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# Geoarchaeological and Archaeobotanical Approaches to Human-Environmental Interactions during the Archaic to Preclassic Periods in Northwestern Belize

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# Geoarchaeological and Archaeobotanical Approaches to Human-Environmental Interactions during the Archaic to Preclassic Periods in Northwestern Belize

**by**

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## Report

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# Dedication

I would like to sincerely thank my advisor, Dr. Fred Valdez, Jr., for giving me a chance to work in beautiful Belize and for being supportive and helpful throughout my research process. I would also like to thank Dr. Timothy Beach and Dr. Arlene Rosen for welcoming me into the geoarchaeology community and for all of their research support and mentorship. I am also extremely grateful for support from my colleagues, especially Angelina Locker, and my loving husband, Joe.

# Abstract

## Geoarchaeological and Archaeobotanical Approaches to Human-Environmental Interactions during the Archaic to Preclassic Periods in Northwestern Belize

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This report reviews human-environmental interactions in Northwestern Belize during the transition from Archaic (8000 to 4000 B.P.) to Preclassic periods (4000 B.P. to 2000 B.P.). Specifically, the transition of subsistence strategies from nomadic hunter-gatherer to more sedentary food production, which we still do not fully understand in the tropical lowlands of the Maya region. It is during this pivotal era that early to mid-Holocene humans domesticated a wide variety of plants and animals, establishing a new human niche strategy that dramatically changed environments around the world. This report considers how human niche construction, a theoretical framework that expressly attributes populations with deliberate ecosystem engineering strategies, plays an integral role in the Anthropocene. I present my plans for analyzing sediments and microbotanical remains to contribute to knowledge about paleoenvironment and human-landscape interactions to provide direct evidence for transformative behavior by humans.

# Table of Contents

# List of Tables

# List of Figures

# Chapter 1: Introduction

## BACKGROUND ON RESEARCH AREA

The Rio Bravo Conservation and Management Area (RBCMA) is an area of over 260,000 acres of protected land, which is owned by the Programme for Belize (PfB), a Belizean conservation organization (Nations 2006). This area is archaeologically studied by Programme for Belize Archaeological Project (PfBAP), which works in conjunction with PfB to encourage research that documents and protects the cultural heritage of Belize (Aylesworth and Valdez 2013).

The study area is included within the Three Rivers Region, which extends to adjacent areas in northeastern Peten, Guatemala and southeastern Quintana Roo, Mexico (Bridgewater et al. 2002; Brokaw and Mallory 1993; Scarborough and Valdez 2003). The region broadly encompasses four ecological zones. First, the La Lucha Uplands, which rest on Eocene bedrock and contain upland forests with well-drained soils and *bajos*. Second, the Rio Bravo Terrace Uplands, which are lower in elevation and lie east of the La Lucha Uplands. This area is characterized by varying elevations between 200 and 30 masl and vegetation including transitional forest, upland forest, and swampland-margin vegetation. Next, the Rio Bravo Embayment area is located east of the La Lucha and Rio Bravo Uplands. This structural valley contains the river and its lagoons as well as swamp and marsh systems. Finally, the Booth's River uplands lie the furthest east of all the uplands described. The Booth's River separates the uplands from the Booth's River depression (Bridgewater et al. 2002; Brokaw and Mallory 1993; Dunning et al. 2003; Scarborough and Valdez 2003).

The central and southern Maya Lowlands are located at approximately 16°N to 19°N latitude and 88°W to 91°N with an elevation of approximately 300 masl. The Cretaceous and Tertiary Yucatan platform gradually increases in elevation inwards from the northern and coastal plains by a series of normal faults with upland horsts and lowland grabens and karstic features cover the area's escarpments (Beach et al. 2006). Karst depressions in the uplands include *bajos*, dolines, and assorted other sinkholes. The lowlands included river valleys and or *bajo* seasonal wetlands, become flooded during the distinct wet season between June and November and water recedes during the remaining drier months. Annual rainfall varies between 600 mm in the Northwest to 2500 mm in the Southeast, and average temperatures range from 26 to 29°C. Areas near the coastal plain transform into perennial wetlands and temporary lakes. The diverse environment supports vegetation including saw-grass wetlands, tropical deciduous forests, and low-scrub forests (Beach et al. 2006).

Soils in the upland slopes of the region include "thin tropical Rendolls, some Alfisols, and Inceptisols" and soils in the majority of depressions in the area include histosols and vertisols (Beach et al. 2006:169). Soils in the region are formed by carbonate parent materials in the karstic landscape. Soils generally differ in characteristics based on their location. Soils in the northern region are formed on top of the carbonate parent materials with volcanic and other eolian inputs. Soils generally differ in characteristics based on their location. Soils in the northern region are "shallow, well-drained, clayey, and calcareous," whereas soils in the southern parts are deeper and more leached in addition to clayey and calcareous (Dunning and Beach 2004:3).

Rendoll soils belong to the suborder mollisol and are formed in humid, temperate regions from the five factors of soil formation such as the highly calcareous, mostly limestone parent material and the broadleaf evergreen forest vegetation. Alfisols are the soil order which have a suface layer of mineral soil, no organic soil material. Inceptisols are an order characterized by mineral-rich soils with one or more pedogenic horizons containing mineral materials which have been altered or removed to a major degree. Histosols consist mainly of wetter soils with large amounts of organics and are commonly known as peat or muck. Vertisols are high in clay content and are unique in that they are susceptible to swelling during wet periods and shrinking and cracking during dry periods (Schaetzl and Anderson 2005; Soil Survey Staff 1999)

Soil aggradation and wetland formation in the northwest region of Belize is well-documented by Luzzadder-Beach and Beach (2008). Soil investigations include more than 100 excavated trenches from the uplands to the wetlands of the coastal plains near Blue Creek with the use of soil chemistry and stratigraphy, water chemistry, and chronology. Water quality investigations include hundreds of samples from sources within and around La Milpa, Chan Chich-Gallon Jug Experimental Farm, and Blue Creek. In general, soil profiles indicate composition rich in calcium carbonate and gypsum. Alluvial fan and wetland soils vary in soil characteristics the most. Regional water quality results indicate that there are at least two main water sources that are hydrologically or chemically separate. Characteristics change from east to west, and wetland and downstream river sites are the most Ca and $SO_4$ rich.

Luzzadder-Beach and Beach (2008) attribute aggradation throughout the Three Rivers Region to four main processes. First, from input caused by ancient Maya practices including ditching and filling. Second, by escarpment erosion, which transports clastic sediments across the region. Next, flooding deposition from Blue Creek, Rio Bravo, and Rio Hondo. Finally, gypsum accumulation from a rising water table saturated in sulfate and calcium, which precipitates gypsum and calcium carbonate during seasonal evaporation and transpiration (Luzzadder-Beach and Beach 2008).

Soil aggradation can occur naturally or by human-induced factors including "increases in input (load) from source areas, increases in the ratio of load to flow, and rises in base levels" Luzzadder-Beach and Beach 2008:4). Soil aggradation is also attributed to changes in climate, vegetation or human land-use changes, as well as changes in flow gradient affected from rising sea levels. Stable surfaces were deeply impacted by human land use intensification by transforming stable surfaces into rapidly accumulating surfaces. For example, the regional landscape in the early to middle Maya Preclassic (3,200 BP to 2,350 BP) was formerly 1.2 m lower and mantled by a soil that is now distinct paleosol. Aggradation in the region between the Late Preclassic (2,350 BP – 1,700 BP) and Classic periods (1,700 BP – 1,050 BP) occurred due to "river flooding, local erosion, ancient Maya landscape manipulation, and gypsum precipitation from a rise in a water table (Luzzadder - Beach and Beach 2008:1).

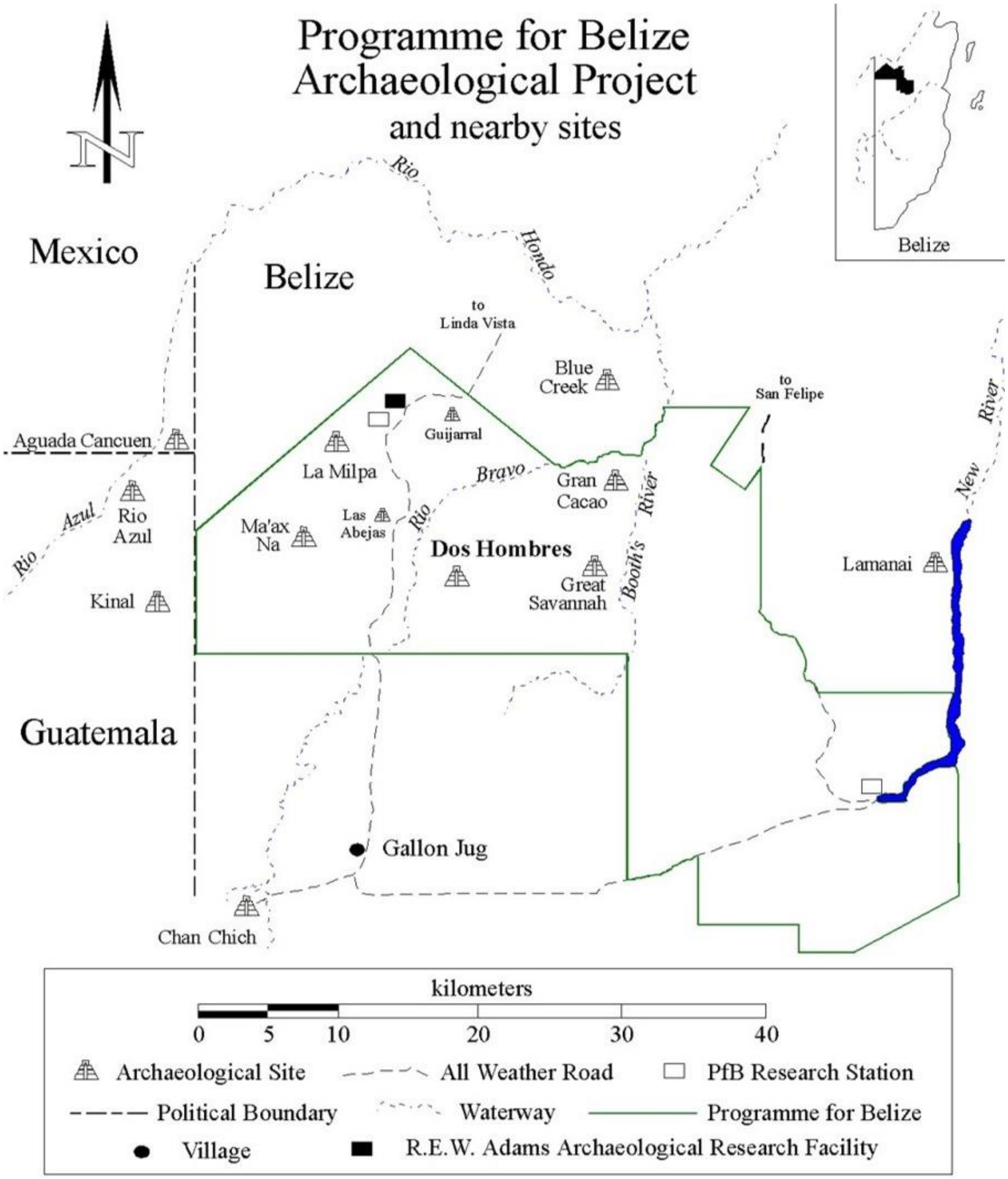


Figure 1: Map of Rio Bravo Conservation and Management Area, with permission by Programme for Belize Archaeological Project.

## PROPOSED RESEARCH

My approach to understanding the transition from Archaic Period to Preclassic Period cultural traditions and their impacts on the environment will be informed by human niche construction or “human ecosystem improvement behavior strategies” (Smith 2011). My data will identify human ecosystem engineering within well-documented Preclassic sites in order to answer *1)* Which cultigens and agricultural technologies did humans develop during the Archaic period that influenced the transition into the Preclassic period, reflecting trajectories of subsistence strategies? *2)* How did environmental change influence Archaic populations and their exploitation of the landscape? *3)* Could the subsistence and settlement habits of these early populations have instigated changes to the environment that affect subsequent ancient and modern-day Maya populations?

# Chapter 2: Theoretical Perspectives

## THE ANTHROPOCENE

Human activities have deeply modified the earth's habitable spaces and have pronounced effects on the earth's processes. These activities are visible throughout the archaeological record and will continue to leave evidence in such areas as "urban development, industrialization, agriculture and mining, and construction and removal of dams and levees" (Chin et al. 2013:1). Recent scientific literature has proposed a new geological epoch defined by cumulative impacts of intense human-environment interactions, the Anthropocene (Chin et al. 2013; Foley et al. 2013; Ruddiman 2013). It may even have prologue in Pleistocene Europe, but certainly starts with the beginning of the Holocene, a time of increased atmospheric $CO_2$ values and warmer temperatures around the world (Kennett and Beach 2013). In this epoch, humans have made immense transformations to the land and have altered natural earth systems at an alarming rate to include air and water pollution, soil erosion, deforestation, species extinction, and the domestication of various plants and animals during the intermittent transition from cold and dry Pleistocene to the temperate Holocene.

It is important to realize that domestication of plants and animals requires a complex trajectory, which potentially lasts up to thousands of years. Some even suggest the natural increase in $CO_2$ in the Pleistocene to Holocene transition may play a role in domestication through its acceleration of plant growth (Sage 1995). The term domestication is also distinct from the term cultivation. Cultivation refers to activities such as deforestation, sowing, harvesting, and storage of plant species, whereas domestication refers to genetic modification and physiological transformation of plant or animal species (Fuller 2010; Scarre 2005). Moreover, cultigens in the Archaic Period "may have been 'commensals': edible weeds that grow in disturbed soils or organic refuse around human encampments, thriving in symbiotic relationships with humans" (Rice 2007:17). The advent of domestication ultimately develops a reliance relationship between domesticates and humans, where domesticates require human interaction in order to successfully reproduce (Fuller 2010; Scarre 2005).

Adaptations of increased sedentary lifestyles and active transformations of the landscape such as deforestation and controlled fire, both associated with agriculture, are arguably the beginning of a world-wide trend in reshaping the earth's environmental systems (Foley et al. 2013; Ruddiman 2013; Smith 2007). This coincides with simultaneous agricultural origins around the world approximately 10,000 to 12,000 years ago (Cohen 2009; Fuller 2010; Scarre 2005). The deep impact of human-environment relationships is argued by some to begin even earlier during the Pleistocene (Koch and Barnosky 2006). According to Koch and Barnosky (2006), large mammal extinctions have been correlated with altering ecological niche systems through the use of fire, massive land clearance, and the introduction of non-human predators (dogs) during the Pleistocene and into the Holocene.

While the majority of scholars agree that a pronounced change in the earth's atmospheric $CO_2$ levels is evident at the beginning of the Industrial Revolution, growing evidence suggests earlier effects on the environment are associated with major shifts in subsistence strategies that occur simultaneously around the world. Some argue that intense forest and wetland destruction represent the first large contribution to increasing greenhouse emissions, long before the Industrial revolution (Ruddiman 2013). Ruddiman compares the views of scholars favoring intense deforestation prior to the industrial era and scholars who favor post-industrial era deforestation. According to scholars who favor a major industrial deforestation period, approximately two-thirds of the cumulative forest clearance occurs during the industrial era and one-third occurs after the industrial era. On the other hand, scholars who take into account not only historical, but archaeological data as well, calculate that as much as three-fourths of the earth's cumulative deforestation occurs prior to the Industrial Revolution (Ruddiman 2013). Massive deforestation, which occurs prior to the industrial era, contributes rises in atmospheric $CO_2$ (carbon dioxide) and $CH_4$ (methane gas) emissions. Anthropogenic influences in past $CO_2$ and $CH_4$ levels come from glacier cores directly and from climate and vegetation models and increasing archaeological data indirectly. $CO_2$ emission trends begin to diverge upwards approximately 7000 years ago and $CH_4$ emission trends diverge upwards approximately 5000 years ago. Both $CO_2$ and $CH_4$ emissions dramatically increase at around 2000 years ago (Ruddiman 2013).

Similarly, Kaplan et al.'s (2011) modeling produces a strong supporting case for anthropogenic forest clearance and its causal effects on atmospheric emissions. Carbon emissions over the last 8000 years are calculated by modifying a Dynamic Global Vegetation (DGV) model with Anthropogenic Land Cover Change (ALCC) data. Two scenarios drive this model, KK10 and HYDE 3.1, to compare a more intense land-use model and a conservative linear model, respectively. Kaplan et al. (2011) also incorporates data from climate studies, soil, and $CO_2$ ice cores to produce a model that reflects carbon emissions as a result of anthropogenic land cover over time. Kaplan et al.'s (2011) approach assumes that as populations increase over time, land-use intensifies and decreases per capita, land availability per capita declines, and technologies improve.

Kaplan et al. (2011) concludes that ALCC emissions continue to rise steadily, and at a higher rate, compared with the earlier models, where Holocene emission rates are more conservative between 3000 years ago and 1,650 years ago. Kaplan et al. also accounts for a drop in $CO_2$ concentrations between A.D. 1500 and 1700 A.D. due to a correlation between a time of maximum carbon uptake as a result of land abandonment in Europe and post contact land abandonment in the Americas. Kaplan et al.'s (2011) new model produces a drastic difference in carbon emissions, in which A.D. 1850 emissions change from 137-189 Pg (HYDE 3.1) to 325-357 Pg. This model supports a major influence by anthropogenic land cover change affecting atmospheric emissions well before the Industrial Revolution.

## HUMAN NICHE CONSTRUCTION THEORY

It is clear that humans have contributed to atmospheric $CO_2$ and $CH_4$ emissions as a result of increased landscape transformations (Kaplan et al. 2011 and Ruddiman 2013). At the same time, a more temperate and seasonal climate allows for the transition from hunter-gatherer to more intensive horticultural and agricultural strategies. Major deforestation events follow the domestication of a wide variety of plants and animals during this warming period. The Archaic Period (6000 BC- 2000 BC) evidence for occupation and cultivation during this time (Piperno and Pearsall 1998). Major cultigens including “Zea mays (maize), *Cucurbita pepo/Cucurbita argyrosperma* (squash), and *Phaseolus vulgaris* (common bean)” are products of domestication in the Mesoamerican region during the Archaic Period, which spread across the Maya Lowlands (Kennett and Beach 2013:91).

Human niche construction theory can inform a theoretical framework for early small-scale populations. This framework has ecological niche origins, but is heavily influenced by intentional human behaviors (Levin et al. 2009; Scheiner 2011). By domesticating various plants and animals, humans have been able to transform various biotic communities and different landscapes in order to fit human needs and wants (Smith 2007). Smith (2007) explains two levels of understanding human niche construction approaches to domestication: regional and species level. Macroevolutionary components are considered with the domestication of plants and animals at a regional level including “climate change, population growth, landscape packing and hardening of between-group boundaries, and intra and intergroup competition for resources and social status” (Smith 2007:188). Species level components are more concerned with spatial and temporal aspects of domestication as well as morphological and genetic changes a domesticate undergoes (Smith 2007). Smith (2011) further organizes the management and transformation of wild plant species and animal resource exploitation into six categories, each detailed below. Each category expands on how humans directly and inadvertently engineer their environment and modify ecosystems for plant and animal resources.

Smith’s (2011) first step in human niche construction includes the general alteration of vegetation in ecosystems where humans create mosaic and edge areas. This includes resetting successional vegetation reproduction cycles. Smith (2007) also considers hydraulic engineering structures and intense deforestation as markers for biome modification behaviors. There is extensive research on Maya examples of complex mosaic agrarian systems, including soil practices such as irrigation canals, raised field systems, and terracing (Gómez-Pompa 1987). Terracing occurs as early as the Late Preclassic period in Rio de la Pasion and Three Rivers Region of Guatemala and Belize (Dunning and Beach 2004). There is also evidence for the transformation of *bajos* from wetlands and lakes to maintained seasonal swamps in the Maya Lowlands as early as 400 BC (Dunning et al. 2002).

Dunning and Beach (2004) expand on the most common types of hydraulic systems such as dry slope, footslope, and checkdam terraces observed in the Maya tropical Lowlands. Dry slope terraces, also known as contouring or semi-contouring terraces, follow slope contours along moderate slopes. These terraces often link to residential complexes, field wall systems, or urban residential clusters. Footslope terraces run along the base of steep slopes and fill by controlled erosion from alluvial and colluvial sources. Farmers use these terraces for dry season farming since deeper soil fills store water longer and the terrace systems often direct water flows into them. Finally, checkdam or cross-channel terrace systems directly slow water flow and control soil erosion. These terracing systems occur in the Three Rivers region, the Petexbatun region, and La Milpa, among other places (Beach et al. 2003; Dunning and Beach 2004).

The second category of human niche construction behavior includes the intentional sowing of wild seed-bearing annuals near perennially inundated zones along river levees and lake edges (Smith 2011). Many deduce this behavior from ample maize pollen and phytoliths present in lake sediments and wetland peripheries throughout Mesoamerican lowlands during the Archaic period (Jones 1994; Kennett et al. 2010; Kennett and Beach 2013; Pohl et al. 1996). These practices can also be due to the vast diversity of periphery biomes, especially within the Neotropics. In particular, aquatic ecozones where wild species diversity is highly productive (Piperno and Pearsall 1998).

A third category of human niche construction outlined by Smith (2011) includes the transplantation of perennial fruit-bearing trees or bushes near settlements to create orchards or bush gardens. Classic Maya people likely maintained gardens that included a variety of "seed and vegetable crops, trees, roots, succulents, condiments, and industrial plants" (Kennett and Beach 2013:92). There is evidence for ancient Maya house gardens (or solars) from before the Classic Period, which include not only edible plants, but condiments and medicinal plants in Chunchucmil and the Puuc region (Dunning and Beach 2004; Kennett and Beach 2013). A conservative estimate for the use of wild plants for medicinal purposes is upwards of one third of the species available in the Maya region (Gómez-Pompa 1987).

Smith (2011) outlines a fourth human niche construction behavior as human manipulation of perennial fruit and nut-bearing plants in order to create landscapes with desired resources without transplantation. This practice describes cultivation rather than domestication and is key in outlining naturally occurring plant taxa in the Neotropics. Wild fruit bearing plants and trees in the Maya region include:

> "*Brosimum alicastrum* (*Ramon* or *osh*)…*Acrocomica mexicana* (palm), *Annona spp.* (pawpaw/sugar apple), *Byrosonima spp.* (Nance), *Calocarpum mammosum* (*zapote rojo*), *Casimiroa edulis* (white *zapote*), *Chrysophyllum caimito* (star apple), *Cordia dodecandra* (*bocote*), *Diospyros digyna* (black *zapote*), *Leucaena spp.* (legume), *Manilkara zapota* (sapodilla), *Muntingia calabura* (berry), *Oribignya spp.* (palm), *Parametiera edulis* (*Cuachilote*), *Spondias spp.* (cashew), *Persea americana* (avocado), *Pimenta dioica* (allspice), *Pithecellobium dulce* (pea), *Pouteria spp.* (mamey sapote), *Psidium spp.* (guava), *Scheelea spp.* (palm), *Spondia spp.* (cashew), *Talisia olivaeformis* (berry), and *Theobroma cacao* (cacao)"(Gómez-Pompa 1987:4).

On the other hand, the creation of desired landscapes is most visible in the archaeological, sedimentological, and microbotanical records, especially for slash-and-burn agriculture. Scheduled and controlled burning, as opposed to wild fires, is visible in the archaeological record around the world as far back as the early Holocene (Smith 2007). This wide-spread behavior is associated with a decrease in closed canopy forest pollen counts as well as an increase in micro-charcoal counts and disturbance taxa pollen (Jones 1994; Kennett et al. 2010; Kennett and Beach 2013; Piperno and Pearsall 1998; Pohl et al. 1996).

Two major advantages of slash-and-burn farming include the high productivity and speedy secondary regrowth of the forest (Culleton 2012). Primary crops such as maize, squash, gourd, and pumpkin are planted following the dry season and are harvested a few months later. Secondary and tertiary crops, which round out diets, are planted along wetland peripheries or river channels near the water table and may take advantage of growing as water recedes in the dry season (Kennett and Beach 2013). Culleton (2012) explains that secondary crops can be planted within *matahambre*, a mulch composed of felled vegetation that is not burned. Planting crops during the drier season allows for continual crop yield and economic buffering without a long-term storage option for crops (Kennett and Beach 2013). Humans have been actively implementing numerous human niche construction behaviors with slash-and-burn farming for millennia. The Maya Lowlands' paleoecological records reflect such trends of the adoption of slash-and-burn agriculture between 2,500 and 2000 B.C. as well as the appearance of increased number of Archaic Period sites (Iceland 1997; Kennett and Beach 2013; Piperno et al. 2009; Pohl et al. 1996; Renere et al. 2009; Rosenswig et al. 2014).

The penultimate human niche construction behavior as described by Smith (2011) is in-place management and transplantation of perennial root crops in order to create root gardens and further expand wild plant habitats. Root crop cultivation is well-documented in archaeobotanical and ethnohistorical records around the world. Mainly based on phytoliths and starch grains in archaeological contexts, New World root crops including *Manihot esculenta* (manioc), *Maranta arundinacea* (arrowroot), and *Calathea allouia* (leren) are domesticated between 9000 and 8000 B.P. (Smith 2007). Smith (2007) states that the initial cultivation of these root crops requires replanting root segments selected for their size and starch characteristics. Furthermore, evidence for manioc as integral to prehistoric diet in Mesoamerica continues to grow (Piperno and Pearsall 1998; Pohl et al. 1996; Sheets et al. 2012).

Lastly, intentional alteration of a landscape in order to increase prey abundance such as deer, fish, mollusk, and shellfish through canals, and fish ponds or gardens is another human niche construction behavior (Smith 2011). There is evidence for ancient Maya hunting and exchange of many species of animals. Intentional alterations of the landscape in order to encourage certain species to thrive for the production of raw materials or food resources are archaeologically abundant in the Maya Lowlands as early as the Preclassic Period (Thornton 2011).

In a major case study, Thornton (2011) uses strontium isotopes to reconstruct ancient Maya hunting ranges and exchange networks. Thornton's (2011) study for the reconstruction of animal trade examines 131 animal remains from 14 archaeological sites across Mexico, Guatemala, Belize, and Honduras, ranging from Preclassic to Colonial times. Common animal remains include *Odocoileus virginianus* (white-tailed deer), *Mazama sp.* (brocket deer), *Canis lupus familiaris* (domestic dog), *Tayassuidae* (peccary), *Pecari tajacu* (collared peccary), *Tayassu Pecari* (white-lipped peccary), and *Tapirus bairdii* (tapir).

Each of these animals serve important societal roles for their use in ritual and subsistence resources (Thornton 2011). For example, ancient trade including these animals is evident between Motul and Trinidad, as well as Dos Pilas and Aguateca. Travel between polities is possible along the Pasion River and exchange is facilitated for products like meat, hides, feathers, and bone artifacts or tools. Peccary remains recovered from both burial and non-burial contexts are observed in Piedras Negras and Caracol. In another example, non-local deer remains recovered from a cache at Lamanai were likely imported from Mayapan. Non-local deer and peccaries are also visible in the archaeological record in Tipu. Lastly, Copan contains local deer found in a disturbed royal tomb (Thornton 2011).

Whether these animals were hunted or domesticated, local biomes were affected due to human intervention in the local food chain and disturbances in population reproduction both for humans and animals. The landscape shows evidence for facilitating prey abundance with deforestation, especially for deer and peccary. Massive deforestation allows for deer and peccary to be easily seen, and without camouflage, it is easier to hunt or prey on those animals. It is clear that long range trade was occurring in the area and this implies hunting those species found at a higher rate, therefore, it is safe to assume that people likely modified their environment in order to facilitate hunting.

Another example for evidence of the domesticaiton of animals in the archaeological record can be observed in a faunal assemblage that contains distinct shifts in sex and age. This change in assemblages may suggest an initial domesticaiton or management of animals for human use (Smith 2007). Animals are not widely domesticated in ancient Mesoamerica, but there is evidence for the early domestication of *Canis canis* (dog), *Meleagris gallopavo gallopavo* (turkey), and *Cairina moschata* (muscovy duck) (Kennett and Beach 2013). Terrestrial protein sources are only supplements to maize and bean protein sources in the ancient Mesoamerican diet. Some of the earliest evidence for domesticated maize comes from the Rio Balsas drainage in the southern Mexicican state of Guerrero as early as approximately 7000 B.C. (Kennett and Beach 2013; Piperno et al. 2009; Pohl et al. 1996; Ranere et al. 2009).

Smith (2007) expands on why *Canis familiaris* (domestic dog) and *Lagenaria siceraria* (bottle gourd) are primary contenders for the first species to be domesticated in the animal and plant worlds. Both are dated to be domesticated as early as 12,000 and

15,000 years ago in Asia for their utilitarian use and brought into the Americas during the Paleoindian Period. Interestingly, neither are presumed to be initially domesticated for food sources. The domesticated hunting dog is said to be first drawn into human niches by its attraction to trash heaps and is later introduced into the human niche by selective morphological and behavioral traits. These same trash or midden heaps are also integral to the initial domestication of bottle gourds. Smith (2007) describes the bottle gourds' domestication process as beginning with humans eating wild bottle gourds and then discarding the seeds and rinds in trash heaps. Since the bottle gourd flourishes in human disturbed areas, not much tending or care by humans is required for its reproduction outside of selection for thicker rinds and larger fruits in the wild. New world gourd domesticates include *Cucurbita pepo* and *Cucurbita ecuadorensis* (squash) with earliest dates of domestication at 10,000 B.P.

Another possibility for identifying human niche construction behaviors is with a comparison of domesticated species and their suspected modern-day wild progenitors. Micobotanical remains are important proxies for environmental signatures that may be a result of human engineering. Phytoliths found in an archaeological context are mostly classified by size and morphology measurements to distinguish between wild (usually smaller) and domesticated (usually larger) phytolith taxa (Piperno 2009; Madella and Ball 2005). Specific structures can also be studied to identify phytoliths based on formation and morphological characteristics. Structures called fruitcases in phytoliths from teosinte are controlled by the *teosinte glume architecture 1* gene and are essential in differentiating between wild and domesticated species. Starch grain analysis has been shown to be a complimentary method to phytolith analysis, which includes similar methodologies based on size and morphology (Piperno 2009).

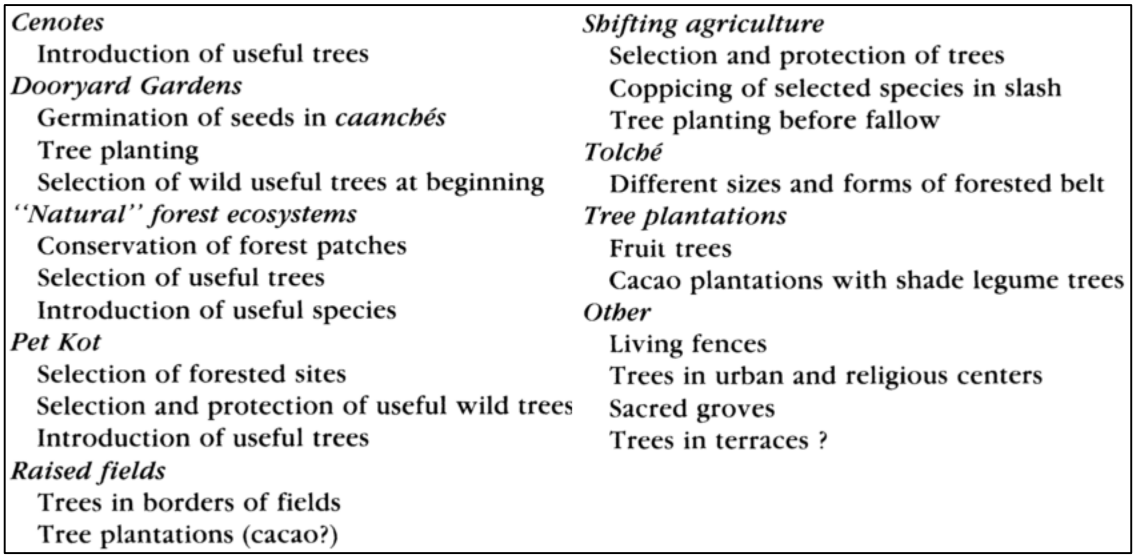
Genetic profiles can be used to identify ancestor species, especially if the species in question are found in similar contexts and nearby environments (Smith 2007). Morphological variation in domesticates over time can also indicate markers of human influences of change. For example, in seed-bearing plants "seed retention, uniform seed maturation, terminal seed clusters, loss of germination dormancy, and increased size" are associated with deliberate human intervention of natural plant reproductive processes (Smith 2007:189). Morphological changes and increased size of plant domesticates are evidence for human selection behaviors during the Archaic Period. The earliest domesticates originate from the Highlands in Central Mexico, including squash and beans (Kennett and Beach 2013). Among the best-known crops in the region are cacao, manioc, maize, chilli pepper, and avocado (Kennett and Beach 2013; Pohl et al. 1996).

Archaeological evidence is not the only source for human environmental exploitation and engineering. Zizumbo-Villarreal et al.'s (2012) experimental ethnoarchaeology comparative study of Archaic and a modern-day peasant community diets in Zaotitlan, Mexico investigates cultigen development. Wild plant taxa considered to be ancient by the community serve as important resources to be exploited for various dishes and drinks. Food preparation techniques and tools considered to be ancient are also continued to be used in the local community.

Results indicate that 68 wild plant species have been and continue to be consumed, including wild progenitors of agaves, maize, beans, squashes, chan, chili peppers, tomatoes, ground cherries, hog plums, and avocadoes (Zizumbo-Villarreal et al. 2012). Several dishes and drinks are presently prepared with ancient techniques and non-ceramic equipment including three-stone fireplaces, stone toasters, sets of fixed or mobile stone crushers and grinders, rock pits, fermenters, and earth ovens.

When compared to the archaeological record, there is evidence for an Archaic Period diet consisting of food items such as squash, bean, chili pepper, chan, ground cherry, and tomato. Preparations of Archaic foodstuffs likely included sun drying, roasting, toasting, cracking, grinding, crushing, soaking with water and ash, fermentation in stone pits, and earthen baking. Zizumbo-Villarreal et al. (2012) suggest that a diet based on wild species and Archaic Period technologies could still be consumed by contemporary residents of the region based on nutritional and ecologically complementary natures.

In sum, Smith (2007) explains that prior to the end of the Pleistocene, domestication of plants and animals was not possible largely due to climatic factors. For instance, plant growth was not well suited for a drier, more turbulent climate with lower $CO_2$ levels (Sage 1995). The warmer, wetter, and more stable early Holocene climate provided an ideal environment to support human domestication behaviors (Smith 2007). A favorable climate and environment for both plants and animals provided an increased carrying capacity for human populations, and therefore increased the probability of human niche construction behaviors (Smith 2007). Additionally, these behaviors have also been loosely categorized as Maya silviculture, or various techniques in which controlled manipulation of the environment is practiced in order to meet diverse needs. Gómez-Pompa (1987) outlines various silvicultural techniques that may have been practiced simultaneously or in succession in a number of places as shown in Figure 1.



- *Cenotes*
  - Introduction of useful trees
- *Dooryard Gardens*
  - Germination of seeds in *caanchés*
  - Tree planting
  - Selection of wild useful trees at beginning
- *"Natural" forest ecosystems*
  - Conservation of forest patches
  - Selection of useful trees
  - Introduction of useful species
- *Pet Kot*
  - Selection of forested sites
  - Selection and protection of useful wild trees
  - Introduction of useful trees
- *Raised fields*
  - Trees in borders of fields
  - Tree plantations (cacao?)
- *Shifting agriculture*
  - Selection and protection of trees
  - Coppicing of selected species in slash
  - Tree planting before fallow
- *Tolché*
  - Different sizes and forms of forested belt
- *Tree plantations*
  - Fruit trees
  - Cacao plantations with shade legume trees
- *Other*
  - Living fences
  - Trees in urban and religious centers
  - Sacred groves
  - Trees in terraces ?

Figure 2: Silviculture Techniques, adopted from Gómez-Pompa (1987).

### ANTHROPOGENIC SEDIMENT HORIZONS

A less conspicuous line of evidence for human niche construction is the imprint humans have left on sediment sequences. The concept of *soil memory* coined by Targulian and Goryachkin (2004) is defined as the ability of soil systems to record environmental change through soil formation processes occurring *in situ*, as well as the soil record itself reflecting environmental processes and changes. *Soil memory* develops naturally in igneous or sedimentary parent materials or through anthropogenic processes. Based on this concept, the term *legacy sediment* refers to sediment produced by major anthropogenic disturbance events such as deforestation, agriculture, mining, and other human-induced environmental changes (James 2013).

This type of sedimentation occurs in the Maya Lowlands region during the Early Preclassic or possibly earlier during the Archaic Period (Beach et al. 2006). Erosional episodes create layers of *legacy sediment* along the karst depressions in the Maya Lowlands during the Early Holocene. These layers, which are associated with artifacts, are known as "Maya Clays" (Beach et al. 2006). Massive erosion rates during the Maya Preclassc and Classic periods deposited sediment that buried the pre-Maya paleosols known as *Eklu'um* or "dark earth." This paleosol is common in many depositional environments of the central and southern Maya Lowlands (Beach et al. 2006; Dunning and Beach 2004; Solís-Castillo et al. 2013).

Coincidentally, it is these types of sediments that are often dated between the blurred boundaries of Archaic and Preclassic Periods. Generally, the Mesoamerican Archaic Period dates between 8000 to 4000 B.P. and Preclassic dates overlap the Late Archaic Period in the literature around 4000 B.P. to 2000 B.P. (Lohse 2010; Rosenswig et al. 2014). The later Preclassic Periods are better documented and there is a definite shift in cultural signatures (Lohse 2010). Some of the better documented Preclassic sites in the Maya Lowlands include Colha, Cerros, Cuello, Altar de Sacrificios, Yaxhá-Sacnab, Nakbe, and El Mirador (Iceland 1997; Lohse 2010; Pohl et al. 1996; Rosenswig et al. 2014; Sullivan and Awe 2013). Other smaller sites include Pulltrouser Swamp, Cobweb Swamp, Dos Hombres, and Medicinal Trail (Aylesworth and Valdez 2013; Iceland 1997; Lohse 2010; Pohl et al. 1996; Rosenswig et al. 2014).

Some of the earliest known pottery, Cunil, in Belize comes from the Maya Lowland site of Cahal Pech. Conservative radiocarbon dates place Cunil pottery between 1000 and

900 BC, Early to Middle Preclassic (Sullivan and Awe 2013). This is a pivotal marker for a more sedentary change in subsistence strategy from nomadic hunter-gatherer to horticultural and even agricultural strategies. The use of pottery would imply at least minimal food storage and possibly more complex cooking techniques. This behavior is characteristically more labor intensive and requires sedentism (Cohen 2009). These complex technologies would also imply a pronounced human niche behavior associated with landscape management.

Archaic Period sites are difficult to locate with poor preservation of sites, rising sea levels along the coast, and no monumental architecture, but there are a few strategies for locating such sites that closely follow human niche construction behaviors within sedimentation profiles. For instance, a large-scale paleopedological survey of a soils within alluvial sediments closely examines Holocene terraces surrounding the Usumacinta River in the Northwestern Lowlands (Solís-Castillo et al. 2013). Solís-Castillo et al. (2013) investigate Holocene environmental change in the Usumacinta River region visible in soil profiles, human management of ancient soils as resources, and the cumulative impacts of human settlement on the landscape. Paleosols within four Holocene terraces associate with one another using "paleosol morphology, radiocarbon dating, and artifact seriation" of Preclassic to Postclassic ceramics (Solís-Castillo et al. 2013:268). The Usumacinta River alluvial banks show strong evidence for the earliest settlements in the region.

Terrace soil profiles generally reflect the oldest paleosols as having gleyic features that likely formed during the Late Pleistocene or the Early Holocene. Gleysols dating to the Late Preclassic, around 2000 to 2,700 B.P., contain vertic features and ceramics. Once again, paleosols dating to this period are known as *Eklu'um* and are classified as vertisols or mollisols. The warmer and wetter environment during the Archaic Period is evident in gleyic paleosols with robust redoximorphic features, leaching, and a high clay composition.

Additionally, Preclassic vertic paleosols point to soil management practices of maize, C4, or CAM cultivation due to positive stable carbon isotope $\delta^{13}C$ values of -16 to -20 ‰ (Solís-Castillo et al. 2013). The authors relay how important it is to understand soil formation processes and the effects human settlement or management of soils is in order to trace earlier occupation sites without monumental structures. Solís-Castillo et al. (2013) suggest that vertic soils are generally associated with Preclassic times, noting their chemical and physical characteristics as markers for formation during an increased seasonality, which favors agriculture (Solís-Castillo et al. 2013).

Similarly, soil erosion episodes have been studied by Beach et al. (2006; 2008) throughout the Maya Lowlands of Mexico, Guatemala, and Belize in order to understand land degradation. These studies used a variety of geoarchaeological and chemical analyses in the field and laboratory to date erosion episodes within the soil and sediments. The most accelerated soil erosion episodes correlate to three time periods including the Preclassic, the Late Classic, and over the last few decades (Beach et al. 2006).

According to Beach et al, *Eklu'um* paleosols are buried from erosion caused by intense deforestation by the ancient Maya. This erosional episode is evident as early as 3000 B.C. as a result of erosional processes during the Late Archaic Period. The two main causes for soil erosion in this region include steep slopes and pioneer land use transformations in many areas where infiltration is lower than expected because of fine sascab horizons. The region's soils are still thin today from ancient erosion. Paleosols in the area support "evidence for early sedimentation and erosion, geographic and chronological ties to urbanization, and less erosion in periods of higher population densities and indigenous management" (Beach et al. 2006:176). Paleosols are identified by characteristics such as "darker colors, more organic matter, artifacts, changes in isotope signatures, radio carbon dating, increased magnetic susceptibility, and elemental concentrations" (Beach et al. 2006:170). Paleosols can also be identified by an older surface age of approximately 1000 to 3000 years along with a composition of higher content of clay, manganese, and more iron nodules.

In another case study, Anselmetti et al. (2007) takes into consideration erosional episodes caused by anthropogenic behavior visible in sedimentological records. Seismic and sediment core data report intense soil erosion in Lake Salpeten located in northern Guatemala from the last 6000 years. Soil erosion is highest during the Middle to Late Preclassic periods, despite lower population densities compared to the peak during the Classic period. This dramatic impact suggests that even smaller populations can have a profound impact on the environment and further reemphasizes the massive effect human niche construction has on the landscape. Erosion rates during peak soil loss times during the Middle to Late Preclassic average approximately 1000 $t/km^2yr^{-1}$, and 457 $t/km^2yr^{-1}$ in the Maya Classic, which greatly contrast with pre-Maya erosional rates of approximately 16.3 $t/km^2yr^{-1}$. A clear erosional impact is observable with the deposition of up to 7m of Maya Clay, which contrasts with the dark, organic-rich sediments deposited before and after Maya occupation of the Lake Salpeten area.

In addition to increased soil rates during the Middle to Late Preclassic periods, disturbance taxa pollen, including grasses and weeds, also correlate to the soil erosion trends. Anselmetti et al. (2007) concludes that soil erosion rates declined after the Late Preclassic periods and could be a product of a change in cultural practices that may have included soil conservation methods. Overall, intense deforestation is closely related to increased soil erosion rates and disturbance pollen taxa signatures. We can associate these trends with human experimentation in niche construction. Pioneers develop new agroecosystems that may cause environmental disturbance, which new generations may adapt with time to become more sustainable.

## Chapter 3: Archaic Period Sites in the Maya Lowlands

Despite the rare nature of finding Archaic Period sites in the Neotropics, there has been increasing publications with evidence for human occupation and its impacts on Pre-Maya sites (Lohse et al. 2006). Most recently, Rosenswig et al. (2014) expands on research based on lithic findings and starch grain analysis from the Archaic Period site of Freshwater Creek, Belize. This case study examines the use of valuable cultigens in order to trace the chronology, range, and adaptive contexts of incipient food production. Pollen from cores taken from the Pulltrouser Swamp indicate that cultigens were grown in a highly forested area with little disturbance early on. Phytolith analysis recovered evidence for maize, beans, squash, manioc, capsicum, and root/tuber. Starch grain analysis results associate tools with economic uses of cultigens such as manioc. The starch grains also reveal a trait selection in maize and that some grains are even damaged from milling, again suggesting niche construction behaviors during the Archaic Period.

Rosenswig et al. (2014) uses multiple lines of evidence to examine economic plants and Archaic settlements in most recent times. According to the environmental data, small-scale horticultural societies were cultivating plants in the northern parts of Belize by 5000 B.P. Gradual intensification of food production had major environmental impacts approximately 1000 years after. What is needed, according to the Rosenswig et al. (2014), is excavated archaeological materials to form a more complete regional comparison of systems of human adaptation.

In another well-preserved context, Piperno et al. (2009) presents archaeological and paleoecological evidence for Archaic Period plant exploitation and cultivation during the occupation of the Xihuatoxtla Rock Shelter in Guerrero, Mexico. Here starch grain and phytolith analysis from sediments and stone tools examined natural flora within deciduous forests. They sampled microbotanical analysis extracted from 21 ground stone and five chipped stone tools recovered from archaeological units. In addition, they studied a column of samples directly associated with stone tools for microbotanical remains. Piperno et al. (2009) found that *Zea* maize was the dominant contributor of starch grains in tools recovered from the Xihuatoxtla Rock Shelter. Another major plant cultigen found in the microbotanical record was *Curcubita* squash.

The microbotanical remains support human niche construction behavior for the domestication of wild plant species. More specifically, morphological evidence suggesting domestication in preceramic contexts includes increased size, irregular shapes and surface contours, defined compression facets, and transverse or y-shaped fissures. They determined that these factors reflected deliberate human selection. Analysis of phytoliths also supports evidence of maize domestication with cob phytoliths found in all samples. Traditionally, long cell phytoliths are markers of wild teosinte in a microbotanical assemblage, but they are not present in any sample analyzed for the Xihuatoxtla Rock Shelter. Archaeological data along with starch grain and phytolith analysis support maize domestication during the early ninth millennium B.P. Interestingly, the authors suggest an alternate reason for the initial cultivation of maize where preceramic cultures exploited the sugary pith or green ears for fermented drinks in ceremonial life (Piperno et al. 2009).

More Archaic Period maize evidence is found in San Andres, Tabasco, Mexico (Pohl et al. 2007). Microbotanical evidence supports the hypothesis of the spread of maize cultivation into the tropics of the Gulf coast around 7,300 B.P. Here they analyzed four sediment samples from their vibracores at depths between 1,095 and 1,190 cm beneath the surface. The San Andres area does not naturally produce teosinte; thus humans must have introduced the plant into the region through deliberate niche construction behaviors. Pohl et al. (2007) provides characteristic microfossil diagnostics to support distinctions between phytoliths from wild species and cultigens. These include a distinction between the fruit cases of teosinte and the cupules and glumes of maize cobs, the diagnostic separation of *Tripsacum spp.* from teosinte and maize, the distinction of reproductive and vegetative structures of teosinte, maize, and non-*Zea* grasses, and the identification of phytoliths originating in glumes and cupules of Zea ears, which are diagnostic of teosinte or maize.

Phytolith analysis of the San Andres Vibracore confirms maize presence, rejects contributions from teosinte, and does not identify *Tripsacum* taxa, a wild grass. Pohl et al. (2007) discusses the significance of phytolith distribution and characteristic finding, strengthening the argument for the spread of maize cultivation in the area. The samples containing maize reflect a significant degree of burning and forest clearing indicative of slash-and-burn agriculture. Furthermore, the appearance of squat saddle-shaped phytoliths are representative of weeds associated with agricultural fields. A few burned bilobate and cross-shaped phytoliths are present and also represent a type of common weed visible in agricultural contexts. All *Heleconia* (false bird-of-paradise) and palm phytoliths appear burned in the samples, yet again alluding to agricultural practices and full-blown human niche construction behaviors (Pohl et al. 2007).

In another well-documented Archaic Period site investigation Kennett et al. (2010) report on the inhabitants of the Acapetehua Estuary located on the Pacific coast of southern Mexico. This study tests the hypothesis that people living in the area between 6,500 and 4,700 B.P. were slash-and-burn farmers along the coastal plain and exploited estuarine zones in order to harvest and process other food sources. Sediment cores are analyzed for weight-loss on ignition, pollen, phytoliths, and charcoal within the vicinity of Archaic Period shellmounds in order to expand on paleoecological findings. One core was taken in close proximity to the Archaic Period shellmounds and another core was taken offsite near Pijijiapan.

Paleoecological findings suggest that disturbance taxa, burning, and the cultivation of maize dates back to 6,500 B.P. in this area (Kennett et al. 2010). Intentional land burning and crop cultivation are indicated by weedy grasses, charcoal and burned phytoliths, as well as maize phytoliths. The wild ancestor of maize (teosinte) does not naturally grow in the region, further reinforcing evidence for human niche construction behaviors. The absence of the ear phytoliths of this wild grass dating to approximately 6,600 B.P. also suggests that the crop was introduced into the area. Finally, high sedimentation rates also support the hypothesis of increased exploitation in the estuarine area that also align with human niche construction markers.

Kennett et al. (2010) concludes that labor intensive slash-and-burn agriculture was maintained by more sedentary farmers who seasonally exploited estuarine shellfish. These settlements would have been located in well-drained alluvial soils with seasonal rainfall.

By the Late Archaic, communities expand across the plain and shellfish exploitation is visible in Pacific coast Archaic Period mounds (Kennett et al. 2010).

In reviewing some of the earliest work on Archaic Period archaeology in Belize, Iceland's dissertation work in the well-documented site of Colha provides some insight to early occupation in the area (1997). The Colha Preceramic Project, between 1993 and 1995, set out to investigate the earliest inhabitants of the site by examining intensive lithic production at approximately 1500 to 900 B.C. Although, lithic production at this site is the main area of research for this dissertation, environmental reconstruction supports evidence for forest clearing, exploitation of wetland areas, and cultigen manipulation within swamp peripheries and upland areas. Analytical methods of lithic assemblages include NAA sourcing and usewear, which provide a basis for investigations on the social complexity and trajectory of adaptive strategies including agriculture and sedentism. Iceland's (1997) research provides the earliest framework for the possible origins of Maya populations supported by archaeological and geological data at Colha.

Pohl et al. (1996) also brings together multiple lines of evidence for early domestication of crops in Mesoamerican wetlands. Early work in the watershed of Santa Maria in central Panama support evidence for *Maranata arundnacea* (arrowroot) and *Acrocomia vinifera* (palm tree) crops dating prior to 5000 B.C. Increased forest disturbance occurs in paleoecological records between 10,000 and 6000 B.C. Maize appears around 5000 and 4000 BC along with accelerated deforestation and the appearance of sedentary villages after the introduction of maize into the Panama watershed (Cooke and Ranere 1992; Piperno 1989; Pohl et al. 1996).

The spread of maize into parts of South America is not made apparent as a staple food during this time. Evidence in isotopic bone chemistry from remains in Mazatan, Chiapas shows relatively low maize consumption compared to people in nearby Acapetahua (Blake et al. 1992; Pohl et al. 1996). In another case, early populations from La Venta, Tabasco settlements subsided mainly off of aquatic proteins (fish, turtle, and mollusk), palms, beans, and maize. Evidence for this diet is based on pollen and macrobotanicals recovered from wetland areas. There is a trend in most early settlements that show agricultural intensification and deforestation by 2000-1000 B.C., followed by major disturbance and the adoption of maize in the archaeobotanical record (Rust and Leyden 1994; Rust and Sharer 1988).

Pohl et al. (1996) established a stratigraphic sequence with radiocarbon dates, pollen, and artifacts from approximately 6000 B.C. to the present through excavation and the coring of freshwater wetlands in northern Belize at Pulltrouser, Cob, Pat, and Douglas Swamps. Significant finds from this work include a maize pollen grain found at Cob Swamp with a radiocarbon date of 3,360. B.C. and additional pollen grains found with radiocarbon dates of approximately 2,400 B.C. These finds are morphologically similar to the earliest grains from Cobweb Swamp near Colha and La Venta, Tabasco. Manioc pollen grains were also identified and are dated to about 3,400 B.C. This evidence presents a strong argument for cultivation.

Combined pollen data from Cob Swamp suggest that maize and manioc were probably introduced before 3000 B.C. or even as early as 3,400 B.C. (Jones 1994; Piperno and Pearsall 1998; Pohl et al. 1996). The abundance of *Moraceae* tree pollen and the relative absence of other vegetation types prior to 3000 B.C. in the Cob core indicate that the introduction of crops took place in a largely tropical forest environment with little disturbance taxa. It is approximately 2,500 B.C. when disturbance vegetation occurs along with maize. At this time there is also a decline in *Moraceae* (upland forest trees) and an increase in charcoal. These combined paleoecological markers indicate extensive expansion of agriculture in the area that follows human niche construction behaviors.

Agriculture occurs alongside hunting and fishing at Pulltrouser Swamp and is evidenced by a recovered Lowe projectile point (Kellley 1993; Pohl et al. 1996). The Lowe projectile point is dated by associated wood to the Late Archaic Period around 2,210 B.C. and was found with abundant chert debitage from tool manufacturing. In addition to chert debitage, freshwater fish, snakes, small mammals like armadillo, and turtles were associated with the assemblage.

Similarly, the widely cited article by Pohl et al. (1996) establishes a chronology for the area from organic material that originally deposited within seasonally inundated zones, which formed the black, organic-rich soil present. Macrobotanical analysis indicates the buried soil is a mangrove peat. Soil further inland represents either an ancient freshwater marsh or a swamp forest environment. Sea level rise, occurring between 6000 and 3000 B.C., likely created mangrove swamps and freshwater lagoons in depressions and floodplains on formerly dry lands. This hypothesis is further supported by excavations at Cob and Pulltrouser swamps that uncovered waterlogged trees that only grow on the swamp margin, but did not survive the sea level water rise event around 3000 B.C. Once the swamp forest developed on the edge of the marsh between 2,500 and 1,300 B.C., a thick soil horizon formed that incorporated micro-charcoal evidence of swamp forest taxa. The thickness of this layer suggests a few hundred years of stable water level. The rich soil became the primary source for later farmers once water levels stabilized or receded at approximately 1500 B.C. (Pohl et al. 1996).

Between 1500 and 1300 B.C. agriculture intensifies along the swamp edges. There is evidence for major deforestation and burning events. Maize is visible in the archeological record at San Antonio, Cob, and Pulltrouser Swamp. Additionally, *manos* and *metates* are found in organic soils on four excavations along with squash and bottle gourd phytoliths. Other artifacts found during this time period include chert tools (biface axes and constricted uniface or adzes), ceramics associated with a disarticulated human skeleton dating to 890 BC, as well as ceramics and lithics deposited with brocket and white-tailed deer remains. The human remains found at Cob Swamp remains were identified to be from a woman in her early 20s who was in good health. Stable carbon isotope analysis suggests that she did not primarily subside on maize.

Pohl et al. (1996) suggests that early cultivation began in the dry season, but after sea levels rose farmers were forced to drain fields using canals. There is evidence for water management at Douglas Swamp and San Antonio and some minor ditching at Cob Swamp. The initial construction of canals coincides with rise of Maya civilization around 1,000-400 B.C. However, water levels continued to rise and wetland fields in the area were forced to be abandoned during the late Preclassic around 400 B.C. to A.D. 250.

Pohl et al. (1996) concludes that the first domesticates in northern Belize were manioc and maize as early as 3400 B.C. The maize cultigen likely spread from its origins in the Balsas region to the Maya Highlands and Lowlands by 3,500 to 3,400 B.C. The Late Archaic here provides ample evidence for settlements, including stone tools, faunal and plant remains, soils, and water resources. The initial Lowland Maya adoption of agriculture coincides with the location of Late Archaic settlements near swamp margins. The transition to agricultural practices was ideal in an area with abundant fauna, edible wild plants, fertile soil, and water resources. In addition, maize was a relatively quick and low effort cultigen to maintain. With forest clearance in effect from the cultivation of maize and other plants, the newly managed ecosystem favored the cultivation of tubers and supported grazing land for a deer presence. Lastly, Pohl et al. (1996) offers alternate scenarios for the introduction of maize into the area. Either established foreigners brought it in to the area or locals were already cultivating it for some time.

Lohse (2010) synthesized much of the Archaic Period research in Belize. He proposes Lowland Maya cultural origins in the Late Archaic with evidence of subsistence, economy and technology, and radio carbon data. Additionally, Lohse proposes that the Archaic Period coincides with the Maya calendar beginnings (Lohse 2010; Rice 2007). Based on his review of many research projects using ceramic, lithic, and site-specific literature mentioned, he argues that Archaic Period settlers transitioned to more intensive strategies closer to the Early Preclassic Period because they had access to mobile water resources for trade. The shift from preceramic to early village life took place around 1,100 and 800 B.C., but is difficult to track due to aforementioned factors and due to the removal of anthropogenic soils to build in later architectural features (Lohse 2010).

## Chapter 4: Methods

I will implement geoarchaeological methods, informed by human ecological theory, in order to analyze how humans deliberately or unintentionally create and modify their environment. For instance, morphological evidence of selective plant use of major crops such as maize, chili pepper, beans, and squash can be observed with phytolith analysis. Furthermore, evidence of slash-and-burn horticulture is preserved within the sediment record and can be analyzed with geomorphological and pedological techniques. I will sample from both Early Preclassic sites within and nearby the RBCMA region and from soil profiles in places that best fit possible Archaic Period site settlements.

### SEDIMENT ANALYSIS

#### Color

A basic field technique to describe one physical characteristic of sediments is identifying color. The standard for identifying color recommended by the U.S. Soil Survey program is the use of the Munsell color-order system (Rapp and Hill 2006 and Gale and Hoare 1991). This notation consists of three dimensions: *hue*, *value*, and *chroma*. The *hue* notation represents the "dominant wavelength of the reflected light" represented by five major *hues* including "red (R), yellow (Y), green (G), blue (B), and purple (P)," as well as intermediate *hues* (Banning 2000:148). The *value* dimension represents the degree of luminosity in a color. The *chroma* dimension represents the saturation level of a color (Gale and Hoare 1991). In order to measure a sediment with the Munsell color chart, a sample must be moist and in natural sunlight, visible without sunglasses (Banning 2000).

## Grain Size Analysis and Texture

Grain or particle size and distribution is widely used in geoarchaeology to characterize sediments. There are both field and laboratory techniques to assess sediment particle size. Grain size assessments may indicate information regarding energy and depositional characteristics of parent source materials which form sediments (Ayala et al. 2007 and Goldberg and Macphail 2006). The Wentworth class scale is commonly used to classify size ranges in sediments. For example, clay (<4μm), silt (4-63μm), sand (63μm - 2mm), granule (2-4mm), pebble (4-64mm), cobble (64-256mm), and boulder (>256mm) (Goldberg and Macphail 2006). Grain sizes in sediments generally make up major classifications including sand, silt, clay, and loam as depicted in Figure 3. Using a grain size analyzer machine is one way to determine grain size. The field method for determining grain size is called finger texturing and is outlined in Ayala et al. (2007) and in Figure 4.

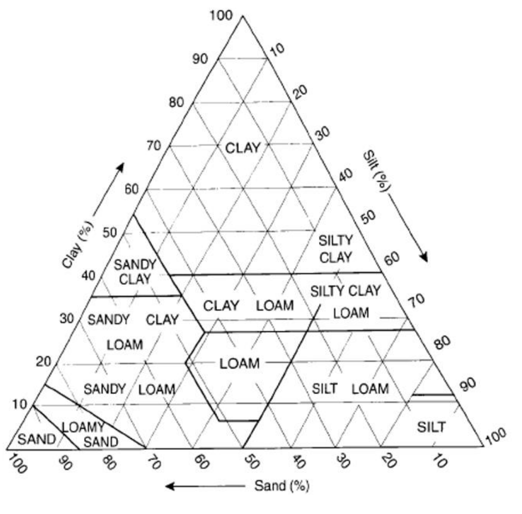
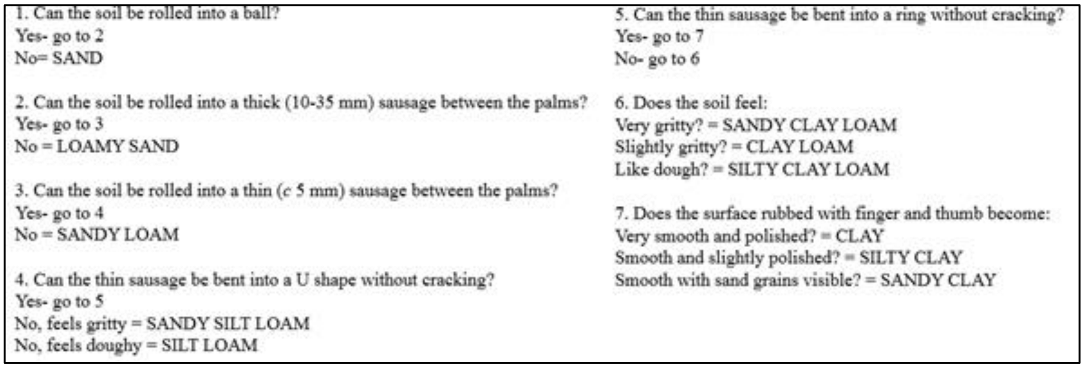


Figure 3: Major Classifications of Mixed Sediments, modified from Goldberg and Macphail (2006).



1. Can the soil be rolled into a ball?
Yes- go to 2
No= SAND

2. Can the soil be rolled into a thick (10-35 mm) sausage between the palms?
Yes- go to 3
No = LOAMY SAND

3. Can the soil be rolled into a thin (*c* 5 mm) sausage between the palms?
Yes- go to 4
No = SANDY LOAM

4. Can the thin sausage be bent into a U shape without cracking?
Yes- go to 5
No, feels gritty = SANDY SILT LOAM
No, feels doughy = SILT LOAM

5. Can the thin sausage be bent into a ring without cracking?
Yes- go to 7
No- go to 6

6. Does the soil feel:
Very gritty? = SANDY CLAY LOAM
Slightly gritty? = CLAY LOAM
Like dough? = SILTY CLAY LOAM

7. Does the surface rubbed with finger and thumb become:
Very smooth and polished? = CLAY
Smooth and slightly polished? = SILTY CLAY
Smooth with sand grains visible? = SANDY CLAY

Figure 4. Field Finger Texturing Flow Chart, adopted from Ayala et al. (2007).

Sorting refers to the proportions or statistical distribution of different sizes that make up a sediment. Sorting is visually assessed in the field or in a laboratory. The general grain size including sand, silt, or clay and degree of sorting such as *well*, *moderate*, or *poor* are used together to describe sorting (Goldberg and Macphail 2006). For example, a sediment can consist of well-sorted clay. The density of classes of particles can also be visually estimated by following the guidelines in Figure 5.

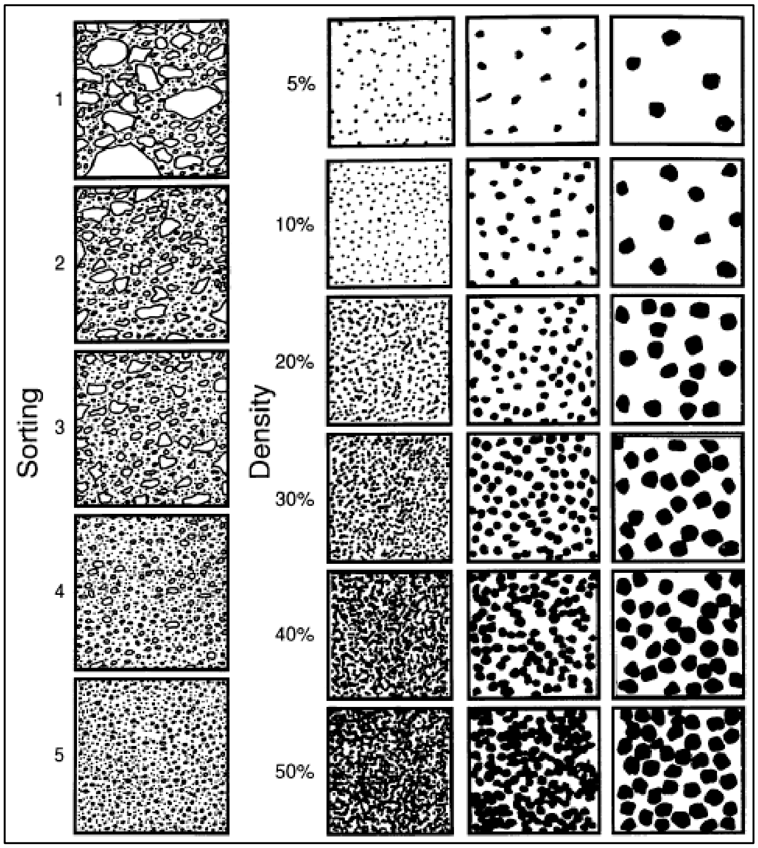
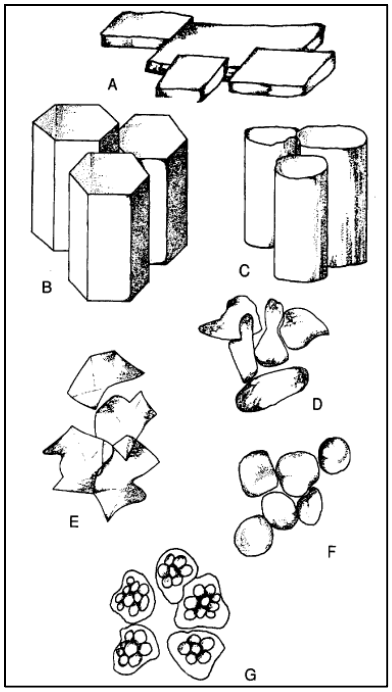


Figure 5: Density of class particles diagram adopted from Banning (2000).

**Shape or Structure**

The shape of particles is another common characteristic that can be identified in the field or in a laboratory. Shape can be described as platy, prismatic, columnar, angular blocky, subangular blocky, granular, or crumbs-like (Figure 6) (Banning 2000). Sedimentary particles can further be described by their sphericity and roundness. This description can indicate levels of intensity or duration of transportation which affect sediment particles over time (Figure 7) (Rapp and Hill 2006).



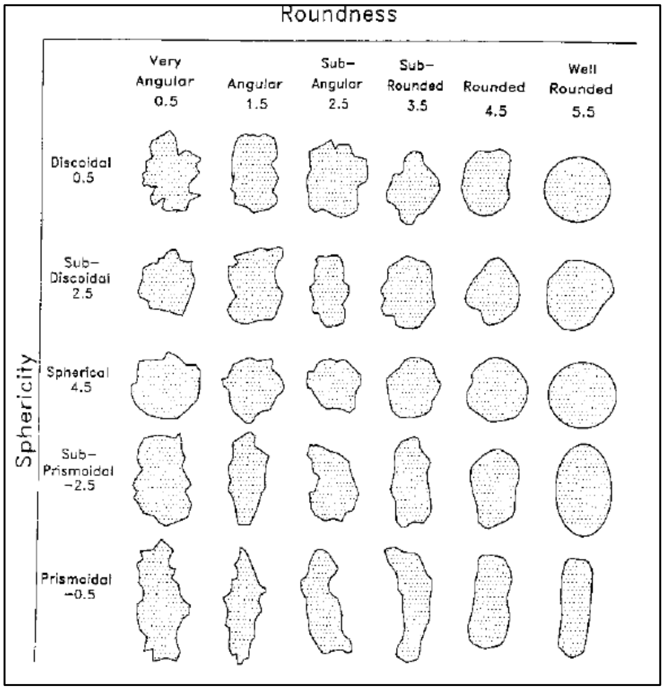


Figure 6: (Left) Shape of Sediment Grains, adopted from Banning (2000).

Figure 7: (Right) Roundness and Sphericity, adopted from Rapp and Hill (2006).

### pH

The pH level in a sediment sample is an indicator of acidity or alkalinity based on overall concentration of hydrogen ions (Ayala et al. 2007 and Banning 2000). Measuring pH levels in sediments is important because the preservation of organic materials, such as bone or pollen, may be affected by acidic pH levels.

### Determination of Carbonates in Sediments

Sediments may contain large amounts of carbonates that can be tested in the field. A solution of 3M diluted HCl (hydrochloric acid) can be used to determine levels of carbonate content in sediments. One to two drops of HCl solution on a small sample of sediments will produce either a range between a highly effervescent reaction to no reaction.

The more effervescent a reaction, the higher the carbonate content a sample contains (Donner and Lynn 1989).

## Magnetic Susceptibility

The degree to which a sediment sample can become magnetized is called magnetic susceptibility. Ferrimagnetic minerals in sediments are extremely sensitive to environmental changes such as burning or biological activity that breaks down organic matter (Ayala et al. 2007 and Thompson and Oldfield 1986). By measuring the magnetic susceptibility throughout sediment profiles, it is possible to identify whether or not anthropogenic events or soil pedogenesis have occurred over time (Ayala et al. 2007 and Gale and Hoare 1991). Highly magnetic materials in soils include iron-rich clay minerals, kilns, “quartz, orthoclase, calcium carbonate, organic matter and water” (Thompson and Oldfield 1986:73).

## Loss on Ignition

Carbonate and organic content in sediments and soils can be calculated by the Loss on Ignition (LOI) method in a laboratory (Dean 1974 and Goldberg and Macphail 2006). Measuring carbonate content based on LOI, measured as $CaCO_3$, is useful for archaeological sediments because it is correlated with human activity as well as soil formation processes (Dean 1974 and Goldberg and Macphail 2006). An effective LOI method is described by Dean (1974) in three steps provided below.

First, disaggregated sediments measuring less than 2mm in size are placed in a previously weighed ceramic crucible. The crucible is then heated for one hour at 90-100°C and cooled. The sample and crucible are weighed for the basis of all weight loss calculations. Next, the crucible with the sample is heated for one hour at 550°C. Once the sample reaches room temperature once more, it is weighed again. The difference in total weight between the first heating and second heating episode is the total calculated measurement of organic carbon in the sample (Dean 1974). We can also convert OM to OC by multiplying ON by 0.58.

In the final step in LOI, the crucible and sample are returned to heat for one hour at 1,000°C. The difference in weight after this heating episode is the measurement of $CO_2$ derived from carbonate rich minerals (Dean 1974). Equations for LOI for calculating organic matter and carbon dioxide by using Dean's (1974) method are expressed as:

% Organic matter=$100[(W_1–W_2)/(W_1-W_c)]$

% Carbon dioxide (total carbonate)=$100[(W_2-W_3)/(W_1-W_c)]$

## MODEL FOR FIELD AND LABORATORY APPROACHES TO PALEOSOLS: A LOWLAND TROPICS CASE STUDY

In this case study, a field model is developed in order to characterize *Eklu'um*, or similar paleosols, for sampling likely sediments dating to the Preclassic or earlier. In order to characterize sediments of interest, samples from the 2011 field season at Chawak But'o'ob are examined. These sediments date to the Archaic and Preclassic (Beach et al. *In Revision*). The goal of this case study aims to answer three main questions: *1) Based on geoarchaeological methods, what are the characteristics of Wetland Field 1 sediment sequence from Chawak But'o'ob? 2) Where are there possible markers for erosional episodes or anthropogenic effects visible in the sediment sequence? 3) Can the sediment* *characteristics used in this study be applied as a model for locating buried paleosols dating to the Archaic Period in the Maya Lowlands?*

## Methods

Soil characteristic lab work was completed at the Soils and Geomorphology Lab in the Department of Geography and Environment at the University of Texas Austin. Samples from a Chawak But'o'ob wetland field (recovered from the 2011 field season) were selected due to accelerator mass spectrometry (AMS) dates ranging between 1955 B.P. to 2936 B.P. sampled from sediments with organic content, terrestrial organics, or charcoal particulates. Similar ranges are identified along the Chawak But'o'ob transect including the Chawak But'o'ob levee ranging in AMS dates between 1821 B.P. to 3648 B.P. (Beach et al. *In Revision*). Samples were air dried under a ventilation hood for several days. Next, samples were ground with a mortar and pestle. Upon observation, it was noted that the particle size of each sample consisted mostly of silt or clay particles, with the exception of less than 5% particles greater than 2mm. Samples were finely ground and sieved through a 63µm mesh in accordance with the Wentworth Scale.

Moistened samples were identified by color using a Munsell Color Chart. A hydrochloric acid (HCl) reaction test with 3M diluted HCl was used to determine carbonate presence based on a *Strong Reaction*, *Weak Reaction*, or *No Reaction*. Each sample was tested for pH levels using a HACH HQ440d Multi pH Meter. I added 4g of prepared sediment to a glass beaker filled with 10ml of deionized water, vigorously stirred, and measured with the pH meter. The pH meter was washed with deionized water between each sample test and dried with Kimtech Science Kimwipes. Results are outlined in Table 1.

| Sample | Depth (cm) | Color | Description | 3M HCl | pH |
|---|---|---|---|---|---|
| 11-2103 | 4.5-16 | 10 YR 3/1 | Brownish Black | No Reaction | 7.46 |
| 11-2089 | 16-52.5 | 7.5 YR 4/1 | Brownish Gray | Strong Reaction | 8.96 |
| 11-2104 | 73-102 | 2.5 Y 4/1 | Yellowish Gray | Weak Reaction | 8.54 |
| 11-2105 | 102-130 | 2.5 Y 3/1 | Brownish Black | Weak Reaction | 8.06 |
| 11-2106 | 135-140 | 2.5 Y 3/1 | Brownish Black | Weak Reaction | 8.45 |
| 11-2107 | 155-165 | 2.5 Y 4/1 | Yellowish Gray | Strong Reaction | 8.39 |
| 11-2108 | 170-180 | 2.5 Y 4/1 | Yellowish Gray | Strong Reaction | 8.43 |
| 11-2159 | 230 | Gley 1 3/N | Very Dark Gray | Strong Reaction | 8.23 |

Table 1: Chawak But'o'ob Wetland Field 1 Color Descriptions, HCl Reaction Test Results, and pH levels.

Magnetic Susceptibility was measured using a SM30 Magnetic Susceptibility Meter by ZH Instruments. Three low frequency readings ($\chi_{LF}$) were recorded up to 0.001 accuracy and the average was used to plot the Wetland Field 1 profile measurements. Organic content and carbonate content were determined by loss on ignition procedures (Dean 1974). A Cole-Parmer Stable Temp 1100° Box Furnace was preheated to 100°C. Approximately 10g of sediments were weighed and placed in a pre-weighed crucible, then heated for one hour. After sediments cooled down, they were weighed and heated once again for one hour at 550°C. After sediments and furnace cooled, they were placed in the furnace at about 200°C and the heat was turned up to 1,000°C for one hour. Finally, the furnace was turned down and off. Sediments were left to cool overnight and the final weight was measured. The amount of organic and carbonate content was calculated using Dean's (1974) equations as previously mentioned. The results are plotted in Figure 8 for comparison with magnetic susceptibility results.

Grain size analysis was conducted using a FRITSCH Analysette LASER Particle Size Analyzer with 1g samples previously sieved through 63µm mesh. The machine was calibrated with a clean water sample for background measurements and the laser was aligned using the FRITSCH Analysettte A22-32 software. I added and diluted 1 g of sediment sample with water to approximately 7% to 15% and analyzed. A clean water sample was run in between each analysis and before shutting down the machine. The software produces a percentage result based on volumes. Everything below 5µm is classified as clay, between 10µm and 63µm is classified as silt, and between 63µm to 125µm is considered very fine sand. The percentage volumes calculated by the software represents a cumulative frequency and in order to calculate 100% volume, each class is subtracted from another class beginning from the larger classes. Histograms are plotted for each sample based on volume in Figure 9. In addition, charcoal particulates analyzed by Dr. Stephen Bozarth at University of Kansas are plotted in Figure 10 to show trends in Wetland Field 1.

## Results

Geoarchaeological methods such as color, HCl reaction, pH, loss on ignition, magnetic susceptibility, and grain size are useful in understanding soil aggradation and environmental histories of landscapes. In summary, the characteristics of the Wetland

Field 1 sediment samples from Chawak but'o'ob range from 10YR, 7.5YR, and 2.5YR to Gley in color and have pH ranges between 7.46 and 8.96. Grain size analysis indicates a predominantly silt or clay composition. This is characteristic of the tropical, fluvial environment that the Rio Bravo floodplain is. This analysis also coincides with the general soil aggradation patterns outlined by Luzzadder-Beach and Beach (2008) due to flooding deposition from the Rio Bravo.

Increased magnetic susceptibility frequency readings below 155-165cm in depth could be a product of events such as burning or biological activity (Thompson and Oldfield 1986). These frequency readings coincide with strong HCl reactions, which indicate carbonate presence. The presence of carbonates in soil help promote clay flocculation, or clumping (Donner and Lynn 1989). This correlates with the highly flocculated physical characteristic noted during sample preparation. Both magnetic susceptibility and the presence of carbonate contents can be indicators of anthropogenic burning events. The increased magnetic susceptibility below 155cm can be linked to increased clay content due to erosional episodes caused by deposition of Maya clays as a result of deforestation. The magnetic susceptibility can also be linked to the increased charcoal counts beyond 195cm for particulates over 10µm. This is possibly related to major anthropogenic burning events or environmental changes associated with a wetter climate. It is clear that deeper paleosol deposits dating to the Preclassic or Archaic Periods have unique signatures when examined with geoarchaeological methods in the laboratory. Texture, HCl, magnetic susceptibility, and visual identification of charcoal particulates is an inexpensive way to identify paleosols characterized by intense human activity in the field, even before dating samples with AMS.

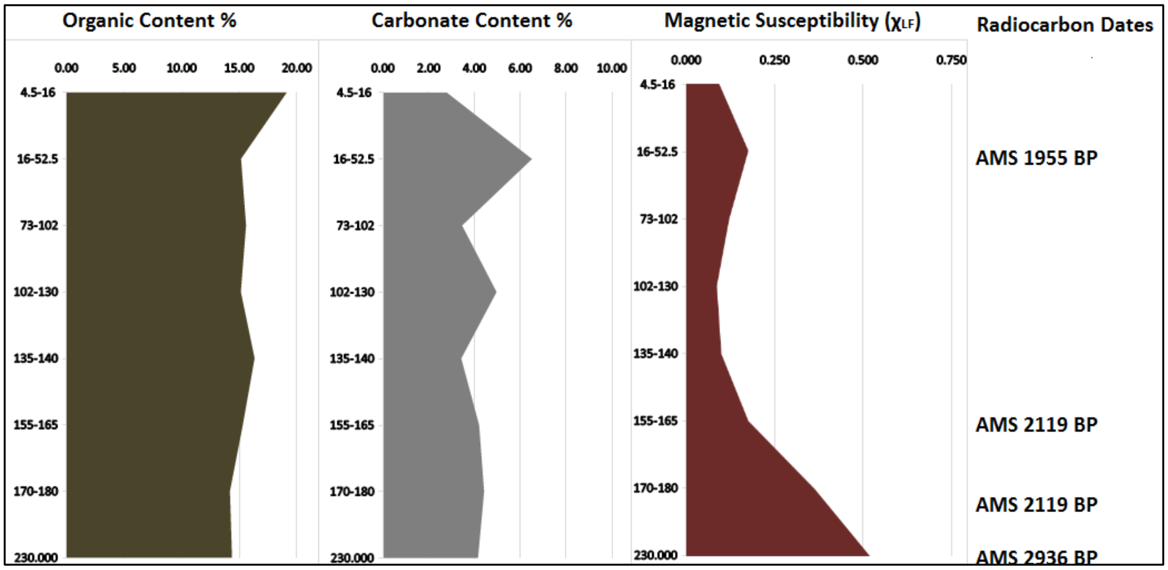


Figure 8: Results from Loss on Ignition and Magnetic Susceptibility Tests.

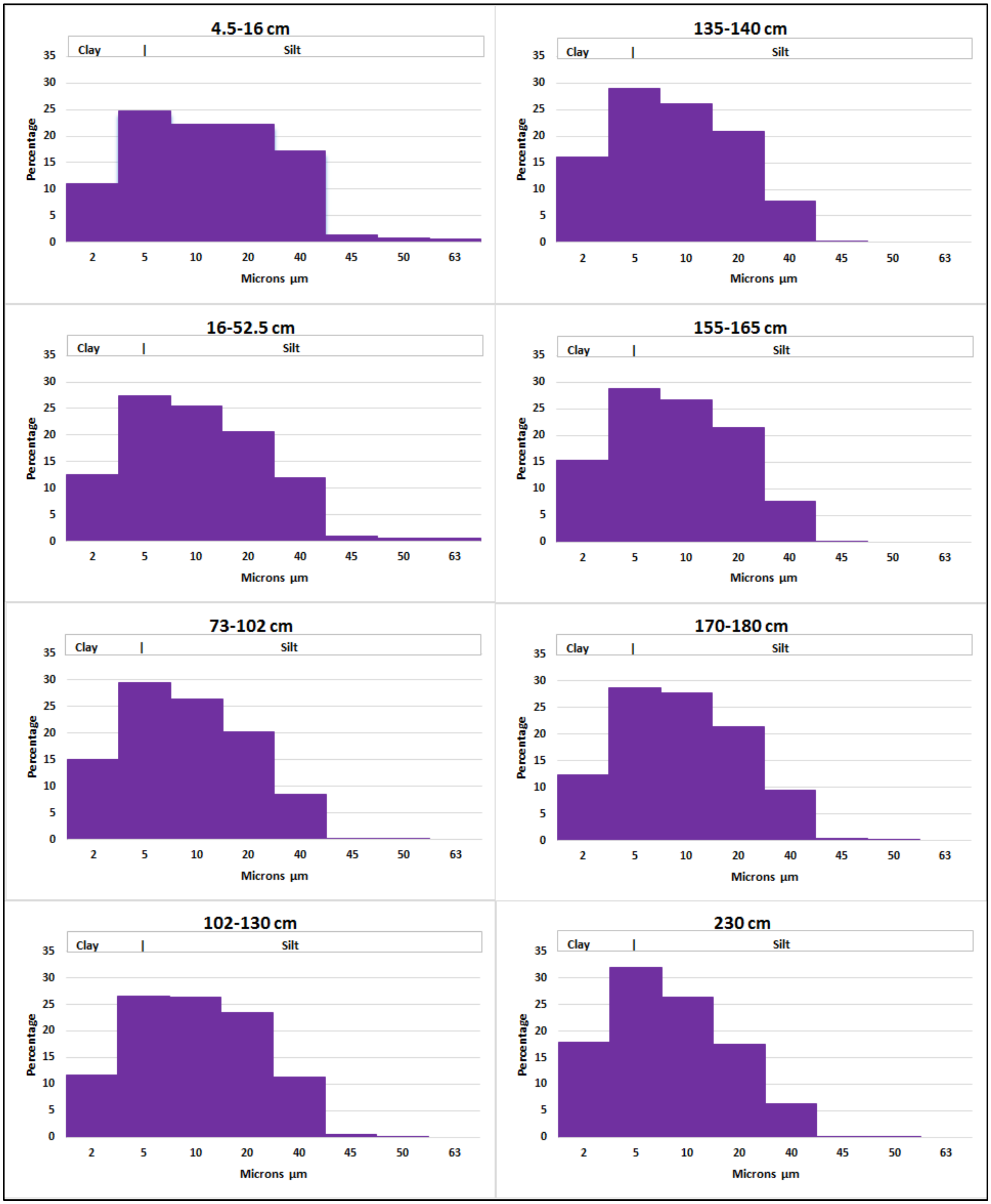


Figure 9: Grain Size Analysis Results for Chawak but'o'ob Samples.

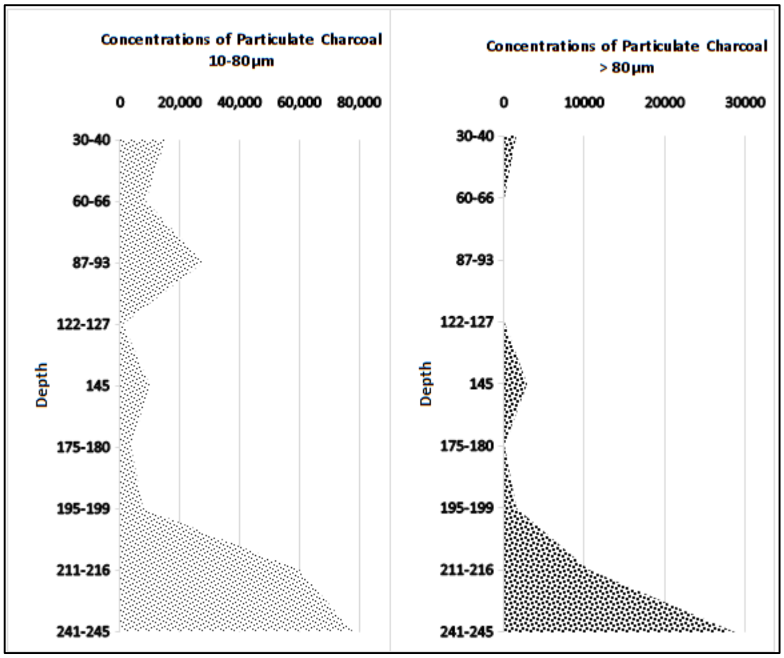


Figure 10: Charcoal Particulate Counts in Wetland Field 1.

### PHYTOLITH ANALYSIS AND PROCESSING

A phytolith is the product of biological and physical processes where plants absorb silica in a soluble state from groundwater and deposit solid silica into living plant cell walls. After the plant dies and decays, the silica-cast cells are deposited into soils and can survive for up to thousands of years due to their non-crystalline, non-organic structure. Phytoliths vary in morphological characteristics depending on the part of a plant they are originally made from, however not all plant species form phytoliths (Piperno 2006).

While there is no single standardized methodology to process phytoliths, the method used in this research is employed and was developed by Dr. Arlene M. Rosen. Samples will be processed in the Geoarchaeology and Environmental Archaeology Lab at the University of Texas Austin.

### Sample Preparation

Sediment samples must be dried and ground with a mortar and pestle in order to be sieved through a 0.25mm sieve. This sieve size is typically used for prehistoric sites where preservation might break down the silica structure of multi-cell phytoliths down to single-cell forms. A sample size of approximately 800mg is necessary for each analysis. If a low density of phytoliths is expected, then samples of up to 5g of sediment are appropriate. Samples should be weighed with an analytical balance to the 0.00001 place.

### Carbonate Removal

Sediments in the Tropical Lowlands are rich in carbonate material. In order to remove pedogenic carbonates, or soil-related carbonates, 10% HCl is added to sediments in plastic test tubes. Samples are shaken and left for about five minutes until fizzing has stopped. Samples are then washed in distilled water and evenly distributed in a centrifuge by multiples of four. The centrifuge is programmed to spin at 2,000 revolutions per minute (rpm) for five minutes. The suspense is poured off and the process is repeated two more times. If a centrifuge is not available, the sample can be left to sit until the suspense is clear and can be poured or pipetted out.

### Clay Removal

Samples from Belize are expected to be rich in clay and require longer deflocculation, or separation, time. Samples are soaked in distilled water in order to assist in the separation of clay particles for at least three to five days. Next, excess water is pipetted and 15-20ml of a dispersant such as Calgon solution is added to the samples and stirred vigorously. Calgon is a sodium hexametaphosphate or sodium pyrophosphate solution that can be made by mixing 50g of powder to 1L of distilled water. Samples are then poured into a tall beaker and distilled water is added or a total height of 8cm. This height is vital for settling sand and silt sized particles. Samples are stirred well and left to settle for exactly 1 hour 10 minutes. The suspense now contains clays that must be poured out. Beakers are filled once again to 8cm and are left to settle for exactly 1 hour. Suspense is poured out again and process is repeated until suspense is clear. Samples are then dried in a drying oven at less than 45°C.

### Organic Matter Removal

At this point, samples consist of only sand and silt sized particles. Any lumps are broken up with a metal spatula and samples are placed in a ceramic crucible. Crucibles are placed in a muffle furnace at 500°C for 2 hours.

### Phytolith Separation

15ml polypropylene centrifuge tubes are filled with 3ml of sodium polytungstate solution which has been calibrated to 2.3 specific gravity. Samples are added to the centrifuge tubes and the tube caps are sealed tightly. Each tube should have the same weight before placing in the centrifuge in multiples of four. The centrifuge is then programmed to run at 800rpm for 10 minutes. Tubes are then removed from the centrifuge and suspense is poured into clean 15ml tubes. This suspense contains phytoliths. Distilled water is added to the clean tubes containing phytoliths and are placed back into the centrifuge at 2,000rpm for five minutes. This pushes the phytoliths to the bottom of the tube and the suspense is poured off through a filter into a wash container for later recovery and recalibration. Water is added and the process is repeated two more times. Clean phytoliths are removed with a pipette into a 5 or 10ml beaker. Samples are dried and the weight of the phytoliths in mg is recorded using an analytical balance to a precision of 0.00001.

### Mounting

After drying, the phytoliths are ready to be mounted. A slide is placed in the analytical balance and zeroed out to get a precise measurement of the mounted phytoliths. Approximately 2mg of phytoliths are added to the slide. The exact weight is recorded and the slide is transferred to a fume hood. Roughly seven drops of Entellan, an embedding agent mix of polymers in xylene, are added to the slide and a toothpick is used to evenly distribute phytoliths around the slide. Good distribution across the entire area of the cover slip is important for analysis. The coverslip should measure 24 x 24mm. We must refrain from pressing down on the cover slip to produce a mount without bubbles.

### Description Procedures based on the International Code for Phytolith Nomenclature 1.0

The first description procedure for analyzing phytoliths is describing shape. A general description of a phytolith 3D or 2D shape is described based on the glossary by Madella and Ball (2005). Phytolith 3D descriptions in terms of shape include conical, cubic, globular, pyramidal, and tabular. Likewise, 2D descriptions for phytoliths include bilobate, lanceolate, oblong, ovate, stellate, and square. It is best to describe phytoliths in both 3D and 2D forms if possible. The second description procedure is texture and ornamentation. These terms are also outlined and examples are exhibited in the glossary section of Madella and Ball (2005). Weathering features are not diagnostic or considered part of texture or ornamentation; however, they may be described and include the descriptions: dendriform, echinate, papillate, and spiraling.

Next, any distinctive symmetrical lines should be noted in the description. In cultivation and domestication research, morphometric data are extremely important. This includes precise measurements of size and shape, including range and mean for large sample sizes. Illustrations or photographs must accompany descriptions. It is common to use optical microscope photographs in combination with detailed drawings or scanning electron microscope photographs. Anatomical designations are assigned only if the phytolith type has been observed *in situ* or if it is widely referenced and clearly identified in publications (Madella and Ball 2005).

## Chapter 5: Conclusion

Humans will continue to exploit the environment for raw materials as well as find new ways to inhabit challenging spaces. Throughout the earth's environmental history, many factors have contributed to vastly modified landscapes visible around the world beginning during the Holocene (Chin et al. 2013; Ruddiman 2013). A warmer, wetter environment jumpstarts an archaeologically visible trend in cultivation and domestication (Kennet and Beach 2013; Fuller 2010; Scarre 2005). Mesoamerica with its biologically diverse landscape had much to offer its early inhabitants. Preceramic inhabitants of Belize, Mexico, Guatemala, Honduras, and El Salvador took advantage and manipulated their environment for various wants and needs. Research regarding these actions should be expanded upon because there is evidence the ancient Maya engineered their surroundings to create an environmental setting to fit specific needs (Scarborough and Valdez 2003). These cultural phenomena are also visible around the world (Fuller 2010; Piperno and Pearsall 1998; Scarre 2005). My research concerning this vital era and region adds to the paucity of tropical research globally.

Both soil profiles and microbotanical remains are proven to support strong lines of evidence for intentional and unintentional anthropogenic effects on the landscape. For instance, Anselmetti et al.'s (2007) work on Lake Salpeten makes a strong case for erosional episodes caused by anthropogenic behavior that survives to modern day sedimentological records. Intense soil erosion in Lake Salpeten during the Middle to Late Preclassic periods support the argument that low populations have long lasting impacts on the environment. Additionally, Solís-Castillo (2013) identify the classic anthropogenic paleosol, *Eklu'um*, along the Usumacinta River in Southern Mexico. Not only are artifacts dating to the Preclassic found, but stable carbon isotope values support increased use of CAM or C4 plants in the soils. Furthermore, work by Beach et al. (2006, 2008) continues to build on the Lowlands of Mexico, Guatemala, and Belize to understand intense anthropogenic erosional episodes during the Preclassic Period.

Recent microbotanical evidence supports this deforestation trend along with intensified agricultural systems and settlement throughout Mesoamerica. Microbotanical remains from Archaic Period sites provide insight into the transition to more intense agricultural practices of the Maya. Rosenswig et al.'s (2014) work in Freshwater Creek, Belize reveals that independent horticultural societies were cultivating plants in the area by 5000 BP. Work done by Piperno et al. (2009) at the Xihuatoxtla Rock Shelter in Guerrero, Mexico provides starch grain and phytolith evidence for maize and squash. Furthermore, Piperno et al. (2009) suggest that the exploitation of maize was initially intended for ritual purposes. Pohl et al. (2007) also confirm microbotanical evidence for maize in the San Andres, Tabasco, Mexico dating to 7,300 BP. Lastly, Kennett et al.'s (2010) work in the Acapetehua Estuary in southern Mexico also supports early slash-and-burn farmers in the area. Maize cultivation dates back to 6,500 BP in this region. Since teosinte does not grow naturally in the area, both the environment and the plant were manipulated by local inhabitants long ago.

Incipient food production includes the domestication of plants such as corn, beans, squash, cacao, chili peppers, cotton, agave, avocado, plums, and cherries were products of this remarkable era (Jones 1994; Kennett and Beach 2013; Piperno and Pearsall 1998;

Piperno et al. 2013; Pohl et al. 1996; Smith 2011; Zizumbo-Villarreal 2012). However, the immense biodiversity visible on the landscape must further be studied. Plants do not serve only as main dishes, condiments, or construction material, they can be used for a number of medicinal, hygienic, or ritual purposes that have not yet been discovered for ancient times or even modern times.

By combining geoarchaeological and archaeobotanical methods with guidelines for locating evidence for human niche construction behaviors, I think that it is possible to locate and examine Archaic Period settlements in order to study the transition into more intense agricultural subsistence strategies in the Maya Lowlands that are visible well into the Preclassic Period. I will need to start with the known geography of this time period provided by the deep, regional Maya archaeological experience of Dr. Fred Valdez. Soil methods including soil characterization, grain size, texture, carbonate determination, magnetic susceptibility, and loss on ignition combined inform my research about environmental history and human-landscape interactions. It is possible to infer long-term occupation, deforestation, or erosional episodes from studying soils. My model for identifying particular anthropogenic paleosols in the Lowland Tropics during the Archaic through Preclassic Periods should be the first step in a series of soil tests, guided by Dr. Dr. Timothy Beach.

In addition, the microbotanical component of my research will also be vital to understanding the transition from hunting and gathering to more sedentary horticultural and intensive subsistence strategies. Collecting and identifying modern-day samples will be the source of reference I will use to compare my archaeological data, under the supervision of Dr. Arlene Rosen. Morphological descriptions and measurements will aid in identifying plant species. By combining soils and microbotanical methods, informed by human niche construction guidelines, I hope to contribute to research gaps within the Archaic to Preclassic Periods concerning subsistence strategies, social complexity, resilience, and the environmental histories left behind.

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