*anona*, soursop (1)
Annona L.	*anona,* annona
Annona reticulata L.	annona
Annona squamosa L.	sweet sop
Astrocaryum Mart.	palm var.
Attalea Kunth	attlea palm
Attalea cohune Mart.	*cohune* palm
Bactris spp.	*huiscoyol*
Bactris gasipaes Kunth	peach palm
Bixa orellana L.	*Achote,* lipstick tree
Brosimum alicastrum (Sw.) ssp. *Alicastrum*	*ramon*, breadnut
Buddleia americana L.	*hoja blanca*
Buddleia L.	butterflybush var.
Brahea dulcis (Kunth.) Mart.	suyate palm
(Bryophyllum) Kalanchoe Adans.	*siempre viva,* widow's thrill
Byrsonima crassifolia (L.) Kunth	*nance*
Calea zacatechichi Schltdl.	mexican calea
Calliandra grandiflora (L'Hér.) Benth.	stickpea var.
Calliandra rubescens (Martens & Galeotti) Standl.	stickpea var.
Calyptranthes hondurensis Standl.	mountainbay var.
Capsicum L.	chili pepper
Carica papaya L.	papaya
Carnegiea Britt & Rose	*saguaro* cactus
Celtis L.	hackberry
Cephalanthus salicifolius Bonpl.	mexican buttonbush
Chamaedorea Willd.	chamaedorea palm
Chenopodium ambrosioides L.	*ipazote,* (goosefoot)
Chenopodium berlanieri Moq.	chenopod

(cont.) Summary botanical list by species with common name

SPECIES	**COMMON NAME**
Chromolaena glaberrima (DC.) King & Rob.	thoroughwort
Citrus aurantifolia Swindle	lemon
Citrus L.	citrus, orange?
Clethra lanata Mart. & Gal. or *macrophylla* Mart. & Gal.	sweetpepperbush var.
Clidemia capitellata (Bonpl.) D. Don	*cerín*
Clusia salvinii Donn. Sm.	attorney var.
Coffea L.	*café,* coffee
Cucurbita argyrosperma Huber	silver seed gourd
Cucurbita ficifolia Bouche	figleaf squash
Cucurbita maxima Duchesne	winter squash
Cucurbita moschata Duchesne	crookneck squash
Cucurbita pepo L.	squash (domestic)
Cucurbita pepo L. var. *ovifera* L. (Harz)	squash (wild)
Cupresus L.	*cipres,* cypress
Disoscorea sp. L.	yam
Dodonaea viscosa (L.) Jacq.	hopshrub
Elaeis Jacq.	oil palm
Enterolobium cyclocarpum (Jacq.) Griseb.	*guanacaste*, monkeysoap
Equisetum giganteum L.	*cola caballo*
Eupatorium laevigatum Lam.	*azota caballo*
Euterpe oleracea Martius	assai
Ficus cotinifolia var. *hondurensis* (Standl. & L.O. Williams) C.C. Berg	fig var.
Galium L.	bedstraw
Geranium L.	*geranio*
Gossypium L.	cotton
Harpalyce rupicola Donn. Sm.	no common name
Hauya elegans DC.	evening primrose tree
Helianthus annuus L.	sunflower
Heliotropium indicum L.	*cola de alacran*
Heterocentron hondurense Gleason	*cerín*
Heteropteris beecheyana Juss.	barbados cherry family
Hibiscus rosa-sinensis L.	*clavel,* carnation
Hordeum pusillum Nutt.	little barley
Hyptis verticillata Jacq.	*verbena*
Inga P. Mill.	inga
Inga vera Willd. / *I. edulis* Mart.	*guamo*
Iva annua var. *annua* L.	Sumpweed, marshelder
Lagenaria siceraria (Molina) Standl.	bottle gourd
Lepidium virginicum L.	*mastuerzo,* VA pepperweed
Lepidocaryum (?) *tenue* Martius	palm var.
Lippia alba N.E. Brown	*juanilama*
Lippia dulcis L.	*orozul*

(cont.) Summary botanical list by species with common name

SPECIES	**COMMON NAME**
Lippia graveolens HBK.	oregano
Lippia graveolens Kunth	mexican oregano
Liquidambar styraciflua L.	sweet gum
Lysiloma auritum (Schltdl.) Benth.	false tamarind
Malvaviscus arboreus Cav. var. *arboreus*	wax mallow
Mangifera L.	mango
Manihot jatropha L.	cassava var.
Manihot P. Mill.	manioc ("Tseed")
Manilkara achras (Mill.) Fosberg (=*Achras sapota*)	*sapodilla*
Manilkara Adans.	manilkara
Manilkara zapote (L.) van Royen	*mamay*
Mentha x *piperita L.*	*herbabuena*
Miconia albicans (Sw.) Triana	*cerín*
Miconia theaezans (Bonpl.) Cogn.	*cerín*
Musa L.	banana
Myrica cerifera L.	wax myrtle
Ocimum micranthum Willd.	*albaca,* basil
Oenocarpus (?) *bacaba* Martius	palm var.
Opuntia P. Mill.	prickly pear cactus
Pachycereus (Berger) Britton & Rose	cardon cactus
Panicum L.	panic grass seed
Persea americana P. Mill. var. *drymifolia* (Schldl. & Chambers) S. F. Blake	avocado, Mexican
Persea americana P. Mill. var. *americana*	avocado
Persea americana P.Mill. var. *nubigena* (L. O. Williams) L.E. Kopp	avocado, Guatemalan
Persea P. Mill.	avocado
Perymenium nicaraguense Blake	no common name
Petiveria alliacea L.	*ipacina,* guinea hen weed
Phalaris caroliniana Walter	maygrass
Phaseolus acutifolius Grey	tepary bean
Phaseolus coccineus L.	scarlet runner bean
Phaseolus L.	bean
Phaseolus lunatus L.	sieva bean
Phaseolus polyanthus Greenman	year bean
Phaseolus vulgaris L.	kidney bean
Pinus L.	pine
Pinus pseudostrobus Lindl.	pine var.
Plantago major L./*australis* Lam.	*llanten,* plantain
Pluchea odorata (L.) Cass.	sweetscent
Pluchea symphytifolia (Mill) Gill.	*siguapate,* camphor weed
Poa L.	bluegrass
Polygonum erectus L.	erect knotweed
Polypodium aureum L.	*calaguala*

(cont.) Summary botanical list by species with common name

SPECIES	**COMMON NAME**
Pouteria sapota (Jacq.) H.E. Moore & Stearn	mamee sapote
Prosopis jutiflora (SW.) DC	mesquite var.
Prosopis L.	mesquite
Prunus persica (L.) Batch	peach, pit
Psidium guajava L.	guava
Psidium guajava L.	*guayabo*
Psidium guineense Sw.	guinea guava
Psychotria jinotegensis Nelson, Molina & Standl.	wild coffee var.
Psychotria L.	wild coffee
Quercus sapotifolia Liebm.	*encino*, oak
Quercus segoviensis Liebm.	*roble*, oak
Roystonea spp. (O.F. Cook)	royal palm
Rubus adenotrichus Schltdl.	blackberry family
Ruta chalepensis L.	*ruda,* rue
Sambucus mexicana Presl. ex. DC.	*sauco,* elderberry
Sapindus saponaria L.	soapberry
Schinziophyton rautanenii Schinz	mongongo nut
Scleria Berg	sedge, nutrush
Senna pallida (Vahl) Irwin & Barneby var.	senna
Setaria Beauv.	bristlegrass
Sida rhombifolia L.F/*acuta* Burm.	*escobilla,* jute
Sideroxylon L.	bully
Sideroxylon capiri (A.DC) Pittier subsp. *tempisque* (Pittier) T.D. Penn.	*cosahuico*
Sideroxylon palmeri (Rose) T.D. Penn.	*tempesquistle*
Solanum L.	nightshade family
Solanum lycopersicum L.	garden tomato
Spondias mombim L.	*ciruela*, hog plum,
Spondias purpurea L.	purple mombim
Syagrus Mart.	queen palm genus
Syzygium jambos (L.) Alston	*manzanito*, rose apple
Tagetes lucida Cav.	*pericon*,sweet scent marigold
Taraxacum officinale L.	*diente de lion,* dandelion
Ternstroemia tepezapote Schltdl. & Cham.	tea family
Theobroma cacao L.	cacao
Tibouchina longifolia (Vahl) Baill.	*cerín*
Tripsacum L.	gamagrass
Typha L.	cattail
unknown	*curarina*
unknown	*cojoyitos*
Vetiveria zizanioides Nash.	*valeriana (zacate)*
Wimmeria acuminata L.O. Williams	staff vine, bittersweet family
Zea diploperennis Iltis and Doebl.	*teosinte*, perennial

(cont.) Summary botanical list by species with common name

SPECIES	**COMMON NAME**
Zea luxurians Iltis and Doebl.	*teosinte*, Guatemala
Zea mays ssp. mays Iltis and Doebl.	domesticated corn
Zea mays ssp. *mexicana* Iltis and Doebl.	*teosinte*, Central plateau
Zea mays ssp. *parviglumis* Iltis and Doebl.	*teosinte*, Balsas variety
Zea mexicana Mangl. & Reeves	highland *teosinte* (old)
Zea nicaraguensis Iltis and Doebl.	*teosinte*
Zingiber oficinales Roscoe	*jengibre,* ginger root

Note: Common names are provided when known or, if they are used regularly in the text. Some common names are drawn from the local vernacular of Highland Honduras. Because the terms used by local people may differ regionally, they may vary from traditional Spanish and/or the Mexican names that readers are more familiar with. The English common name is also supplied.

List 3 of 3, Summary botanical list by common name with species

COMMON NAME	**SPECIES**
achote, lipstick tree	*Bixa orellana* L.
agave var.	*Agave pachycentra* Trelease
agave var.	*Agave seemanniana* Jacobi
agave var.	*Agave wercklei* Weber x Berger
albaca, basil	*Ocimum micranthum Willd.*
altamisa, ragweed	*Ambrosia cumanensis* HBK.
annona	*Annona reticulata* L.
anona, annona	*Annona* L.
anona, soursop (1)	*Annona glabra* L.
assai	*Euterpe oleracea* Martius
attalea palm	*Attalea* Kunth
attorney var.	*Clusia salvinii* Donn. Sm.
avocado	*Persea americana* P. Mill. var. Americana
avocado	*Persea* P. Mill.
avocado, Guatemalan	*Persea americana* P. Mill. var. *nubigena* (L. O. Williams) L.E. Kopp
avocado, Mexican	*Persea americana* P. Mill. var. *drymifolia* (Schldl. & Chambers) S. F. Blake
Azota caballo	*Eupatorium laevigatum Lam.*
banana	*Musa* L.
barbados cherry family	*Heteropteris beecheyana* Juss.
bean	*Phaseolus* L.
bedstraw	*Galium* L.
blackberry family	*Rubus adenotrichus* Schltdl.
bluegrass	*Poa* L.
bottle gourd	*Lagenaria siceraria* (Molina) Standl.
bristlegrass	*Setaria* Beauv.
bully	*Sideroxylon* L.
butterflybush var.	*Buddleja* L.
cacao	*Theobroma cacao* L.
café, coffee	*Coffea* L.
calaguala	*Polypodium aureum* L.
cardon cactus	*Pachycereus* (Berger) Britton & Rose
cassava var.	*Manihot jatropha* L.
cattail	*Typha* L.
cerín	*Clidemia capitellata* (Bonpl.) D. Don
cerín	*Heterocentron hondurense* Gleason
cerín	*Miconia albicans* (Sw.) Triana
cerín	*Miconia theaezans* (Bonpl.) Cogn.
cerín	*Tibouchina longifolia* (Vahl) Baill.
chamaedorea palm	*Chamaedorea* Willd.
chenopod	*Chenopoium berlanieri* Moq.
cherimoya	*Annona cherimolia* P. Hill

(cont.) Summary botanical list by common name with species

COMMON NAME	**SPECIES**
chili pepper	*Capsicum* L.
cipres, cypress	*Cupresus* L.
ciruela, hog plum	*Spondias mombim* L.
citrus, orange?	*Citrus* L.
clavel, carnation	*Hibiscus rosa-sinensis* L.
cohune palm	*Attalea cohune* Mart.
cojoyitos	unknown
cola caballo	*Equisetum giganteum* L.
cola de alacran	*Heliotropium indicum* L.
cosahuico	*Sideroxylon capiri* (A.DC) Pittier subsp. *tempisque* (Pittier) T.D. Penn.
cotton	*Gossypium* L.
coyol palm	*Acrocomia mexicana* Karw. or, *A. aculeata* (Jacq.) Lodd. ex Mart.
crookneck squash	*Cucurbita moschata* Duchesne
curarina	unknown
diente de lion, dandelion	*Taraxacum officinale* L.
domesticated corn	*Zea mays ssp. mays* Iltis and Doebl.
encino, oak	*Quercus sapotifolia* Liebm.
erect knotweed	*Polygonum erectum* L.
escobilla, jute	*Sida rhombifolia* L.F/*acuta* Burm.
evening primrose tree	*Hauya elegans* DC.
false tamarind	*Lysiloma auritum* (Schltdl.) Benth.
fig var.	*Ficus cotinifolia* var. *hondurensis* (Standl. & L.O. Williams) C.C. Berg
figleaf squash	*Cucurbita ficifolia* Bouche
gamagrass	*Tripsacum* L.
garden tomato	*Solanum lycopersicum* L.
geranio	*Geranium* L.
guamo	*Inga vera* Willd. / *I. edulis* Mart.
guanacaste, monkeysoap	*Enterolobium cyclocarpum* (Jacq.) Griseb.
guava	*Psidium guajava* L.
guayabo	*Psidium guajava* L.
guinea guava	*Psidium guineense* Sw.
hackberry	*Celtis* L.
herbabuena	*Mentha* x *piperita L.*
highland *teosinte* (old)	*Zea mexicana* Mangl. & Reeves
hoja blanca	*Buddleia americana* L.
hopshrub	*Dodonaea viscosa* (L.) Jacq.
huiscoyol	*Bactris* spp.
iliama, anona blanca	*Annona diversifolia* Saff.
inga	*Inga* P. Mill.
ipacina, guinea hen weed	*Petiveria alliacea L.*
ipazote, goosefoot	*Chenopodium ambrosioides* L.
jengibre, ginger root	*Zingiber oficinales* Roscoe

(cont.) Summary botanical list by common name with species

COMMON NAME	**SPECIES**
juanilama	*Lippia alba* N.E. Brown
kidney bean	*Phaseolus vulgaris* L.
lemon	*Citrus aurantifolia* Swindle
little barley	*Hordeum pusillum* Nutt.
llanten, plantain	*Plantago major* L./*australis* Lam.
maguey, agave	*Agave* L.
mamay	*Manilkara zapote* (L.) van Royen
mamee sapote	*Pouteria sapota* (Jacq.) H.E. Moore & Stearn
mango	*Mangifera* L.
manilkara	*Manilkara* Adans.
manioc ("Tseed")	*Manihot* P. Mill.
manzanito, rose apple	*Syzygium jambos* (L.) Alston
maranon, cashew	*Anacardium occidentale* L.
marshelder, sumpweed	*Iva annua* L. var. *annua*
mastuerzo, VA pepperweed	*Lepidium virginicum* L.
maygrass	*Phalaris caroliniana* Walter
mesquite	*Prosopis* L.
mesquite var.	*Prosopis jutiflora* (SW.) DC
mexican buttonbush	*Cephalanthus salicifolius* Bonpl.
mexican calea	*Calea zacatechichi* Schltdl.
mexican oregano	*Lippia graveolens* Kunth
mongongo nut	*Schinziophyton rautanenii* Schinz
mountainbay var.	*Calyptranthes hondurensis* Standl.
nance	*Byrsonima crassifolia* (L.) Kunth
nightshade family	*Solanum* L.
no common name	*Anisomeris protracta* (Benth.) Standl.
no common name	*Harpalyce rupicola* Donn. Sm.
no common name	*Perymenium nacaraguense* Blake
oil palm	*Elaeis* Jacq.
oregano	*Lippia graveolens* HBK.
orozul	*Lippia dulcis* L.
palm var.	*Astrocaryum* Mart.
palm var.	*Lepidocaryum* (?) *tenue* Martius
palm var.	*Oenocarpus* (?) *bacaba* Martius
panic grass seed	*Panicum* L.
papaya	*Carica papaya* L.
peach palm	*Bactris gasipaes* Kunth
peach, pit	*Prunus persica* (L.) Batch
Pericon, sweet scented marigold	*Tagetes lucida* Cav.
pigweed	*Amaranthus* L.
pine	*Pinus L.*
pine var.	*Pinus pseudostrobus* Lindl.

(cont.) Summary botanical list by common name with species

COMMON NAME	**SPECIES**
prickly pear cactus	*Opuntia* P. Mill.
purple mombim	*Spondias purpurea* L.
queen palm genus	*Syagrus* Mart.
ramon, breadnut	*Brosimum alicastrum* (Sw.) ssp. *Alicastrum*
roble, oak	*Quercus segoviensis* Liebm.
royal palm	*Roystonea spp.* O.F. Cook
ruda, rue	*Ruta chalepensis* L.
sabila	*Aloe vera* L.
saguaro cactus	*Carnegiea* Britt & Rose
sapodilla	*Manilkara achras* (Mill.) Fosberg (=*Achras sapota*)
sunflower	*Helianthus annuus L.*
sauco, elderberry	*Sambucus mexicana* Presl. ex. DC.
scarlet runner bean	*Phaseolus coccineus* L.
sedge, nutrush	*Scleria* Berg
senna	*Senna pallida* (Vahl) Irwin & Barneby var.
siempre viva, widow's thrill	*(Bryophyllum) Kalanchoe* Adans.
sieva bean	*Phaseolus lunatus* L.
siguapate, camphor weed	*Pluchea symphytifolia* (Mill) Gill.
silver seed gourd	*Cucurbita argyrosperma* Huber
soapberry	*Sapindus saponaria* L.
squash (domestic)	*Cucurbita pepo* L.
squash (wild)	*Cucurbita pepo* L. var. *ovifera* L. (Harz)
staff vine, bittersweet family	*Wimmeria acuminata* L.O. Williams
stickpea var.	*Calliandra grandiflora* (L'Hér.) Benth.
stickpea var.	*Calliandra rubescens (Martens & Galeotti) Standl.*
suyate palm	*Brahea dulcis* (Kunth.) Mart.
sweet gum	*Liquidambar styraciflua* L.
sweet sop	*Annona squamosa* L.
sweetpepperbush var.	*Clethra lanata* Mart. & Gal. or *macrophylla* Mart. & Gal.
sweetscent	*Pluchea odorata* (L.) Cass.
tea family	*Ternstroemia tepezapote* Schltdl. & Cham.
tempesquistle	*Sideroxylon palmeri* (Rose) T.D. Penn.
teosinte	*Zea nicaraguensis* Iltis and Doebl.
teosinte, Balsas variety	*Zea mays* ssp. *parviglumis* Iltis and Doebl.
teosinte, Central plateau	*Zea mays* ssp. *mexicana* Iltis and Doebl.
teosinte, Guatemala	*Zea luxurians* Iltis and Doebl.
teosinte, perennial	*Zea diploperennis* Iltis and Doebl.
tepary bean	*Phaseolus acutifolius* Grey
thoroughwrot	*Chromolaena glaberrima* (DC.) King & Rob.
valeriana (zacate)	*Vetiveria zizanioides* Nash.
verbena	*Hyptis verticillata* Jacq.
wax mallow	*Malvaviscus arboreus* Cav. var. *arboreus*

(cont.) Summary botanical list by common name with species

COMMON NAME	**SPECIES**
wax myrtle	*Myrica cerifera* L.
wild coffe	*Psychotria* L.
wild coffee var.	*Psychotria jinotegensis* Nelson, Molina & Standl.
wild onion, garlic, leek	*Allium* sp. L.
winter squash	*Cucurbita maxima* Duchesne
yam	*Disoscorea* sp. L.
year bean	*Phaseolus polyanthus* Greenman

Note: Common names are provided when known or, if they are used regularly in the text. Some common names are drawn from the local vernacular of Highland Honduras. Because the terms used by local people may differ regionally, they may vary from traditional Spanish and/or the Mexican names that readers are more familiar with. The English common name is also supplied.

Appendix B

Concordance of excavated Levels and features with Strata, Sub-strata and Layers

Unit 1:

UNIT 1		***Depths are below datum # 00-1 (10cm above ground surface)***						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		11.5	17	12	19	14.5		
1	Ia	13	17.5	13	21.5	15		
2	Ia	18.5	23	22	18.5	27		
3	Ia	24.5	28.5	27.5	24	32		
4	Ia	30	33.5	33	29.5	38.5		
5	Ib	36.5	43.5	41.5	36.5	43.5		FEATURE 1
6	Ib	45.5	49	49	46	52		FEATURE 1
7	Ic	77						FEATURE 1
8	III		54.5	53.5	52	57		
9	IIIc4		59	58.5	57	60.5		
10	IIId		66	59	63.5	68		FEATURE 4
11	IIId		66.5	63				FEATURE 4
12a	III				70			
12b	IIId						74	East wall
12c	III		72	69		71		
13a	IIIf2					80		
13aa	IIIf2				76			
13b	IIIf2		79	78				
14	IVb	81.5	85	82.5	81	85		
15	IVb	88	89.5	88	87	89.5		
16a	IV						110	South wall
16b	IV	95						FEATURE 10
16c	IVb			95	94	95		
17a	IVb						103	NE quadrant
17b	IVb	100.5	102	101.5				
17c	IVb				99.5	100.5		
17d	IVb						103	NE quadrant
18	Va	102	103	106	110	110		FEATURE 5
19	VI	102	107	109.5	110	116.5		FEATURE 5
20	VI	106.5	110	115	113.5	121		FEATURE 5
21	VI	113	116	118.5	118	123		FEATURE 5
22a	VI					130		FEATURE 5
22b	VIIa	122	122.5	125.5	126			
23a	VIIa					134		
23b	VIIIa	128.5	129	132	133.5			
24a	VIIa					140		
24b	VIIIa	135	131	136	141			
25	VIIIa	144.5	144	145	147	146.5		
26	VIIIb	149.5	151	150	153.5	154		

Unit 1 (continued):

UNIT 1		***Depths are below datum # 00-3 (93.5cm below ground surface)***						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
27	VIIIc	55	53.5	56.5	58	59		
28	VIIId						70	NE quadrant
29	VIIId						81	NE quadrant
30	VIIIe						89	NE quadrant
31	VIIIe						93.5	NE quadrant
32	VIIIe						100	NE quadrant
33	IX						108.5	NE quadrant
34	IX						114	NE quadrant
								BED ROCK

Unit 2:

UNIT 2		***Depths are below datum # 00-2 (10cm above ground surface)***						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
		16	17.5	22.5	26.5	29		
1	Ia	16.5	18	23	27.5	30		
2	Ia	23.5	25.5	27.5	31.5	30		
3a	Ia	33		36	36.5			
3b	Ia		34.5			38.5		
4a	Ia				41			
4b	Ib		39			42		FEATURE 1
4c	Ic	42		41.5				FEATURE 1
5a	Ia				47.5			
5b	Ib		45	46		47.5		FEATURE 1
6a	Ic	50			51.5			FEATURE 1
6b	Ib		50			58		FEATURE 1
6c	IId			51				
7	Ic	58		56	63			FEATURE 1
8	Ic	70			73.5			FEATURE 1
9	Ic				88.5			FEATURE 1
10	IIIc4	54	56	57.5		60		
11	IIIc4	59	62	61		65.5		
12	III		65.5	61.5		66		FEATURE 9
13	III		67	63		68.5		FEATURE 9
14a	III	64	73.5	69.5				FEATURE 9
14b	IIIc					73		
15a	III	70.5	76.5	72				
15b	III					77		
16a	III	81						
16b	III		80	78.5		81		
17a	IIIe	81.5	86	85		85.5		FEATURE 3
17b	III						86.5	FEATURE 3
18a	IVb	88.5	92	91	90	94		
18b	IV						99.5	East wall
18c	IV						94	North wall
19a	IVb	93	96	97	97	100		
19b	IV						95	Center
20	IVb	98	103.5	104	101	105.5		
21a	Va						107.5	South wall
21b	Va	106	108	108.5	107.5	110		
22	Va		109	111	113.5	117		
23	VI	115.5	120	114.5	113	116		
24	VIIa	119	121	120	120	127		
25	VIIa	123	128.5	126	127	129.5		
26	VIIb	130	132.5	132.5		134		
27	VIIb	136.5	138.5	139		140		
28	VIIIa	147	139	141		141.5		

Unit 3:

UNIT 3 ***Depths are below datum # 01-3 (10cm above ground surface)***

Level	Stratum	NW	NE	Center	SW	SE	Other	Description
		7.5	23	17	9	28.5		
1	Ia	9.5	23.5	19.5	11	27.5		
2	Ia	13	27.5	25.5	17	33.5		
3	Ib	20	35.5	30.5	24.5	38		FEATURE 2
4	Ib	27	42	35	31	42		FEATURE 2
5a	Ib	32.5	46.5	41.5	35			FEATURE 2
5b	Ia					46.5		
6	Ia		57.5					
7	Ia		62.5					
8	Ib	38		46	36	52		FEATURE 2
9	Ib	40.5		47	41	54		FEATURE 2
10	IId	41		52	47	58		
11	IId						65	South wall
12	IIIe						48	North half
13	IIIe						51	North half
14	IIIe						55	FEATURE 13
15	IIIf2	48		54	50			
16	IIc						61	SW quad
17	IIIf2	53		59	55			
18	IId					65		
19	IIIf2			65	62	70		
20	IVb	65	70	70	67	76		
21	IIIf2	.					77	NW quad
22	IIIf3				69.5			
23	IVb	69	76	75	71	81		
24	Va	75	80.5	78	79	85		
25	Va	78.5	86.5	84	82	90		
26	VI	87	91	90	90	96		
27	VI	91.5	100	97	93	102		
28	VI						109	FEATURE 16
29	VIIa	96.5	106.5	101	101	108		
30	VIIa	106.5	110	107	103	110		
31	VIIa	111	114	114	110	118		
32	VIIIa	116	118.5	120	118.5	122		

Unit 4:

UNIT 4		**Depths are below datum # 01-04 (08cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
		8	15	18	23	14		
1	Ia	12	15	19	22	15		
2	Ia	17	20	22	27	21		
3	Ia	22.5	25	28	32	26		
4	Ia	28	31	34	37	32		
5	Ia	35	37	39	42	37		
6	Ia	41	42	45	47	44		
7	Ib	47		50	51	52		FEATURE 1
8	Ib	52		56	56	58		FEATURE 1
9	Ib	53		62	62	64		FEATURE 1
10	Ic			70	67	69		FEATURE 1
11	Ic			80		76		FEATURE 1
12a	IIId2		54					FEATURE 9
12b	IIId2.1		63					
12c	IIId2		68					
12d	IIId2		75					
13	III						60	West wall
14	III	65					65	West wall
15	IVb	70					70	West wall
16	IVb				78	76		
17	Va				80	80		
18	Va		85	82		85		
19	VI		88	88		90		
20	VI		99	96		94		
21	VIIa		101			103		
22	VIIa						108	SE quad
23	VIIa						115	SE quad
24	VIIa						125	SE quad

Unit 5:

UNIT 5		**Depths are below datum # 01-05 (12cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
		11	7	9	13	11		
1	Ia	11	8	9	13	11		
2	Ia	17	14	16	20	16		
3	Ia	24	24	25	26	23		
4a	II(?)			30		30		
4b	Ia	30	30		32			
5a	II(?)		39					
5b	Ia	39		37	36	38		
6	Ia	42	43	37	41	42		
7	Ia		49		47			
8	Ia		53		52			

Unit 6:

UNIT 6		**Depths are below datum # 01-06 (06cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
		10	5	4	15	16		
1	Ia	18	7	6	16	15		
2	Ia		15	15	14	16		
3	Ia	19	20	20		21		
4a	Ib						23	FEATURE 1
4b	Ia	26	25	27	25	27		
5a	Ib						29	FEATURE 1
5b	Ia	31	31	29	29	30		
6	Ib	34	36	36	35	35		FEATURE 1
7a	IIc3				43			
7b	IIa1	39	40	39		40		
8a	IIc3				47			
8b	IIa1	42	45	45		45		
9	IIa1	50	53	51				
10	IIa1						46	South wall
11	IIa6						48	South wall
12	IIa6						53	South wall
13	Ic3	53		54	53	53		
14	IIa4	59	61					FEATURE 8
15a	IIa6.1						71	FEATURE 8
15b	IId			61	60	58		
16	IId		64			66		
17a	IIa6		68	66	65	68		FEATURE 8
17b	IIIe	66						
18	IIa6.4		75	72	66	78		FEATURE 8
19	IIa7		80				79	FEATURE 8
20	IIa7		92				88	FEATURE 8
21	IIIe			70	71	83		
22	IIIe	75		73	72	74		
23	IIIf	80		77	76	78		
24	IIIf	85		84	82	84		
25	IIIf	90		89	88	89		
26a	IIIf2					96		
26b	IVa	95	96	94	93			
27a	IVb						103	South wall
27b	IVa	99	101	98	95	102		
28	IVa	115						
29	IVb		109	106	99	106		
30	Va		112	110	104	111		
31	VI		121	117	114	120		
32a	IVa						132	NW quad
32b	VI		127	127	123	127		
33	VIIa		133	132	133	132	132	NW quad
34	VIIa		140	145	145	139		

Unit 7:

UNIT 7		**Depths are below datum # 01-07 (06cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		4.5	24.5	24	9	34		
1	Ia	9	24.5	25	12	34		
2	Ia	14	32	29	21	41		
3	Ia						34	FEATURE 2
4	Ia						45	FEATURE 2
5	Ia						48	FEATURE 2
6	Ib	24	48	38	30	48		FEATURE 2
7	Ib	33	48	48	38	53		FEATURE 2
8	IId	42	55	49	45	56		
9	IId				48			
10	IId				53			
11	Ib	48	58	52		62		
12	Ib	51	57			67		
13	Ib		78			81		
14	IVb	57		57	62		57	South wall
15	IVb	57		62	67		65	
16	Va	61		67	68		72	
17	Va	68		71	76		74	
18	Va	75		78	77		81	
19	Va	80		83	82		86	
20	Ib2		97			91		
21	VI	88.5	94	96	84	89		
22	VI	89	95	97	90	100		
23	VIIa	93	100	98	98	102		
24	VIIa	98	108	102	105	103		

Unit 8:

UNIT 8		**Depths are below ground surface**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		0	0	0	0	0		
1	Ia	10	10	10	10	10		
2	Ia	20	20	20	20	20		
3	Ia	30	30	30	30	30		
4	Ia	40	40	40	40	40		
5	Ia		50	50	50	50		
6	Ia		60	60	60	60		
7	Ia		70	70	70	70		
8	II/III(?)				80	80		
9	II/III(?)		78		81	90		
10	II/III(?)				100	100		
11	II/III(?)				110	110		
12	II/III(?)				120	120		

Unit 9:

UNIT 9		**Depths are below datum # 01-09 (26cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		13	24	22	21	24		
1	Ia	15	25	23	24	26		
2	Ia	20	30	30	27	32		
3	Ib	28	36	36	34	33		
4	Ib	36	46	43	38	46		FEATURE 2
5a	Ib		53			52		FEATURE 2
5b	Ib				48			FEATURE 2
5c	Ib	46		50				FEATURE 2
6	Ib	47		55				FEATURE 2
7	Ib		66			57		FEATURE 2
8	Ib		71			69	72	FEATURE 2, Center
9	Ib				54			FEATURE 2
10	Ib				65			FEATURE 2
11	Ib	53					65	FEATURE 2, NW Quad
12	Ib			69			62	FEATURE 2, West wall
13	Ib			72			62	FEATURE 2
14	Ib	60						FEATURE 2
15	Ib	68	71					FEATURE 2
16	Ib2	78	84					FEATURE 2
17	Ib2	87	87					FEATURE 2
18	Ib2				80			FEATURE 2
19	Ib2					90	89	FEATURE 2, East wall
20	Ib2					96	95	FEATURE 2, East wall
21	VI			80				
22	VI	83		85	86			
23	VIIa	89	87.5	87	87	102		

Unit 10:

UNIT 10		**Depths are below datum 01-05**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		0	0	0	0	0		
1	Ia	20	20	20	20	20		
2	Ia	40	40	40	40	40		
3	Ia	60	60	60	60	60		
4	Ia	80	80	80	80	80		
5	Ia	90	90			90		
6	Ia	100	100			100		
7	Ia	110	110			110		
8	Ia	120	120			120		
9	II/III(?)				85			
10	II/III(?)				90			
11	II/III(?)				95			
12	II/III(?)				101			
13	II/III(?)				109			
14	II/III(?)				117			
15	II/III(?)				128			
16a	II/III(?)				136			
16b	IV(?)	148	150			139		
17	IV(?)						150	East wall
18a	IV(?)				145			
18b	VI/VII(?)	158	167			152		

Unit 11:

UNIT 11		***Depths are measured from ground surface***						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		0	0	0	0	0		
1	Ia	10	10	10	10	10		
2	Ia	20	20	20	20	20		
3	Ia	30	30	30	30	30		
4	Ia	40	40	40	40	40		

Unit 12:

UNIT 12		***Depths are measured from ground surface***						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		0	0	0	0	0		
1	Ia	10	10	10	10	10		
2	Ia	20	20	20	20	20		
3	Ia	30	30	30	30	30		
4	Ia	40	40	40	40	40		
5	Ia	50	50	50	50	50		
6	Ia	60	60	60	60	60		
7	Ia	70	70	70	70	70		
8	Ia	80	80	80	80	80		

Unit 13:

UNIT 13		**Depths are below datum # 01-09 (26cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
		21	26	22	24	15		
1	1a	21	30	22	26	16		
2	1a	27	33	27	29	22		
3	1a	30	39		32			
4	1a	34	43					
5	1b	39	47	33	33	34		FEATURE 2
6	1b	42	48	40	38	38		FEATURE 2
7	1b	48	53	48	43	43		FEATURE 2
8a	1b2					56		FEATURE 2
8b	1b	55	63	59				FEATURE 2
8c	1b				56			FEATURE 2
9a	1b2					59		FEATURE 2
9b	1b	61	71	64	61			FEATURE 2
10	1	66	71	69	66			FEATURE 2
11	1	75	77	78	76			FEATURE 2
12	1	76	81	80	80			FEATURE 2
13	1		86					FEATURE 2
14	1			90	87			FEATURE 2
15	1				95			FEATURE 2
16	1b2	82	83					FEATURE 2

Unit 14:

UNIT 14		**Depths are below ground surface**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		0	0	0	0	0		
1	Ia	30	30	30	30	30		
2	Ia	60	60	60	60	60		
3	Ia	90	90	90	90	90		
4	IV(?)	100	100	100	100	100		
5	IV/VI(?)	110	110	110	110	110		
6	VI/VII(?)	120	120	120	120	120		

Unit 15:

UNIT 15		***Depths are measured from datum (01-15) 120cm below ground surface***						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		0	0	0	0	0		
1	VI	10	10	10	10	10		
2	VI	20	20	20	20	20		
3	VI/VII(?)	25	25	25	25	25		
4	VI/VII(?)	30	30	30	30	30		
5	VI/VII(?)	35	35	35	35	35		
6	VI/VIII(?)	40	40	40	40	40		
7	VIIIa	50	50	50	50	50		
8	VIIIb	60	60	60	60	60		
9	VIIIc	70	70	70	70	70		
10	VIIId	80	80	80	80	80		
11	VIIId	90	90	90	90	90		
12	VIIIe	110	94	100	110	91		
13	IX	120	120	120	120	120		
14	IX	130	130	130	130	130		BED ROCK

Unit 16:

UNIT 16		Depths are below datum # 01-16 (12cm above ground surface)						
Level	Stratum	NW	NE	Center	SW	SE	Other	Description
		15	28	23	13	29		
1	Ia	15	41	24	16	33		
2	Ia	20	45	26	21	38		
3	Ia	27	49	32	26	42		
4	Ia	31	51	38	31	48		
5	Ia	37	58	46	38	51		
6	Ia	43	61	54	43	58		
7	Ia	49	66	62	51	65		
8	Ib	57	73	67	54	67		FEATURE 2
9a	Ib2	62			55			FEATURE 2
9b	Ib		77	71		73		FEATURE 2
10a	Ib2	69			55			FEATURE 2
10b	Ib		79	79		79		FEATURE 2
11a	Ib2						91	FEATURE 2, NE wall
11b	Ib					84		FEATURE 2
12a	Ib2						105	FEATURE 2, NE wall
12b	Ib2					91		FEATURE 2
13	Ib2					99		FEATURE 2
14	Ib2						88	FEATURE 2, East wall
15	Ib2						93	FEATURE 2, East wall
16	Ib2						110	FEATURE 2, East wall
17	IId	75		70	62			
18	IVb	80		74	67			
19	Va	84		77	72			
20a	Va						96	NW quad
20b	Vb	88		85	80			
21	VI	93		90	86			
22	VI	96		95	91			
23	VIIa	102		103	96			
24	VI		116			106		
25	VIIa	108		106	105			
26	VIIa	109	118	107	107	111		

Unit 17:

UNIT 17		**Depths are below datum # 01-06 (7cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		36	72	51	46	76		
1	Ia	37	76	53	48	78		
2	Ia	47	80	62	54	80		
3	Ia	43	87	68	58	86		
4	Ia	56	90	72	64	95		
5	Ib	63	94	78	67	98		FEATURE 2
6	Ib	67	100	86	76	100		FEATURE 2
7	Ib			92	80	103		FEATURE 2
8	Ib2			92	89	108		FEATURE 2
9	Ib2			92	92	111		FEATURE 2
10	Ib2					117		FEATURE 2
11	Ib2					121		FEATURE 2
12	Ib2					127		FEATURE 2
13	Ib2					131		FEATURE 2
14	Ib2					142		FEATURE 2
15	Ib2				105			FEATURE 2
16a	IIIa						75	NW quad
16b	IIa	72	100					
17	IIa5	77	100					
18a	III						89	FEATURE 6, NW quad
18b	IVb	83						
19a	IVb	92						
19b	III						100	North wall
20	IVb	96						
21	IVb	102	106					
22	IVb	107	110	107	108			
23	IVc	111	113	108	111			
24	IIIa2						113	West wall
25	V	112	118	113	114			
26	VI	119	125	119	117			
27	VI	126	130	125	127			
28	VI	127	136	132	127			
29	VI					149		
30	VI		143	137	132			
31	VI		148	143	136			
32	VIIa	132	151	145	139	150		
33	VIIa	146	151	153	147	154		

Unit 18:

UNIT 18		**Depths are below datum # 01-18 (7cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		-2	29	26	18	34		
1	Ia	12	30	25	18	34		
2	Ia	18	31	28	20	33		
3	Ib	18	38	34	20	38		FEATURE 2
4	Ib	18	44	34	20	44		FEATURE 2
5	Ib		46					FEATURE 2
6	Ib						52	FEATURE 2, SE quad
7	Ib	23			26			FEATURE 2
8	Ib	31		40	34			FEATURE 2
9	Ib	33		44	37			FEATURE 2
10	Ib					44		FEATURE 2
11	Ib					50		FEATURE 2
12	IIc2		58					
13a	IIc1	42						
13b	IIc1			50		51		
14	IIc1		59	55	49	59		
15	IIc3		66				67	East wall
16	IIc3		85				77	East wall
17	IId					63	61	South wall
18	IId				50	73		
19	IId						78	SE quad
20	IIc3	44						
21	IIIc1	47						
22	IIIc2						57	East wall
23	IIIc3	51						
24	IIId3.1	60						
25	IIIc4			60	60			
26	IIId3.3						69	FEATURE 3, East wall
27	IIId3.3						83	FEATURE 3, East wall
28	IIIe						66	FEATURE 12, North half
29	IIIe	66			66			
30	IIIf2	69		70	70			
31	IIIf2	74	75		76	77		
32a	IIIf1	79						FEATURE 11
32b	IIIf2		81			79		FEATURE 15
33a	IIIf2					84		
33b	IIIf1	80	84	78				
34	IVb	84	92	85	87	87		
35	Va	89	93		91	93		
36	Vb						101	South wall
37	IVb						114	NE quad
38	Va	95	100	97	97	100		
39	Va		106			104		
40	VI	104	105	107	108	109		
41	VIIa	113	113	113	114	114		
42	VIIa	121	123	123	125	126		

Unit 19:

UNIT 19		**Depths are below datum # 01-06 (7cm above ground surface)**						
Level	**Stratum**	**NW**	**NE**	**Center**	**SW**	**SE**	**Other**	**Description**
surface		6	32	17	17	44		
1	Ia	36	34	40	25	44		
2	Ib		39		33	42		FEATURE 2
3	Ib		43			48		FEATURE 2
4	Ib		49	46		50		FEATURE 2
5	Ib2		53			54		FEATURE 2
6	Ib2					68		FEATURE 2
7	Ib2		61	53		73		FEATURE 2
8	Ib2						99	FEATURE 2, SE quad
9	Ia						46	West wall
10	IIa1	45					48	West wall
11	IIa1	54		56			55	West wall
12	IIa1						78	West wall
13	IIa1	59	61	60				
14a	Ia4	67						
14b	III						81	FEATURE 6, NE quad
14c	IIa3			65				FEATURE 8
15	IIa6.2	75						FEATURE 8
16	IIa6.3						89	FEATURE 8, NW quad
17	Ib				38			
18	Ib				46			
19	Ib				50			
20	IIc3				55			
21	IIc3			71	59			
22	IIIc4						80	Center
23	IIIc4				69		75	NE quad
24	IIId2				77			
25	IIIe	78	79		78	78		
26	IIc3						95	Center
27	IIIe	85	87		85	85		
28	IVa						104	NW wall
29	IIIe	90	92	90				
30	IIIf2				90			
31	IIIf2				101			
32	IIIf2						100	FEATURE 14, NE quad
33	IIIf2						105	FEATURE 14, SE quad
34	IIIf2						112	FEATURE 14, North wall
35	IVb	98	98	99	99	101		FEATURE 7
36	IVb	102	108	103	102	107		FEATURE 7
37	Vb	108	110	109	109	109		
38	IVb						121	North wall
39	Vb	114	120	114	112	115		
40	VI	122	124	123	120	122		

Unit 19 (continued):

Level	Stratum	NW	NE	Center	SW	SE	Other	Description
41	VI	127			126			
42	VIIa	128	129	129	128	129		
43	VIIa	133	134	133	134	135		
44	VIIa	141	140	140	139	141		

Appendix C

Inventory of bulk sediment samples.

Designation	Location	Stratum	Volume	Comment
Bulk soil samples				
B1	north wall unit 2	IVb	400cc	Used in small seed analysis
B2	west wall unit 2	IId2	500cc	Feature 9, used in small seed analysis
B3	east wall unit 2	IIId3.4	1500cc	Feature 3, used in small seed analysis
Intended for pollen analysis, column-like but not continuous collection				
P1	east wall unit 2	Ib	125cc	Unexamined
P2	east wall unit 2	Ib	125cc	Unexamined
P3	east wall unit 2	IIc1	125cc	Unexamined
P4	east wall unit 2	IIc3	125cc	Unexamined
P5	east wall unit 2	IIIc1	125cc	Unexamined
P6	east wall unit 2	IIc4	125cc	Unexamined
P7	east wall unit 2	IIIe	125cc	Unexamined
P8	east wall unit 2	IIIe	125cc	Negative for pollen
P9	east wall unit 2	IIIf2	125cc	Negative for pollen
P10	east wall unit 2	IVb	125cc	Negative for pollen (TS and JJ)
P11	east wall unit 2	Va	125cc	Negative for pollen
P12	east wall unit 2	VI	125cc	Unexamined
P13	east wall unit 2	VII	125cc	Unexamined
P14	unit 1, level 34	IX	125cc	Negative for pollen (JJ)

(continued next page)

Inventory of bulk sediment samples (cont.)

Designation	**Location**	**Stratum**	**Volume**	**Comment**
Column sample				
C1	south wall unit 3	Ia	375cc	Used in carbon content analysis
C2	south wall unit 3	Ib	200cc	"
C3	south wall unit 3	Ib	125cc	"
C4	south wall unit 3	Id	100cc	"
C5	south wall unit 3	IIIc4	100cc	"
C6	south wall unit 3	IIIe	75cc	"
C7	south wall unit 3	IIIe	150cc	"
C8	south wall unit 3	IIIf2	125cc	"
C9	south wall unit 3	IIIf3	150cc	"
C10	south wall unit 3	IVb	150cc	"
C11	south wall unit 3	IVb	175cc	"
C12	south wall unit 3	Va	225cc	"
C13	south wall unit 3	Vb	200cc	"
C14	south wall unit 3	Vb	150cc	"
C15	south wall unit 3	VI	125cc	"
C16	south wall unit 3	VI	275cc	"
C17	south wall unit 3	VIIa	225cc	"
C18	south wall unit 3	VIIa	100cc	"
Column segment sample				
C19	west wall unit 6	IIIe	75cc	Unexamined
C20	west wall unit 6	IIIe	75cc	Unexamined
C21	west wall unit 6	IIIe	75cc	Unexamined
C22	west wall unit 6	IIIf	75cc	Unexamined
C23	west wall unit 6	IIIf	75cc	Unexamined
C24	west wall unit 6	IIIf	75cc	Unexamined
C25	west wall unit 6	IIIf	75cc	Unexamined
C26	west wall unit 6	IIIf	75cc	Unexamined
C27	west wall unit 6	IVa	75cc	Unexamined
C28	west wall unit 6	IVa	75cc	Unexamined
C29	west wall unit 6	IVa	75cc	Unexamined

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Professional Papers:

-Scheffler, T.E. (In press) “Paleoindian and Archaic Settlement in Honduras: Evidence from the rock shelter site of “El Gigante” in *George Hasemann Memorial Volume*, Gloria Lara-Hasemann and Boyd Dixon eds., Tegucigalpa, Honduras.
-Scheffler, T.E. (In press) "Las Cuevas y Los Abrigos del Sur-Oeste de Honduras: Hallazgos y Inferencia del Recorrido El Gigante - 1998." *Yaxkin*.
-Scheffler, T.E. 2000, “El Gigante Rockshelter: Archaic Mesoamerica and Transitions to Settled Life.” http://www.famsi.org/reports/00071/. Final Research Report to the Foundation for the Advancement of Mesoamerican Studies.
-Scheffler, T.E. 2001, "Research Report on the Proyecto Cueva El Gigante 2000, La Paz, Honduras." *Mexicon*. Volume XXIII, p115-123.
-Scheffler, T.E. 1999, "Work Plan: Archaeological Surveys for Five Training Areas at Marine Corps Base Camp Pendleton" Prepared for U.S. Dept. of the Navy, Southwest Division, Naval Facilities Engineering Command, March 1999.
-Scheffler, T.E. 1998, "The Cave in Mesoamerica." Masters Thesis on file at the Pennsylvania State University, Dept. of Anthropology.
-Scheffler T.E. 1995, "Panau Iki Emergency Survey." Report on file with Hawai`i Volcanoes National Park.
-Scheffler, T.E. 1994, "Kamo`oali`i Petrogyphs." Report on file with Hawai`i Volcanoes National Park.

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