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# Spatial analysis of the preserved wooden architectural remains of eight late Classic Maya salt works in Punta Ycacos Lagoon, Toledo District, Belize

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SPATIAL ANALYSIS OF THE PRESERVED WOODEN ARCHITECTURAL  
REMAINS OF EIGHT LATE CLASSIC MAYA SALT WORKS IN  
PUNTA YCACOS LAGOON, TOLEDO DISTRICT, BELIZE

A Dissertation

Submitted to the Graduate Faculty of the  
Louisiana State University and  
Agricultural and Mechanical College  
in partial fulfillment of the  
requirements for the degree of  
Doctor of Philosophy

in

The Department of Geography and Anthropology

by

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M.A., Louisiana State University, 2004

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For Joe, whose silent companionship and many long walks provided the necessary pause for contemplation.

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## Table of Contents

Acknowledgments.....	iii
List of Figures.....	viii
Abstract.....	xi
Chapter 1	
Introduction.....	1
Research Questions.....	4
Anthrogeography.....	6
Salt of the Maya.....	20
Salt as a Preservative.....	24
Ritual and Medicinal Salt.....	24
Salt Technology.....	26
Salt Works in Punta Ycacos Lagoon.....	35
Indigenous Wooden Architecture of Mesoamerica.....	37
Ethnohistoric Accounts.....	44
The Modern Analog.....	44
Of Wood and Salt.....	51
The Physical Context.....	56
Chapter 2	
Methods.....	63
Chapter 3	
Results of the Survey.....	70
Ceramics.....	72
Stone Artifacts.....	82
Wooden Architecture by Site.....	86
Site 46.....	86
Site 47.....	89
Site 48.....	91
Site 49.....	93
Site 51.....	95
Site 52.....	97
Site 53.....	98
Site 54.....	100
Chapter 4	
Analysis.....	102
Data Reconstruction.....	103
Solid Wood Post Classification.....	104
Template Development.....	106
Solid Wood Analysis.....	111
Pimenta Posts.....	131
Discussion.....	133

Chapter 5	Summary and Conclusions.....	137
References.....		144
Appendix: Glossary of Recurring Spanish Terms Described in the Text.....		154
Vita.....		155



## List of Figures

\*All figures created by Bretton Somers unless specified. Photos are copyright Paynes Creek project and used with permission of Dr. Heather McKillop.

Figure 1-1	Map of Belize and neighbors showing location of study area.....	1
Figure 1-2	Map of mesoamerican salt production sites. ....	22
Figure 1-3	Inscribed bones from Burial 116 Tikal. Drawing by Linda Schele, David Schele, with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., www.famsi.org.....	36
Figure 1-4	Wooden beams inside a corbelled vault of Structure 5D-65 in the Central Acropolis of Tikal, Guatemala. Photograph by Linda Schele, David Schele, reprinted with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., www.famsi.org.....	40
Figure 1-5	Carved wooden Lintel 3 from Temple 1 Tikal, Guatemala. Photograph by Linda Schele, David Schele, reprinted with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., www.famsi.org.....	41
Figure 1-6	Lintel 3 from Temple IV from Tikal, Guatemala carved in wood. Photograph by Linda Schele, David Schele, reprinted with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., www.famsi.org .....	41
Figure 1-7	Map of sites and landscape features of Belize and Central America.....	57
Figure 3-1	Aerial photograph of study area (Photo by Dr. Heather McKillop).....	70
Figure 3-2	GIS display of study area.....	71
Figure 3-3	Punta Ycacos Unslipped rim sherd found at Site 46.....	74
Figure 3-4	Mangrove Unslipped rim and neck sherd found at Site 46.....	76
Figure 3-5	Interior of Moho Red dish sherd found at Site 48.....	78
Figure 3-6	Warrie Red rim, neck and body sherd with comb stamping found at Site 49.....	79
Figure 3-7	Warrie Red body sherd with unit stamping found at Site 48.....	80
Figure 3-8	Unknown ceramic type vessel support found at Site 53, similar to forms found in Honduras.....	81

Figure 3-9	Chert unifacial point found at Site 46.....	82
Figure 3-10	Chert bifacial adze found at Site 54.....	83
Figure 3-11	Chert chopper-pounder found at Site 52.....	84
Figure 3-12	Obsidian prismatic blade found at Site 48.....	85
Figure 3-13	Greenstone adze found at Site 46.....	86
Figure 3-14	Ceramic debitage at Site 46 exposed during a Norther low tide. Punta Ycaos Unslipped ceramic cylinder in the foreground.....	87
Figure 3-15	GIS display of Site 46.....	88
Figure 3-16	GIS display of Site 47.....	90
Figure 3-17	GIS display of Site 48.....	92
Figure 3-18	GIS display of Site 49.....	94
Figure 3-19	GIS display of Site 51.....	96
Figure 3-20	GIS display of Site 52.....	98
Figure 3-21	GIS display of Site 53.....	99
Figure 3-22	GIS display of Site 54.....	100
Figure 4-1	Example of post size range classification.....	105
Figure 4-2	Wauchope template feature class with structure dimensions.....	107
Figure 4-3	Salt apparatus template feature class.....	108
Figure 4-4	Site 46 potential salt apparatus locations within 1.5-meter density clusters.....	112
Figure 4-5	Site 46 potential salt apparatus locations within 5-meter density clusters.....	113
Figure 4-6	Site 47 potential Wauchope structure locations within 5-meter density clusters.....	115

Figure 4-7	Site 47 second potential Wauchope structure locations within 1.5-meter density clusters.....	116
Figure 4-8	Site 47 potential salt apparatus locations within 1.5-meter density clusters.....	118
Figure 4-9	Site 47 second potential salt apparatus locations within 1.5-meter density clusters.....	120
Figure 4-10	Site 47 third potential salt apparatus locations within 1.5-meter density clusters.....	121
Figure 4-11	Site 48 potential salt apparatus locations within 1.5-meter density clusters.....	122
Figure 4-12	Site 48 potential Wauchope structure locations within 5-meter density clusters.....	124
Figure 4-13	Site 49 potential salt apparatus locations within 1.5-meter density clusters.....	126
Figure 4-14	Site 52 potential salt apparatus locations within 1.5-meter density clusters.....	127
Figure 4-15	Site 53 potential Wauchope structure locations within 5-meter density clusters.....	129
Figure 4-16	Site 53 potential salt apparatus locations with 1.5-meter density clusters.....	130
Figure 4-17	Study area schematic with potential architectural features.....	136

## **Abstract**

This dissertation examined the remains of wooden architecture at eight Late Classic Maya sites found beneath the surface of Punta Ycacos Lagoon in southern Belize. The presence of briquetage on the surface and embedded among the clusters of wooden architectural features implies association with salt production activity. This research is significant in that the preservation of wooden structures at the salt works has not previously been reported for the ancient Maya.

This dissertation includes a detailed discussion of documented evidence of salt production throughout Mesoamerica from archaeological, historical and modern examples. The discussion also addressed the evidence of Maya wooden architecture from archaeological, historical and modern examples with attention to wooden features reported at salt production sites. Additional background discussion includes a description of the physical landscape of the region and study area.

The methods used in this dissertation involved specialized strategies adapted from conventional research methods to overcome the challenges of gathering data in the inundated context of Punta Ycacos Lagoon. Additionally, this research involved the post-processing of a large body of survey data to build the project GIS used in the analysis of this study.

The results of the study included the discovery of 372 wooden posts as well as scatters of ceramic and lithic artifacts distributed among the eight sites. Analysis of a sample collection of artifacts recovered revealed the presence of Late Classic Maya ceramic types found in association with salt production sites elsewhere. Stone tools made of non-local materials were also present.

Analysis of the wooden posts recorded in the field survey, used GIS to compare patterns in the distribution of posts to modern and historical distributions of posts in Maya architectural features discussed during the background portion of the text. The comparison included the use of templates, based on the modern and historical examples, to identify similarities in the post distributions.

This research found that there are patterns in post distribution, some of which compare to modern and historical examples of Maya wooden architecture. This study emphasizes that there are rectilinear patterns in the placement of posts. This research demonstrates how GIS analysis offers an effective interactive medium from which to investigate and test patterns in this archaeological dataset. The use of GIS also demonstrated effective in-the-field potential for investigative decision making. The use of GIS in fieldwork may serve to direct efforts in a more effective and efficient manner, maximizing the output of often-limited time in the field.

Like many scholars before me, my research combined archaeological field methods and data, ethnographic and ethnohistoric accounts with geographic spatial analysis methods. My research examined the spatial distribution of wooden posts at Late Classic Maya salt workshops with GIS in an attempt to explain what these posts represent in the ancient Maya relationship with the coastal lagoon environment of Punta Ycacos Lagoon. In this analysis my research uses salt production examples from the pan-Maya lowlands and Mesoamerica to look for similarities with documented sources from the greater region. Following in the footsteps of a long history of anthropogeography in the Department of Geography and Anthropology at LSU my dissertation was intended to continue in this tradition under the recently formalized concentration in anthrogeography.

## Chapter 1: Introduction

In this dissertation I investigate the remains of wooden architecture associated with Late Classic Maya salt works found in a cluster of now inundated sites in the Punta Yacos Lagoon of Paynes Creek National Park, Belize (Figure 1-1).



**Figure 1-1:** Map of Belize and neighbors showing location of study area.

The research I present here is significant in that the preservation of wooden structures at the salt works has not been previously reported for the ancient Maya. In this dissertation I use ethnographic and ethnohistorical reports on wooden architecture including that used in salt production to create templates for comparing to the distribution of wooden posts found in my study area. I report the discovery, mapping and spatial

analysis of the post distribution using GIS, Geomedia 6.0™ and Arc View Spatial Analyst™ to study the post clusters. I suggest interpretations for the spatial patterns of posts in terms of salt production.

This dissertation research is part of a larger project “Mapping Ancient Maya Wooden Architecture on the Seafloor” in Paynes Creek National Park southern Belize, directed by my advisor, Dr Heather McKillop to search for and map the distribution of wooden architecture preserved in the mangrove peat below the seafloor in Punta Ycacos lagoon. Following the discovery and excavation of four salt works (McKillop 2002), a comprehensive underwater survey of Punta Ycacos Lagoon was begun in April 2004 to see if there were more sites. With the discovery of 23 sites with wooden architecture, a multi-year project to search for and map wooden architecture was begun. I have been a project team member since July 2004.

The overall research project found the architecture consists of posts that were pointed at the bottom with axe-like cut marks indicating purposeful human construction and placement. The wooden posts appeared to be aligned in rows and clustered in enclosure-like patterns at many of the sites. Two wood samples were radiocarbon dated to 1300 years B. P.  $\pm$  60 and 1300 years B. P.  $\pm$  40, contemporaneous with the Late Classic Maya (AD 600-900); (McKillop 2005a).

Among the wooden posts, survey of the seafloor revealed an abundance of debris from poorly fired ceramics complete with a large occurrence of cylindrical vessel supports characteristic of salt production sites identified at over 45 other sites in the Punta Ycacos Lagoon area (McKillop 2002, 2005a, 2005b, 2005c, 2006a, 2006b). The ceramics are dated through type-variety analysis to be consistent with the Late Classic period radiocarbon dates. The lack of artifacts associated with domestic activities

suggests these sites were not households. These preliminary observations of surface artifact concentrations suggest the ancient Maya at these sites were engaged in specialized non-domestic salt making activities (McKillop 2002, 2005a). The number of sites in close proximity implies a mass production of salt and has lead McKillop (2002; 2005a) to hypothesize these sites were salt production workshops. Although ancient salt production is reported for coastal areas (Andrews 1983; Coe and Flannery 1967; Graham and Pendergast 1989; Mackinnon and Kepecs 1989; McKillop 1995, 2002; Valdez and Mock 1991; Williams 1999), wooden structures associated with the activity have not been reported until now (McKillop 2005a, 2005b).

For my dissertation fieldwork in 2006, I mapped and studied the architecture of eight sites in a section of the lagoon discovered in 2005 in the course of the “Mapping Ancient Maya Wooden Architecture on the Seafloor” project. Along with fellow project members the sites were systematically surveyed and wooden features were mapped. The spatial distribution of wooden features was compared to existing data reported for Maya wooden architecture to suggest possible architectural forms present. Earlier study of the standardization of salt making ceramics found salt manufacturing in the area was specialized (McKillop 2002). My investigation examined whether architecture and the organization of surrounding spatial activity associated with salt production was similarly standardized by looking for relationships among sites.

There are eight salt production sites with wooden architectural features in my dissertation study area that have been mapped in this study. The area is now a small shallow cove in a mangrove lagoon. Sites were defined as distinct when one area of artifact presence is separated by a void where cessation of artifact presence is observed. Other researchers have identified sites with evidence as minimal as a single artifact or



cultural activity feature (Kelley 1993). In Punta Ycacos Lagoon, there are dense clusters of artifacts often separated by distances no greater than a meter. We have yet to determine whether the sites were occupied contemporaneously. Sites share similar salt making artifacts that indicate the builders of the sites were engaged in salt production. However, operation as individual units or collaboration as one industrial area remains to be determined.

### **Research Questions**

The overall project and my dissertation research are the first opportunity to examine and define ancient Maya wooden architecture. Given the context among salt production artifacts, my study will focus on the function the architecture served in this process. I will attempt to gain insight into the role architecture played in the lives the ancient Maya who engaged in salt making. Are there patterns in the distribution of wooden features at the salt making sites in the study area? Are there similarities between the patterns of wooden features at sites in the study area and wooden features documented in ethnographic and ethnohistoric sources? Can distinct architectural forms be distinguished from the distribution of wooden features? What do patterns in the wooden features or distinguishable architectural forms imply regarding the function of wooden features at these sites? Are the wooden architectural features standardized like the salt production debris found among them lending further support for the specialization of the activity? Is there a standard Classic Maya salt production workshop? Was the organization of space similar from one workshop to the next? How are these sites related to one another? What would standardization imply about the organization of salt production in the Punta Ycacos Lagoon? Are these salt production sites all one massive industrial operation or separate small-scale ventures?

To begin answering some of the questions posed here, this Chapter includes a discussion of documented evidence of salt production throughout Mesoamerica from archaeological, historical and modern examples. Later in the chapter the discussion will proceed to address evidence of Maya wooden architecture from archaeological, historical and modern examples with attention to wooden features reported at salt production sites. This chapter discussion will conclude with some contextual background including a description of the physical landscape of the region and study area.

In Chapter 2 the methodology of the research will be discussed focusing on the specialized strategies adapted from conventional research methods to overcome the challenges of gathering data in an inundated context. The methodology discussion will also describe the post-processing of survey data as well as building the project GIS.

The results of the study will be the subject of Chapter 3. The results discussion will include a description of the types of data found and recorded as well as their distribution within the study area.

In Chapter 4 the analysis of the data recorded within the study area will be explained. The analysis will relate the early discussions regarding the physical landscape, salt production and wooden architecture with the distribution of data discussed in the results. The use of GIS was extensive throughout the analysis and will be described at length. This analysis chapter will reveal the major findings of this study.

The final chapter will synthesize the dissertation focusing on how the findings of this research answers the questions posed in this chapter. Additionally, Chapter 5 will include discussion of the highlights and limitations of the research, posing further questions and suggesting how future research can improve on this study.

## **Anthrogeography**

My dissertation combines aspects from the disciplines of anthropology and geography. This study examines the material culture of the ancient Maya in an attempt to understand the use of wood among salt workshops during the Late Classic Period. My examination draws from archaeological field methods in data collection and grounds interpretations in archaeological theories regarding the ancient Maya. Recording the provenience of cultural artifacts and study of the spatial relationships among them and their locations is a major aspect of archaeology and shared in common with geography. Additionally, this research considered ethnographic and ethnohistoric accounts of modern and historic Maya salt production and architecture in an attempt to find consistencies with the cultural activity of the ancient past. This ethnographic analogy is part of middle range theory, exposed by Lewis Binford (1968) and widely considered in the mainstream of archaeology and provides a link with cultural anthropology.

From geography this research considered the human/environment interaction in the Late Classic Period landscape. The Late Classic Maya decision to occupy this coastal lagoon area for production of salt has broader implications for salt demands in the Maya area at that time and suggests the conditions in the physical landscape fit their needs or could be modified to fit their needs. The majority of this dissertation focused on the spatial distribution of the wooden architectural features at the sites studied. This spatial analysis employed the use of GIS, an increasingly more common technology used in both geography and anthropology. GIS is an outgrowth of spatial analysis an analytic approach originating perhaps with the first attempts at cartography but not combining techniques formally until the twentieth century. Spatial analysis includes many techniques that attempt to describe patterns in distribution of spatially referenced

phenomena at all scales. GIS allows for the computer based modeling and statistical analysis of vast geographic databases.

The use of GIS in archaeology is relatively new but has become increasingly more common (Kvamme 1999). The importance of recording the spatial context of cultural material is an important component of archaeology. GIS facilitates this need and allows for the recording and access to vast amounts of field data as well as introducing archaeologists to new methods of visualizing data and analyzing patterns in datasets (Kvamme 1999). The future of GIS in archaeology will have an enormous impact in both field and laboratory analysis (Kvamme 1999)

The blending of geography and anthropology is not a new concept. If anything the concept of splitting the two fields is more a product of the specialization of academic fields in more recent history. The sub-field anthropogeography, originating in geography, best represents this cross-disciplinary approach.

Central to anthropogeography is the concept of humans and their relationship to the Earth. Throughout history and perhaps prehistory scholars have expressed this relationship differently. Various ideologies have guided this discussion among humans across time. Clarence Glacken best summarizes the key concepts in western thought by which humans have formed their scholarly thought regarding their role on Earth in *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century* (Glacken 1967). In his discussion Glacken describes three approaches by which scholars in western philosophy have formed their ideas, these are; a designed earth, the influence of the environment on man, and man as a modifier of the environment (Glacken 1967). Designed earth suggests the Earth was constructed as “the abode of man” according to a preconceived master plan by a god or

creator entity (Glacken 1967). The role of humans is to improve upon this plan. The closer humans come to understanding the inner workings of the earth's processes, the closer they come to the creator.

The environment as an influence on humans suggests the conditions or laws of nature determine all cultural manifestations of humans. Differences among humans can be explained by differences in the forces of nature acting upon them. The role of humans is to explain the laws of the natural world in order to allow a better chance of survival.

The third concept described by Glacken portrays humans as modifiers or agents of environmental change. This concept has become included more in modern thought. Humans by way of expressing their cultural existence modify the landscape in a way that best suits their livelihood. Humans continue to adapt the environment to improve their own state of being.

In a way anthropogeography has embraced all three concepts during its development but has come to draw mostly from the latter two in its most recent manifestation. Human activity weighs heavily in the concentration of anthropogeography. Anthropogeography posits humans as agents of change but recognizes the advantages and limitations existing in the environment. The human adaptation of the environment to suit their needs is more of an interaction, where the environment poses advantages and limitations in which, humans must modify their cultural existence to incorporate.

Friedrich Ratzel coined Anthropogeography, as a term, in 1882 as *Anthropogeographie* the title of the first of two volumes. *Anthropogeographie* directly translated means human geography. Ratzel's background was in natural history and early in his career he was greatly influenced by Darwinian ideas. *Anthropogeographie* marked

a movement toward a more humanistic approach for Ratzel (Bassin 1987). Ratzel's *Anthropogeographie* included three major discussions, the regions of the earth and human distribution, human migratory movements with emphasis on their dependency on the land and the effects of the environment on the humans physically and mentally (Bassin 1987). This introductory piece on anthropogeography exhibited a very strong environmental determinist perspective. This is partially reflective of the dominating paradigm of the time. Following *Anthropogeographie* Ratzel's work began to focus more on ethnographic content. The second volume of *Anthropogeographie* in 1891 was more of a reflection of this work (Bassin 1987). Ratzel's focus had evolved farther from physical earth features and their effects on humans toward a greater emphasis on human groups with some reference to their physical environment. The concept of *Kulturkreis* or culture area, an area characterized as containing people with similar cultural traits, becomes a major theme in this work (Bassin 1987). Ratzel examines these culture areas as results of human migrations often leading to isolated pockets, which manifest themselves into culturally different entities. Additionally, Ratzel suggested the routes of major historical migrations could be traced by comparative mapping of culture areas (Bassin 1987). This latter concept was an introduction to ethnographic cartography. This second volume clearly shows a movement in Ratzel's thinking from environmental determinist to one that supported humans as agents of landscape change, especially the cultural landscape. Ratzel's work although forming the founding affirmation of anthropogeographic thought was only briefly embraced by scholars of the period. Ratzel was outspoken politically during the unification of German states, the Franco-Prussian war and the building of Germany as a nation. Out of his later work *Political Geography* Ratzel inspired *Geopolitiks* with his state as an organism concept with a need for more territory to sustain

its growth. The nationalistic political campaigns of Germany, including the Nazi party, drew inspiration from these concepts and adapted them to suit their needs (Bassin 1987). Ratzel's recognition among these groups whether desired or not, distanced many scholars outside of Germany from acknowledging his work. Ratzel's work was also criticized for its earlier environmentally deterministic assumptions. The unsound platform of race and culture being a product of the environment in which people live caused a paradigm shift throughout the academy worldwide away from this basis for study. Although much of Ratzel's later work had moved away from an environmental determinist basis his collective work was still interpreted and looked upon with that association. Although some of Ratzel's work continues to have relevance today much of his work including *Anthropogeographie* and *Anthropogeographie II* remain untranslated and often ignored to this day.

A brief glimmer of Ratzelian anthropogeography lived on in the United States through the interpretations of Ellen Churchill Semple. Semple attended Ratzel's lectures at Leipzig in the early 1890's and was greatly influenced by his work (Bushong 1984). Her work reflected his influence and was often an interpretation of his concepts. Her book *Influences of Geographic Environment* best represents the key concepts of her work (Semple 1911). In this work she attempts to synthesize the key elements of the physical world and their effects on human historical development. Semple strongly supported an environmental determinist perspective on anthropogeography (Semple 1911). She recognized Ratzel's work rendering the social organism and *Kulturkreis* but she felt it was secondary to his work relating it to the physical environment (Bushong 1984). Semple was fiercely criticized for her environmental determinist stance and her work lost credibility. Unfortunately, her interpretation of Ratzel's work was incomplete according

to her particular interests and as a result his influence on American geography also suffered. While Semple was responsible for introducing anthropogeography to American geography it was not widely embraced considering the paradigmatic flux of the period. The use of the term anthropogeography to describe later work focusing on human environment interactions appears to have discontinued likely to avoid association with these earlier connotations.

Coinciding in proximity and contemporaneity with Ratzel's efforts in anthropogeography were other German scholars of geography. Much of what is known as modern geography originated among German geographers during the late nineteenth and early twentieth centuries. The legacy of Ferdinand von Richthofen, considered the founder of modern geography, adapted the earliest strategies of settlement pattern studies and focused on the human and land relationship in geography. Richthofen was known as a field geographer and was perhaps the first to look beyond geologic landforms to include soils, climatic conditions and hydrography and noted the differences of human distribution based on the natural setting (Kolb 1983). His basis of study was somewhat environmental deterministic in nature although, he viewed the field of geography as a “bridge between the natural and human sciences (Kolb 1983).” Richthofen is best known for his twelve years of field research 1860 – 1872 in China and California where among other things he studied the differences among central arid regions, humid coastal regions and the differences in the human condition associated with them (Kolb 1983). August Meitzen a student of Richtofen is credited with the first settlement studies in Germany with his studies on farming conditions, relationships with rural communities and their ethnic history. Meitzen also contributed greatly to the study of house types and rural settlement forms in their historical and cultural context (West 1990). Building further off



of Meitzen's ideas, Otto Schluter made the largest contributions to anthropogeography coming from the German tradition. Schluter defined the concrete phenomena from which geographic and especially anthropogeographic studies must originate. Schluter proposed *Landschaftkunde* or landscape science as the study of the "form and arrangement of phenomena on the earth's surface, as far as they are perceived spatially through vision and touch" (Schluter quoted in West 1990:61). Schluter identified two kinds of landscape, the *Urlandschaft* or natural landscape untouched by humans and the *Kulturlandschaft*, the landscape modified by human cultural activity (Martin and James 1993). This attention to *Kulturlandschaft* was an attempt to draw emphasis away from the predominant focus on physical landforms within geographic study at the time. This diversion marked a movement toward humans as agents of landscape modification in geographical thought. Schluter preferred the historical approach to understanding how landscapes were modified from their earliest untouched state to the present day observable human induced manifestation (West 1990). Other notable students of the Richthofen legacy include, Eduard Hahn; Alfred Hettner; Sigfried Passarge; and Karl Sapper who all contributed to landscape studies and the historical, regional and cultural geography which have become components of anthropogeography. Although this German brand of geography did not entirely expose itself as anthropogeography, its key concepts were fundamental to the future of anthropogeographic thought.

In American geography the work of George Perkins Marsh exhibited anthropogeographic concepts. Marsh focused on humans as agents of change and their ability to modify the environment. In *Man and Nature*, 1867, Marsh provides an ambitious far-reaching description of human modifications of plant and animal species, the woods, the waters, the sands and projected landscape modification projects of that

period. Marsh is critical of these endeavors with explanation of the possible advantages and consequences of these actions. Marsh was outspoken regarding the destructive nature of human agency on the landscape during a period where the political and economic minds driving the industrial revolution and westward expansion of American settlement were not interested. Marsh's work although ahead of its time was not embraced by his contemporaries and was not fully appreciated for almost sixty years.

The works of the Germans and George Perkins Marsh had a profound effect on American geography in the twentieth century particularly with Carl Sauer founder of the Berkeley school of geography. Carl Sauer's *The Morphology of Landscape* 1925 very closely mirrored Schluter's study of *Landschaftkunde* with his division between natural and cultural landscapes. Sauer and Leighley's *An Introduction to Geography* 1929 heavily reference the work of earlier German geographers and emphasizes a divergence in the field of geography between physical geography and a more humanistic geography. Sauer was outspoken regarding Marsh's contributions to the human agency concept (Sauer 1938, 1941, 1944, 1981). Sauer, himself studied historical geography and landscape forms in Latin America. His interest was to establish methods of reading past cultural activity from the landscape calling his approach cultural historical geography (Sauer 1925, 1941, 1944, 1981). His research took him to Mexico where in studying landscape change during the period of Spanish contact he discovered evidence of a large, long-established native population (Sauer 1981). His later work continued to examine the longevity, extent and nature of native populations in the Americas. He supported the idea of an earlier human occupation of the Americas than had been suggested by previous scholars. Additionally, Sauer coined the term archaeogeography for the employment of archaeological field methods to look for evidence of former occupation in the landscape

(Sauer 1941; West 1979). The influence of anthropologists Alfred Kroeber and Robert Lowie, Sauer's colleagues at Berkeley played an influential role in Sauer's cultural historical geography (Sauer 1925, 1936; West 1979). What cultural historical geographers observed of the cultural landscape at this time was further enhanced and expanded by the collaborative efforts with anthropologists at Berkeley. Students of Sauer conducted most of their research in the United States and Latin America focusing on landscape change with emphasis to its cultural constituents (Johnston 1997). With attention to empirical observation in field methods and drawing insight from anthropology on reading culture in the landscape, anthropogeographic thought experienced a golden age in research advancement from the work of cultural historical geographers.

The intellectual exchange between the departments of geography and anthropology at Berkeley during this period sparked an awareness of the advantages of multi-disciplinary cooperation in research. Stemming from similar origins geographers and anthropologists were finding considerable sharing and overlapping in research endeavors (Steward 1950; Mikesell 1967; Denevan 1974). The two fields operating independently drew from one another where the shortcomings of the respective fields occurred. Cultural historical geography in its focus on human landscape modification began to find it necessary to explore the concept of culture with greater emphasis. Anthropology with culture as its core concept found a need to understand the environment to explain the spatial distribution of culture and the limits and advantages inspiring cultural adaptations and change (Steward 1955; Mikesell 1967).

The Berkeley connection provided many contributions to the field of anthropology and its relationship to key concepts of anthropogeography. If the cultural

historical geographic approach had a counterpart in the field of anthropology it would be best expressed as cultural ecology ( Mikesell 1967; Denevan 1974). Cultural ecology developed out of the culture area studies of Alfred Kroeber. Kroeber's *Cultural and Natural Areas of Native North America* 1939, attempted to define culture areas according to uniform areas of cultural distribution. These areas, although not considering the natural landscape, was an attempt at a spatial understanding of cultural distribution (Kroeber 1939). Julian Steward, a student of Kroeber, further modified the culture area approach to include nature as a player in the human spatial context (Steward 1946; 1950; 1955). This modification Steward called cultural ecology (Steward 1955). Cultural ecology seeks "to explain the origin of particular cultural features and patterns which characterize different areas rather than to derive general principles applicable to any cultural environmental situation"(Steward 1955:36). "Cultural ecology pays primary attention to those features which empirical analysis shows to be most closely involved in the utilization of environment in culturally prescribed ways" (Steward 1955:37). Cultural ecology provided a mechanism for which anthropologists could explain cultural change and differences. Steward was careful to distinguish cultural ecology from possible environmental determinist views by qualifying with nature does not preside over culture but provides " a certain range of possible behaviors" (Steward 1955:36). Steward also called for multidisciplinary participation in research but cautioned that the terms of collaboration should be agreed upon in advance (Steward 1950). Steward argued all collaborative research endeavors should be comparative in nature to allow for integrated results (Steward 1950). Steward describes the Carnegie Institution's Maya program in the Yucatan as a well intended program with poorly integrated results. The program

experienced comparative difficulties between the ethnographic studies of folk communities and the archaeological work of other collaborators (Steward 1950).

Steward's involvement as director of the Smithsonian Institution's Institute of Social Anthropology oversaw large-scale area research projects incorporating multiple disciplines in an effort to gain a comprehensive study of changes in native cultures under hispanic influences. The two original areas of focus were the Tarascan Valley in Mexico and an area study of Peru. The area studies included the collaborative efforts of archaeologists, geographers, ethnologists and historians (Steward 1950). The Peruvian area study joined forces with the Institute of Andean Research lead by Gordon Willey, an archaeologist (Steward 1950, Willey 1953). Gordon Willey's settlement pattern study of the Viru Valley in Peru was trend-setting research for settlement pattern studies.

Willey recognized a preoccupation of archaeologists with artifacts and not the larger context of the settlements in which they were a part. Particularly many archaeologists were focused on the ceremonial manifestations of ancient cultures. In turning toward the study of settlements as artifacts themselves Willey sought to see a larger picture where settlement features were viewed as "adaptations to natural-environmental, social, and ideological factors" (Willey 1968:225). In positing his approach to his settlement study of the Maya Willey writes the following statement.

How were the ancient Maya distributed upon the land? And how do these distributions reflect the former relationships of man to nature and man to man? An examination of these questions is, we believe, one important starting point in any attack on the difficult questions raised above. If we can answer these basic inquiries about settlement arrangement we will be staking out some of the reference points for the interpretations of class structure and the socio-economic components of past Maya society. For in settlement man has etched upon the landscape the bolder outlines of his design for living (Willey et al. 1965:5).

This excerpt follows very close to the basic fundamentals of anthropogeography. The “man to nature” and “man to man” relationship echo the words of German settlement geography and Sauer’s cultural historical geography. Willey’s settlement archaeology was influential to American archaeology as whole and especially among Maya archaeologists after his work in Central America (Willey 1965, 1968).

The need for continued collaboration and the expression of a shared interest is best summarized in two critiques:

Mikesell writes “with the exception of some recent work in prehistory, it is hard to find examples in the anthropological literature of adequate descriptions of climate, vegetation, landforms, or soil. Consequently, it is not unfair to suggest that cultural ecology, as practiced thus far, represents an attempt to derive a sophisticated view of culture from a naïve view of nature” (Mikesell 1967:633).

William Denevan writes “unlike anthropologists (with reference to Willey 1956), geographers have done relatively little with pre-Columbian settlement morphology, location and growth, possibly because of an inadequate background in archaeology”(Denevan 1974:139) with the exception of Carl Sauer and students.

These critiques show a perceived benefit from the interaction of the fields but a suggestion that there are still obstacles of theoretical sharing and understanding to overcome. There also appears some attempt at defining the conceptual strength of each field in light of the other field’s weaknesses, as a means of maintaining self-distinction in the roles played in collaboration.

As the Berkeley school turned out graduates the influence of the school expanded to include Louisiana State University (LSU). Fred Kniffen a student of Sauer was profoundly influenced by cultural historical geography in his study of the distribution of

house types or folk houses and rural architecture. Kniffen looked at regional variations and housing and was able to surmise diffusion of house type ideas across the migratory routes taken by early settlers of the United States. He qualifies his position:

Even at the level of the individual trait, the house, we view the processes whereby culture acts within itself and reflects its natural setting. Diffusion, adaptation, invention, and evolution are geographic processes insofar as they relate cultural stability or change to the natural environment in which they function: space, distance, relief, vegetation, drainage, and climate, soil. In short there is a matching of cultural capability against natural possibility. The result is the cultural form, the house type (Kniffen 1990:38).

The article in which this excerpt appears is based on Kniffen's research in the 60's although it remained unpublished until 1990. Kniffen's work offers insightful means of reading culture and cultural history in the landscape. His work is very reminiscent of Ratzel's ethnographic cartography and Meitzen's settlement pattern studies. Kniffen's move to LSU in 1929 filled out a department with H.V. Howe, R.J. Russell and B.C. Craft. Initially these four scholars made up the School of Geology. In time courses were offered beyond geology to include geography and anthropology (Walker 1998). By 1944 the Department of Geography and Anthropology at LSU emerged as its own entity. Following in the Berkeley tradition and while stocking its ranks with Berkeley trained geographers or academic descendents of, LSU continued to train scholars in "a geography that used the concept of culture to explain the distribution of human activity, as expressed in material works, across the physical landscape" (Richardson 1984:63).

This influence was carried farther a field with Dennis Jones and Malcolm Shuman in their study of the ancient mounds of Louisiana Indians. The Louisiana mound project included locating mounds, describing their morphology, interpreting their significance and analyzing their distribution over the landscape (Jones and Shuman 1993). Jones and

Shuman used Sauer's term archaeogeography to describe this study, as a further specialization of the anthropogeography at LSU.

Throughout its development the contributions of a great many scholars have rendered anthropogeographic ideas into a dynamic, holistic approach for understanding the interrelationship between humans and their environment. Understanding the processes of the natural world as well as the cultural world are necessary to understand how this interaction manifests itself through time and how this interaction is represented in the landscape. Human activity can take the form of landform modifications, buildings, monuments, artifacts and middens (Willey 1953; Ashmore and Willey 1981; McKillop 2004). Additionally, human activity can include, deforestation, agriculture, mineral extraction, water diversion and plant and animal selectivity (Marsh 1867; Glacken 1967; Mikesell 1967; Denevan 1974; Netting 1977; Sauer 1981). Humans tend to organize this activity toward an efficient means of exploiting their social and natural environment (Kurjack 1974). The study of this interrelationship is the guiding principle of anthropogeography. Considered a sub-discipline of geography, anthropogeography offers one of the few opportunities where it is possible to synthesize the ideas of social theory and the laws of physical science.

Today in the intra-specialized world of academia the term anthropogeography is a rare association despite its continued relevance. The Department of Geography and Anthropology at LSU offers graduates the opportunity to earn degrees in the two disciplines of geography and anthropology with a doctoral specialization in anthropogeography. The term anthropogeography marks a turn from earlier unfavorable associations with anthropogeography. The program at LSU is the only one of its kind allowing for the free integration of thought from the two disciplines in one department.



The department at LSU has embraced anthropogeography for over seventy years and continues to produce competent scholars contributing immeasurably to their field. The department at LSU is distinct in that as of 2006, it formally offers the only doctoral anthropogeography concentration in the United States. While the department has long recognized the advantages of the combined anthropology and geography scholarship, the concentration has been only informally considered as a concentration since 1990. The curriculum maintains the fundamentals of the longer geographic background but allows the two disciplines to blend with formal coursework in each field. In doing so this concentration goes beyond the earlier usage of the term anthropogeography in that actual anthropologists representing all fields of the four-field approach are included in the representative faculty. This rare opportunity has allowed the contributions of anthropologists to social theory, archaeology, settlement pattern studies and methodology to be incorporated with those of geography, rendering a more complete research experience. Even without an intended concentration in anthropogeography the influence and resources offered in the classrooms and laboratories by both geography and anthropology are available to all within the department at LSU.

### **Salt of the Maya**

Salt is a biological necessity for much of the animal kingdom. For humans worldwide, the acquisition of salt has played a vital role throughout time. Salt sources are not evenly distributed over the Earth's surface. Past and present cultures have had to locate near salt sources or organize some arrangement to acquire the compound from afar. Some debate whether people with a diet high in red meat may be able to forgo using salt as a food additive such as the Inuit, or Yanomamo deserves consideration (Marcus 1984). However, with the domestication of plants and rise of agriculture, many

cultures such as those in Mesoamerica, became reliant on cereal crops which are not as high in salt content as meat, thus requiring the dietary supplement (Mendizábal 1946; Webster 2002). The recovery of archaeological materials near salt sources all over the world is testimonial to the human quest for this resource. Some scholars argue that control over this resource may have led to the organization of complex societies (Andrews 1980, 1983; Rathje 1971).

Although the acquisition of salt was likely a need of the first humans to settle in the region later occupied by the Maya, earliest archaeological evidence of its procurement dates to around 1300 B. C. from the northern coast of Yucatan and the Pacific coast of Chiapas, Mexico and Guatemala (Figure 1-2)(Andrews 1983).

For the Classic Maya, the production and exchange of salt was an important part of society. Classic Maya procurement of this resource comes from a long tradition of salt production and acquisition in Mesoamerica, with earliest archaeological evidence dating to 3000 B. P. along the Pacific littoral of Mexico, Guatemala and as far south as Costa Rica, a practice that continues through today (Andrews 1983; Coe and Flannery 1967; Williams 1999). Other archaeological evidence suggests the salt flats of the north and west coasts of the Yucatan Peninsula and Gulf Coast of Vera Cruz, Mexico (Figure 1-2) were exploited as early as 2300 B. P. and also continue to be a modern salt source (Andrews 1983; Santley 2004). Inland salt springs in the highlands of modern day Guatemala and the one known lowland source of Salinas de los Nueve Cerros were also sources of salt production as early as 2500 B. P. (Dillon 1977). Evidence from the Caribbean coast of Belize indicates salt manufacturing began as early as 2000 B. P. and reached an apogee around 1300 B. P. during the Classic Period, perhaps in response to

increased demand from growing populations (Graham and Pendergast 1989; McKillop 1995, 2002).



**Figure 1-2:** Map of Mesoamerican salt production sites.

Salt resources do not occur in widely distributed natural abundance in the immediate vicinity of the large Classic Maya population centers of the interior of the Yucatan peninsula (Andrews 1983; McKillop 2002, 2005a). The core of Classic Maya population centers was deficient in a necessary dietary requirement. These populations would only have been sustainable with importation of salt from the few salt works at saline springs in the highlands of modern day Guatemala such as Sacapulas (Reina and Monaghan 1981), the one known lowland source of Salinas de los Nueve Cerros (Dillon

1977) and the salt works along the Pacific, Caribbean and Gulf coasts (Andrews 1983; McKillop 2002; 2005b).

The daily recommended intake of salt for a human varies greatly depending many variables including stature, activity and climate. There is debate about how much salt per day the average Classic Maya would have needed. In the tropics, a human loses salt and water more rapidly than someone in a more temperate climate. Andrews (1983), based on ethnographic data, found that modern Maya consumed between 8 and 12 grams of salt a day. Someone engaged in physical exertion, such as clearing a milpa, would require up to 30 grams a day as suggested by MacKinnon and Kepecs (1989). Marcus (1984) has argued that there is a difference between salt need and salt appetite suggesting that need is what is actually required to maintain good health and appetite is that which is consumed based on personal or cultural preference. Marcus in consulting nutritional experts, reports that the need for salt is only between .5 and .9 grams a day (Marcus 1984). Marcus also uses the Yanomamo, a rainforest people of South America, as an example who are reported to only consume .017 to .058 grams a day (Marcus 1984). According to Marcus (1984), the figures suggested by Andrews for modern Maya salt intake are not representative of actual need for salt but are more an expression of an appetite based on cultural food preference. Marcus (1984) suggests the ancient Maya may have acquired the dietary salt requirement through consumption of red meat and from the burning of palms augmented with local lowland salt sources at Salinas de Nueve Cerros and Ambergris Cay. However, population estimates at the height of the Classic Maya period would likely have outstripped any natural supply of these resources (Andrews 1983; McKillop 1984, 1996). Another factor to consider in the salt need

versus salt appetite discussion is that not all-Maya salt use is based solely on the consumption of salt for dietary needs.

### **Salt as a Preservative**

In addition to satisfying dietary requirements, salt also fulfills other purposes. Salt is used to treat animal skins and hides and to preserve meat. Valdez and Mock (1991) suggest a link between salt making and the preservation of seafood using salt at the site of New River Lagoon on the north coast of Belize. The presence of salt making artifacts in proximity to the abundant remains of marine species suggests the Late Classic Maya of New River Lagoon were processing seafood beyond local needs (Valdez and Mock 1991). Marine animal remains found at the site include catfish, multiple unspecified fish bones and manatee. Also included in the middens were the bones of terrestrial fauna suggesting the possibility that salt preservation of meat was more diversified (Valdez and Mock 1991). The remains of seafood is not excessively common at inland Classic sites. Where seafood remains does occur tends to be in elite contexts which may imply this connection existed as a delicacy for the privileged few of Classic Maya society (MacKinnon and Kepecs 1991; McKillop 1984, 1995, 2002; Valdez and Mock 1991). These alternative uses for salt in addition to the need to satisfy the dietary needs of the growing Classic Maya population underscore the importance of salt as a resource.

### **Ritual and Medicinal Salt**

Salt in ritual and medicinal use has also been documented by ethnohistorical and ethnographic sources (Reina and Monaghan 1981). Among the modern Maya, salt from different sources often have differing characteristics leading to some sources being preferred over others. Color, taste, medicinal and spiritual attributes are qualities that

distinguish salt from some sources from others. Several salt sources such as Sacapulas, San Mateo Ixtatán and Salinas Atzam are believed to be sacred among modern Maya. The salt from these sources is sought for its ritual significance (Andrews 1983; Reina and Monaghan 1981). Temple platforms at prehistoric salt sources likely indicate the sacredness of salt in Maya belief has considerable antiquity. This sacred significance was reported by early Spanish chroniclers and continues today with many Catholic traditions becoming interwoven with the Maya beliefs (Andrews 1983; Reina and Monaghan 1981). The presence of shrines and other religious iconography from colonial and modern periods at salt sources is a testimonial to the continuity of sacred belief regarding salt among the Maya (Andrews 1983). At Sacapulas, an annual celebration held on May 3<sup>rd</sup> is held in honor of the spiritual essence that presides over the salinas (Reina and Monaghan 1981). The recovery of fine ware ceramics and anthropomorphic and zoomorphic ocarinas from the archaeological contexts of the Punta Ycacos Lagoon, Belize, suggests celebrations and festivals were likely a part of the Late Classic salt-production community as well (McKillop 2002).

Different salts sought for their various spiritual, medicinal and taste may be acquired even by a single household and be used for a variety of purposes (Andrews 1983). Depending on sources of salt, different trace elements such as calcium, iron, magnesium and others may be included in the manufactured salt, which may add some differences in mineral value (Andrews 1983). These subtle differences give distinction to various salt manufacturing sites such as the highland salt sources of Sacapulas and San Mateo Ixtatán, Guatemala (Andrews 1983; Reina and Monaghan 1981). Reina and Monaghan (1981) document that neighboring communities of Sacapulas prefer the Sacapultecán salt to other sources for its taste and some believe that particular salt

enhances growth in their livestock. Salt has been reported to be used in curing ceremonies, birth and death ceremonies, to prevent conception, to treat glaucoma and epilepsy and a variety of other medicinal and ritual uses. (Andrews 1983). Some researchers believe that among the Classic Maya, the pure white salt acquired from the salt flats of the northern Yucatan coast was the preferred salt among the elite of lowland population centers (MacKinnon and Kepecs 1989).

In addition to natural qualitative differences in salt from one location to the next, techniques in salt manufacturing can produce differences in salt qualities. At Sacapulas, the salt workers observed by Reina and Monaghan manufactured two kinds of salt by boiling the brine they leached from salt saturated soil (Reina and Monaghan 1981). Mr. and Mrs. Acietuno created a white salt by removing the contents of their salt bowls just prior to the complete evaporation of its water content and shaping it into oval shaped *panitos* before drying. The couple also produced a black salt from leaving the salt in the boiling vessels until all the water was cooked off and the salt was hardened and blackened. This black salt is preferred by the modern Maya around Sacapulas for its taste and medicinal properties, believed to be useful in treating eye and stomach ailments. By cooking the black salt longer, the mineral apthitalite becomes a part of the mineral content, which does not occur in the white salt (Reina and Monaghan 1981). Salts from various sources, manufactured by a variety of methods with differing products have been documented throughout Mesoamerica (Andrews 1983; MacKinnon and Kepecs 1989).

### **Salt Technology**

Evidence for ancient salt production in the Maya area comes from the remains of broken pottery and from landscape modifications in coastal zones and inland salt springs.

Understanding how these artifacts were used to produce salt has largely come from ethnohistoric and ethnographic analogy.

Salt was and continues to be produced by two general methods: *sal solar*, which involves solar evaporation of saline-rich brine in salt flats or pans and *sal cocida*, which involves boiling saline-rich brine in pots to evaporate the water (Andrews 1983). In some cases, a combination of the two general methods occurs such as the *tepesco* or *tapeite* process where saline-rich brine is further enriched or reduced through solar evaporation and sometimes finished through cooking (Andrews 1983; Williams 1999).

Salt production exclusively by the *sal solar* method is common along the northern and northwestern coasts of the Yucatan Peninsula where a natural shallow coastal zone with a high salinity and a pronounced dry season provides optimal conditions for salt to crystallize in shallow coastal swamps and lagoons and simply be raked or scooped from the floor (Andrews 1983). Often landscape modifications are employed to improve salt drying conditions or increase production area (Andrews 1983). Such landscape modifications may include the digging of flat bottom ponds, referred to as salt pans, to fill with coastal brine and allowing it to stand until the water evaporates and crystal salt remains (Andrews 1983). In other cases, lagoons and coastal marshes are dammed off to create an evaporation zone (Andrews 1983). Other features associated with salt pans include canals, embankments and dams. Archaeological evidence the Maya engaged in *sal solar* salt production is difficult to identify, as in many places such as the Yucatan coast, crystallized salt can be simply scooped up and carried away. Andrews (1983) reports that celts made of shell used for scraping salt from the ground and used throughout the historic period are found at Formative encampments along the Yucatan coast, suggesting the earliest evidence for *sal solar* activity but shell celts are also found



in other non-salt making contexts such as Moho Cay (McKillop 1984). Evidence for landscape modification to create saltpans occurs in the archaeological record by the end of the Late Formative 2000 B. P. (Andrews 1983). Researchers have believed the salt flats of the northern Yucatan were the primary source of salt for the Classic Maya of the interior lowlands (Andrews 1983; MacKinnon and Kepecs 1989).

The optimal *sal solar* conditions of the northern Yucatan do not occur with much reliability elsewhere in the Maya area. In general, rainfall increases in volume and seasonal duration southward along the Yucatan peninsula into the core of the Maya area and along the Pacific littoral limiting the dry periods necessary for brine to become salt. Where rainfall prevents solar evaporation from effectively rendering salt from brine, the boiling method (*sal cocida*) is commonly employed.

The first step in *sal cocida* is acquiring a high saline solution. Seawater is normally not saline enough. At an average salinity of 3.5 percent, a large volume of seawater and fuel would be necessary to make boiling seawater a worthwhile endeavor. In coastal lagoons and estuaries along the coastline of Mesoamerica, salinity levels are much higher, up to 8 percent (Andrews 1983). At inland salt springs, such as those at Sacapulas, San Mateo Ixtatán, Salinas Atzam and Salinas de Nueve Cerros in Guatemala, salinity levels can be in excess of 20 percent (Andrews 1983). In some locations, salt is a component of the soil matrix or peat and requires the further step of leaching from the soil to create brine. This method has been documented at modern Sacapulas, Guatemala, in coastal Chiapas and Western Mexico (Andrews 1983; Reina and Monaghan 1981; Williams 1999). Leaching soil is accomplished by raking up the salt bearing soil and transferring it to some form filtering apparatus. At Sacapulas, Reina and Monaghan (1981) report the salineros pouring salt laden soil into a *cajon*, a raised wooden 1.5-meter

by 1.5-meter box set on top of a mound. Water is poured over the soil and it absorbs the salt from the soil as the brine percolates through to be collected as brine in a collection tray below the *cajon*. Williams (1999) reports a similar apparatus called an *estiladera* at western Mexico salt production sites although after leaching the soil the brine is evaporated in wooden troughs, called *canoas* made from dugout pine trunks, instead of being boiled. Along the Pacific littoral of Chiapas, Mexico and Guatemala, leaching of brine from soil has been reported to be performed in old dug out canoes with holes drilled through the bottom to drain and collect the brine (Andrews 1983; Coe and Flannery 1967). The leached soils are later discarded forming mounds, which occasionally survive as an identifiable characteristic associated with archaeological salt making sites (Andrews 1983; MacKinnon and Kepecs 1989; McKillop 2002).

A further step often included in *sal cocida* is brine enrichment. Salineros often will try to increase the salinity level of brine as much as possible before boiling. Methods of brine enrichment include letting the solution stand out in pans or vessels and allowing it to evaporate substantially (Andrews 1983; Williams 1999) and/or pouring and squeezing the brine through salt enriched soil or peat to leach more salt into the solution (Andrews 1983; MacKinnon and Kepecs 1989; Reina and Monaghan 1981; Williams 1999). Methods and technology of salt enrichment do not differ greatly from the leaching process discussed above but may involve repetition of the process. After achieving acceptable high-saline brine, which some salineros determine by tossing balls of maize dough in the solution and checking if it floats (Reina and Monaghan 1981), the boiling stage is ready to begin.

Many modern salineros have converted to using metal pans for boiling, but traditionally and prehistorically brine was boiled in ceramic vessels as documented by

historic sources and evidenced by the scatter of briquetage around pre-Hispanic salt production sites (Andrews 1981; Coe and Flannery 1967; Graham and Pendergast 1989; MacKinnon and Kepecs 1989; McKillop 1995, 2002; Reina and Monaghan 1981).

Of the ceramic vessels reported to be used in the *sal cocida* process, there appears to be variation. At Sacapulas, the salineros practicing a centuries old tradition, use shallow open bowls supported over a fire by stones. The Sacapultecan ceramics are of a coarse, porous material, which the salineros seal with a maize dough solution as they add the brine for firing (Reina and Monaghan 1981). Similar ceramics and firing process are also reported for other highland Guatemala salt making sites (Andrews 1983). For Pacific coast Guatemala, Coe and Flannery (1967) report restricted neck ollas and jars were used for salt firing at Terminal Formative sites and documented historically by Juan de Estrada in 1579. Andrews (1983) concurs citing similar historical accounts and ceramic evidence in archaeological contexts in coastal Guatemala and Chiapas, Mexico.

Salt cylinders are commonly found at prehispanic *sal cocida* sites along the Pacific coast from Mexico to Costa Rica and among some highland locations (Andrews 1983; Coe and Flannery 1967). Early speculation over their purpose compared them to similar shaped ceramics found in Europe where they supported porous vessels over low heat for final processing of a salt mush by allowing it to drain and harden into molds. (Coe and Flannery 1967). Andrews (1983) and later MacKinnon and Kepecs (1989) suggest these cylinders found in abundance at *sal cocida* sites were used to support brine-boiling vessels over a heat source similar in function to the stones used to support vessels at Sacapulas. In south coastal Belize where evidence for salt production was recovered at Placencia Lagoon, MacKinnon and Kepecs (1989) encountered another innovation on the *sal cocida* technology. Along with clay cylinders and restricted neck jar sherds

MacKinnon and Kepecs (1989) recovered “amorphous fist sized clay lumps” which they interpreted as being fixed to both ends of support cylinders to form a base to attach to the firing vessels and stable foot on the ground surface. Additionally, MacKinnon and Kepecs (1989) also found amorphous clay disks they called spacers, placed between multiple ceramic vessels to evenly space them over a fire allowing heat to circulate evenly around them. This cylinder, socket, spacer jar apparatus allowed multiple jars of brine to be fired in tandem. Mounds of leached soil and briquetage are also associated with the Placencia Lagoon sites, suggesting brine leaching and enhancement were also practiced at these Late Classic sites (MacKinnon and Kepecs 1989).

Nearly 40 kilometers to the south of the Placencia Lagoon sites McKillop (1995, 2002) identified the identical cylinder, socket, spacer and jar and bowl *sal cocida* technology at numerous Paynes Creek sites. These ceramics are the predominant ceramic type encountered in the current study area within the Punta Ycacos Lagoon. The presence of a mound of leached soil at Killer Bee site in Punta Ycacos Lagoon suggests brine enhancement was also practiced here. This ceramic, salt boiling, support technology has also been reported for northern Belize sites (Valdez and Mock 1991).

At El Salado, Vera Cruz, Mexico, Santley (2004) recovered evidence of *sal cocida* spanning the Early Formative Period beginning 3800 B. P. through the Late Classic Period near a saline spring. Santley reports the presence of collared jars, tecomates and large shallow ceramic trays at El Salado. Santley interprets the different ceramic forms at El Salado as representing multiple stages in the salt production process. These stages include transferring the brine from the saline spring with the collared jars to the shallow salt pans for evaporation. The brine was allowed to either fully evaporate

into granular salt or it could be combined with other partially reduced brine to be stored in large storage jars and latter cooked in tecomates and collared jars (Santley 2004).

The boiling process has been reported to be historically performed inside special cooking houses or *cocinas* at Sacapulas, Guatemala, Ixtapa, Chiapas, Mexico and inside homes at Salinas Atzam, Chiapas, Mexico Salinas de Although *sal cocida* appears to have been a very common salt processing method in historic and prehistoric periods, the use of *cocinas* is not widely reported nor do their remains occur at ancient salt sites.

From Reina and Monaghan's observations at Sacapulas we can see that considerable care is involved in the brine boiling process. Variations in technique can produce different products as mentioned earlier with regard to the creation of black salt versus white salt by the Sacapultecans (Reina and Monaghan 1981). Another part of the boiling process at Sacapulas was the adding of a maize dough solution to the boiling vessels to seal any pores (Reina and Monaghan 1981). As previously mentioned maize dough was also used to check salinity levels of brine. McKillop (2002:92) reports the presences of manos and metates at Punta Ycacos Lagoon sites further generating support for the use of maize in salt production.

Andrews (1983) describes a *tepesco* method of salt production from the Chiapas littoral. The method involves leaching salt rich marsh soil from estuaries and salt water marshes during the dry season on raised wooden platforms called *tepescos*. These raised wooden platforms consist of multiple layers of sticks, grass reeds and sand serving as a filter upon with salt laden soil is piled. Brine is then poured over the top of the *tepescos* and collected as it percolates through to be transferred into shallow solar evaporation pans (Andrews 1983). Williams (1999) also describes the *tepescos* from the Chiapas coastal zone and a very similar process by another name farther north along the coast into

coastal Colima and Guerrero, Mexico. This similar method is called *tapeite*, derived from *tapeixtles* the Nahuatl word for the wooden filter platforms that are described in nearly the same way as the *tepescos*. Williams (1999) describes *taipete* as being a technology introduced to the Colima and Guerrero areas of Mexico in the 16<sup>th</sup> century but does not indicate from where. Andrews (1983) expresses uncertainty regarding the antiquity of the *tepesco* method, as the wooden apparatus involved in the process does not survive in the archaeological record.

Although each of the aforementioned steps in the *sal cocida* process directly incurs a substantial investment of time and labor, there are numerous additional costs involved in supporting such an operation. From modern and historic examples, we can observe the infrastructure of the salinas that the salineros have built to produce salt. Much of this infrastructure does not survive in the archaeological record. It is uncertain how much of the historic and modern Mesoamerican salt production is influenced by Spanish colonialism or a legacy of pre-Columbian innovation. However, clearly salt production did occur on a large scale and pre-Hispanic people of Mesoamerica would have had to develop some form of infrastructure at their salinas. From historic and modern examples we can get an idea of the costs involved in salt production operations. Such infrastructure may include landscape modifications to build salt pans or brine containment areas. To modify the landscape for such a purpose people may have built embankments, dams and canals. Salineros would have to move soil to form such modifications and for added reinforcement use wood or stone for retaining walls as illustrated in photographs of modern salt works in Andrews (1983:24-25) and Williams (1999:412).

For brine enrichment, salineros must build the apparatus for pouring and squeezing the brine through a saline enriched matrix. The *cajones*, *estiladeras*, *canoas*, *tepescoes*, *tapeixtles* and old dug out canoes discussed by various researchers were used for this purpose and are all constructed of wood (Andrews 1983; Coe and Flannery; Reina and Monaghan 1981; Williams 1999). Acquiring the wood and other building supplies for these apparatuses would involve an additional initial investment of time and labor for the salineros. For some sites, brine is boiled in specialized cookhouses or in peoples homes, adding yet another building to consider in the infrastructure of salt making (Andrews 1983; Reina and Monaghan 1981). Salt sheds are also reported for Yucatan salt sites (Andrews 1983). Until recently, wood has not been recovered from ancient salt making contexts. In this dissertation I report and analyze wood in a Late Classic Maya salt making context.

As described previously, abundant evidence for the use of ceramics for a variety of tasks in the salt making process exists for historic and prehistoric periods. Examination of ceramics from prehistoric sites suggests in most locations salt making materials were crudely made of local materials (Andrews 1983; Coe and Flannery 1967; Mackinnon and Kepecs 1989; McKillop 1995, 2002). The rigors of salt making would have lead to a short lifespan for ceramics used in salt production, particularly those subjected to repeated firing. By using local materials, salineros would have reduced costs in making salt-making ceramics, but they still would have needed to spend the time to make the pots. These pots could be acquired from elsewhere, possibly from a specialist or made locally.

Another important cost of the *sal cocida* method is the firewood used to heat the brine boiling vessels (Valdez and Mock 1991). Firewood requires significant time and

labor to gather. This resource would constantly need to be replenished as supplies were burned. If not in the immediate proximity of sites, firewood would also accrue additional costs in transport to sites. Excessive exploitation of firewood resources could lead to environmental complications and shortages due to deforestation as suggested by Richard Hansen (1991) with regard to production of stucco at the Late Formative site El Mirador.

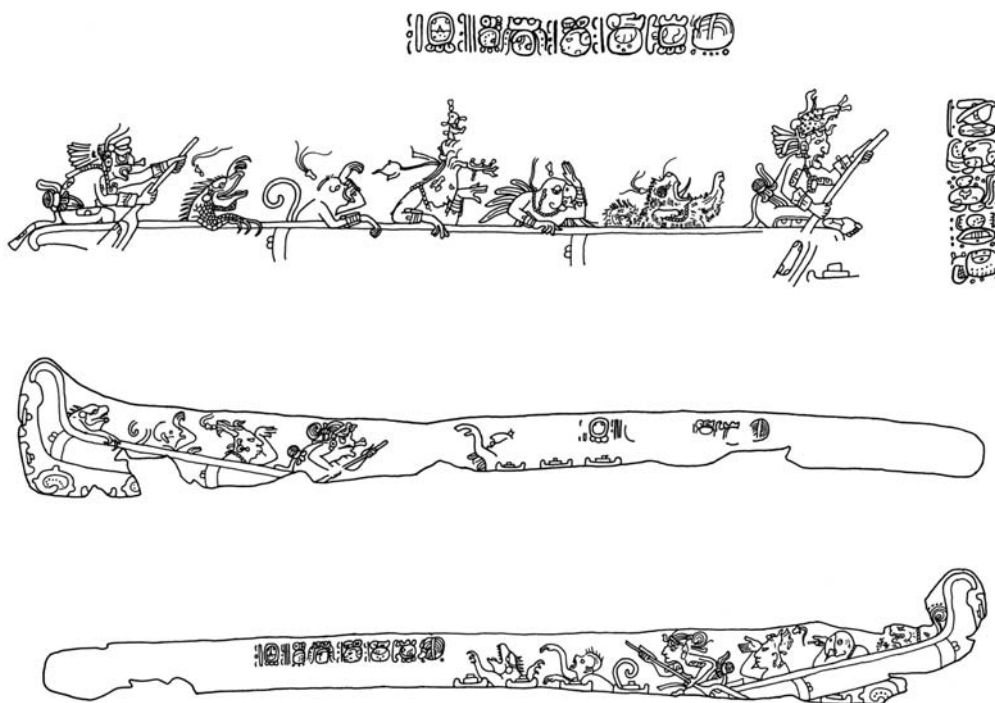
This evaluation of costs is likely incomplete as there are many unforeseen and unknown idiosyncrasies of ancient salt production methods. This synopsis does not include the hand tools likely used in the variety of tasks involved in production or the transportation costs of moving the finished salt product to consumers. The presence of non local materials such as obsidian, chert, fine ware ceramics at Punta Ycacos lagoon sites suggest exchange did occur between these sites and elsewhere in the Maya realm. Although the actual presence of salt is undetectable at inland Classic Maya sites, the sheer volume of production sites along the coasts suggests a response to demand far beyond local necessity.

### **Salt Works in Punta Ycacos Lagoon**

In Punta Ycacos Lagoon of Paynes Creek National Park in southern Belize, where the current study is located, well over 41 pre-Columbian salt making sites have been reported suggesting a high density of production in this area (McKillop 2005a). Quantities of briquetage at these sites suggest the *sal cocida* method was employed. Interestingly, evidence of the domestic activities associated with permanent settlement has not been found in association with the Punta Ycacos salt works, suggesting deliberate mass production beyond the needs of individual households (McKillop 1995, 2002, 2004a, 2005a).



Obsidian and chert, unavailable locally, and distinct Late Classic Period stylized ceramics such as ocarinas from inland sources, are found among the salt-making debris, supporting the notion that these salt works were involved in interregional exchange (McKillop 2002, 2005a). Support for interaction of the Punta Ycaos salt works with the Maya area was recovered in 2004 when a preserved wooden canoe paddle radiocarbon dated to 1,300 +/- 40 B. P., falling within the Classic Maya period, was found among salt making debris at the K'ak Naab salt works in Paynes Creek National Park. The paddle is similar in form to those depicted in Maya iconography found carved into bone and painted on pots in Classic Maya contexts (Figure 1-3). This paddle serves as a critical link to the production of salt to canoe transport and ultimately trade (McKillop 2005a).



**Figure 1-3:** Inscribed bones from Burial 116 Tikal. Drawing by Linda Schele, David Schele, with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., [www.famsi.org](http://www.famsi.org).

Other wooden features forming architectural elements suggest an additional investment in labor associated with these salt-making areas. A wooden post found at the nearby Sak Nak Naj salt works was radiocarbon dated to 1,300 +/- 60 B. P., making the wooden features of at least one site contemporaneous with the Late Classic salt making activity (McKillop 2005a). The wooden features found amid the briquetage indicate the Maya used wood for part of the salt making process. The lack of typical household artifacts in association with these wooden features supports the idea they served a specialized function and were not domestic structures (McKillop 2005a). Further discussion of wood in Mesoamerican contexts for understanding its possible role at the Punta Ycacos Lagoon salt works will be the subject of the following discussion.

### **Indigenous Wooden Architecture of Mesoamerica**

There is little doubt that wood from the dense forests of the Maya area was and remains a readily available building material, yet wooden architecture is scarce at Maya archaeological sites. Preservation of wood and other organic materials in the moist tropical environment is poor contributing to the void in the archaeological record of wooden architecture. This absence is challenging for archaeologists, as a vast unknown body of evidence from the ancient Maya past lies “invisible” in the modern landscape and remains under-represented in our contemporary evaluation of this culture (Chase 1990; Johnston 2004; McKillop 1996; Pyburn 1990; Somers and McKillop 2005).

Wood has been acknowledged as a component of Maya architecture. Haviland et al. (1985) recognize wood as a likely architectural component at Tikal but cite no physical evidence to support this idea. Archaeologists have long agreed that the common Maya lived in buildings of pole and thatch much like their modern counterparts in the region (Bullard 1960; Wauchope 1934, 1938; Willey 1956). Similar constructions are

also believed to have adorned temple and palace superstructures (Wauchope 1934). However, much of the reported remains of ancient Maya architecture are in the form of masonry construction. The limited remains of wood in construction material and an early trend in Maya archaeology to study large ceremonial centers has contributed to a limited body of research on ancient wooden buildings.

Settlement pattern studies, largely inspired by Gordon Willey (1953, 1956) during the 1950s and 60s, have drawn research attention to modest architectural features of the ancient Maya (Adams 1981; Bullard 1960; Chase 1990; Ford and Fedick 1992; Garber 2004; Hammond 1981; Harrison and Turner 1978; Kurjack 1974; Leventhal 1981; McKillop 1996; McKillop et al. 2004; Rice and Puleston 1981; Pyburn 1990; Sanders 1981; Somers 2004; Somers and McKillop 2005; Webster and Fretter 1990). Growing focus on domestic structures and settlement patterns of the common and rural Maya has indicated the use of wood in construction was widespread. Although wood is worthy of mention, archaeologists often only have artifact scatters, tamped floor spaces, mound platforms and stone retaining walls as evidence of past cultural activity. The suggestions of wooden architecture occasionally occur as post molds or impressions left in clay and daub hinting at the under-representation of wooden structures.

The site of Ceren in El Salvador provides a rare look into the lives of the ancient Maya as a complete village rapidly buried by volcanic ash and tephra by the nearby volcanic eruption of the Loma Caldera around A. D. 600 (Sheets 2002). Evidence for wooden architecture is present in the form of charred remains of wooden posts, wattle and daub walls, roofing poles and grass roof thatch (Sheets 2002). More representative than the preserved organic architectural remains at Ceren, are organic remains that were covered in the rapid deposition of superheated debris creating hollow forms or molds as

the remains were incinerated within. Filling in these hollow cavities in the volcanic deposits with plaster provides casts of the original material (Lentz and Ramerirez – Sosa 2002). Analysis of these casts has revealed a tremendous amount of data regarding the organic material used in the daily life of the ancient Maya from agricultural crops, tools, and architectural remains. Architectural remains reveal fences made from *Tithonia rotundifolia* a relative of the sunflower family (Lentz and Ramirez – Sosa 2002), posts, poles and fiber cords (Beaudry-Corbett et al. 2002). The buildings excavated at Ceren were built upon solid fired earthen platforms and aligned to 30° east of north for reasons unknown. Walls of wattle and daub abutted solid earthen corner columns. Poles topped the earthen columns supporting roof poles and thatch made from grass. Shelves of wooden poles were built in the rafters. Sleeping benches of fired earth were within the dwelling structures. Lesser structures of similar construction were also present. Storehouses identified by the debris left behind were of similar size and design as the dwellings but of lighter construction. Kitchen structures lacked the earthen columns and were made primarily of wattle and daub and thin thatching (Sheets 2002). The preservation context at Ceren is found nowhere else in the Maya area and provides an invaluable analog for studying the architectural design and village life of the ancient Maya. Emphasized in the archaeology project at Ceren is the diversity of activities in which Classic Maya were engaged and various activity areas, often enclosed in separate buildings.

Wooden support beams (Figure 1-4) have been found as part of monumental architecture at several sites including Tikal, Bonampak, Edzna, and Palenque in the interior of the Maya lowlands (Andrews 1977; Henderson 1997; Thompson 1954). The beams were found in the corbelled vaults of temple and palace structures (Figure 1-4).

Andrews contends these beams were not load bearing and contributed little or nothing to the integrity of the vaulted rooms. Later versions of the vaults omitted the use of beams (Andrews 1977). The beams may have served another purpose in earlier vault constructions. The presence of carved wooden lintels (Figures 1-5 and 1-6) is described as being used as supports in doorways of ancient masonry constructions (Roys 1934).



**Figure 1-4:** Wooden beams inside a corbelled vault of Structure 5D-65 in the Central Acropolis of Tikal, Guatemala. Photograph by Linda Schele, David Schele, reprinted with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., [www.famsi.org](http://www.famsi.org).

Roys believes the work involved in squaring hardwood logs with the lithic technology possessed by the ancient Maya would have been more labor intensive than carving stone lintels with less load bearing strength. Wooden lintels were probably only used in cases of wide doorways (Roys 1934). Additionally, lintels serve an ornamental purpose with detailed carvings of Maya iconography and hieroglyphs (Figures 1-5 and 1-6).

Freidel and Schele (1990) reported the presence of post-molds at Cerros. Four postmolds were discovered on top of Structure 5C – 2<sup>nd</sup>, a temple structure in a quadripartite arrangement. Freidel and Schele interpret the posts as ritual representations

of the four corners of the world held up by world trees, symbols of cosmic support for the ancient Maya.



**Figure 1-5:** Carved wooden Lintel 3 from Temple 1 Tikal, Guatemala. Photograph by Linda Schele, David Schele, reprinted with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., [www.famsi.org](http://www.famsi.org).



**Figure 1-6:** Lintel 3 from Temple IV from Tikal, Guatemala carved in wood. Photograph by Linda Schele, David Schele, reprinted with permission of Foundation for the Advancement of Mesoamerican Studies, Inc., [www.famsi.org](http://www.famsi.org).

Post molds on low platforms, the ground surface and in bedrock are evidence of wooden structures at Ambergris Caye, Blackman Eddy, Cahal Pech, Pacbitun, Cuello,

Cerros, Copan and Moho Cay (Garber et al. 2004; Gerhardt and Hammond 1990; Guderjan and Brody-Foley 1995; Healy et al. 2004a; Healy et al. 2004b; McKillop 2004a; Webster et al. 2000). The post molds at Blackman Eddy and Cahal Pech are in circular or apsidal arrangement suggesting the structures were in that form. Maynard Cliff (1988) reports the presence of perishable structures associated with elite and non-elite domestic settlement at Cerros. From evidence of post molds, Cliff's analysis demonstrates the presence of domicile structures as well as a kitchen and palisade structures. Cliff (1988) bases his status assessment on the elevation of platforms, the presence of elite ceramics, elaboration of burials and presence of ancillary structures such as kitchens. The identification of wooden structures from scant evidence at these sites among others in the Maya area suggests variability in size, shape and function of wooden structures.

Kurjack (1974) found no wooden remains of structures at the ancient Maya site Dzibalchaltun, but his analysis of the vestiges of domestic structures revealed their likely former presence. Analysis of platform and foundation remains revealed single room apsidal, single room rectangular and multi-room rectangular perishable structures existed. Kurjack's findings indicate heterogeneity in building form and possibly associated class structure in ancient Maya society.

Post-molds in defensive earthworks at Petexbatun sites suggest the use of wood was indispensable in their construction (Demarest et.al 1997). Evidence for palisades has been found enclosing dozens of sites in the Petexbatun. The palisades are believed to have been a defensive measure during a period of endemic warfare in the Late Classic Maya period.

In a rural survey in the Copan Valley, Webster et al. (2000) discovered, in addition to residential sites, evidence for other specialized activities such as ceramic production, obsidian tool manufacturing, a kiln, and field huts made of perishable material. The findings expand our knowledge of cultural activity beyond the household level, necessitating specialized building types including some made from wood.

The discovery of preserved wooden features at Late Classic Period salt works in Punta Ycacos Lagoon of Paynes Creek National Park underscores the use of non-domestic and specialized use buildings constructed of wood among the ancient Maya (McKillop 2005a). The study of wood at the Punta Ycacos Lagoon salt making sites in this dissertation offers insight into wood construction during this pre-Columbian Period.

Wooden structures are represented in ancient Maya depictions as temple superstructures and domestic buildings. Frescoes on walls at the Temple of the Warriors at Chichen Itza, Tulum and graffiti at Nakum picture structures with post-like walls and thatched roofs (Wauchope 1934). The Chichen Itza frescoes show the buildings elevated on platforms of various heights and roof tops with a tightly woven crowning tuft (Wauchope 1934, 1938). The people in the frescoes are engaged in a variety of activities from carrying loads, to cooking, sweeping, sitting and warriors standing on roof-tops. A large storage vessel, bushes, a non-descript post within a basket and a container holding fish (interpreted by Wauchope 1934) within a structure also appear in the frescoes. Clearly, a number of activities domestic and non-domestic occur within and around these structures implying wooden structures had multiple uses beyond being domiciles for the common Maya.



## **Ethnohistoric Accounts**

Spanish accounts of Maya buildings from early in the conquest and colonial era provide depth to the ethnographic data of Maya architecture (Wauchope 1934). Most accounts have several details in common. The majority of accounts report houses made of wood with thick poles and forked sticks, reinforced with vines, and supporting a roof thatched with palm or straw. Walls were constructed of wattle and daub (Wauchope 1934). The *Relación de Hocaba* and the *Relación de la Villa de Santa* describe the support structure of houses lasting up to twenty years and the roofing material being replaced every five (as translated by Wauchope 1934). Bishop de Landa's *Relación de las Cosas de Yucatan* informs that groupings of houses occurred when younger family members married and built separate buildings adjoining a central open area (Tozzer 1941). According to Wauchope's (1934) reports of the *Relación de Tecanto y Tepecán*, the Maya preferred the wood and thatch houses to stone as being healthier because they were cooler in the intense summer heat. The *Relación de Tecanto y Tepecán* also describes dwelling structures facing north, south and east but not west, a direction reserved for temple structures. Francisco Saverio Clavigero, in 1780, describes ordinary houses as having only one chamber where all occupants, belongings and animals resided and wealthier houses containing partitions for multiple chambers (Wauchope 1934). These ethnohistoric accounts, provide a continuum from which we can compare to modern day examples of wooden architecture.

## **The Modern Analog**

Robert Wauchope (1934) provides the first in depth research of Maya domestic structures. His research with the Carnegie Institution in the 1930s and 40s focused on housemounds at Uaxactun. His original plan was to use the research as a method of

estimating population for the site. Wauchope was dissatisfied with his final statistical conclusions for the smaller residences of the Maya from his excavations of five house mounds at Uaxactun. Seeking more clues regarding form and function of Maya houses, Wauchope turned his attention toward the structures of the modern (1930s) Maya. Using ethnographic analogy, Wauchope hoped to learn from the modern Maya how the ancient Maya might have constructed their homes.

Wauchope contends that the general principles of house construction are consistent throughout the Maya area and he describes the construction process (Wauchope 1938). Parallel rows of postholes are excavated to a depth of approximately one meter. Mainposts, 12 cm – 18 cm in diameter and forked at the top are inserted in the holes. Then longitudinal beams are laid across through the forks and secured with lianas (Wauchope 1938). Crossbeams are laid across the two longitudinal beams and tied down. Roofs vary from two-sided saddle roofs to four sided hip roofs. For attaching the roof, two additional longitudinal poles are tied on above the crossbeams where rafters are tied at varying angles. At the bottom, the rafters extend beyond the line of original posts where the drip line from run off will be carried away from the building. Rafter poles cross at the top and are lashed together with two longitudinal ridge poles lashed above and below where the rafters cross. Two more longitudinal poles are tied to the rafters at intermediate distances between the roof ridge and the roof base. Crossbeams are attached between these intermediate longitudinal poles. Two vertical roof posts further support the roof ridge from the outermost crossbeams. A series of light longitudinal beams are lashed outside of the rafters where thatching is attached. A tightly woven cap of thatch material is attached to the roof ridge to make it waterproof. Thatching varies from palm leaves to sugar cane leaves, according to Wauchope (1938). Variety in construction is

influenced by environmental variability in the Maya area. In highland regions, walls are necessary to block high winds, whereas in more hot and humid regions walls are not needed. Roofs tend to have steeper inclines where rainfall is heavier (Wauchope 1938).

Wauchope's modern Maya house study (1938) finds ground plans of modern Maya houses vary considerably throughout the Maya area. Ground plans are the shape of structures from plan view. Apsidal ground plans for buildings are rectangular with rounded ends. This ground plan is most common in Yucatan. Flattened ends are rectangular with only the corners rounded. This ground plan is also common in Yucatan, northern Guatemala and Belize. Square ground plans are absent from the lowlands but are found mostly in the highlands of Guatemala, with some reported in Honduras (Wauchope 1938). Roof design is less variable than ground plans, with only two common types. The hip roof is standard throughout the Maya area with a roof pitched over all four sides of the house. Variability in the pitch of the roof occurs with shape of ground plan as well as local configurations accounting for rainfall and winds. The saddle roof is pitched on only two sides of a building and is less common. This roof style is only common in the Alta Vera Paz of Guatemala (Wauchope 1938).

The materials used by the Maya in construction are also quite variable as described by Wauchope (1938). Variability is mostly determined by the local availability of materials. The main posts are made from durable hardwood. The wood must be able to hold the weight of the structure as well as be resistant to rot when placed in postholes. In Yucatan, chucum (*Pithecolobium albicans*) a black dye tree, chacté (*Caesalpinia platyoba*) a red dye tree, kikche (*Castilla elastica*), also known as a rubber tree, chulul (*Apoplanesia paniculata*), known as the strongest tree and habin (*Ichthyomethia communis*), a tree strong like oak, are used as posts. Chacté also called sapoté is most

commonly used, although a local informant using chucum suggested it is more difficult to obtain (Wauchope 1938). Yaxek, oxcitinche, dzudzuc, chichem and sapodilla are also reported for southern Yucatan and Belize (Wauchope 1938). In the highlands of Guatemala, Guachipilin, k'antse, kus or tasiskab, tseux or tsax known as pine, saq tsax known as white pine, atarai, chapulin, ilamo, and tux a form of oak are used.

Crossbeams also need to be durable but not necessarily as resistant to rot like the posts inserted in the ground. In Yucatan, chacté is also used for cross beams. Other wood species used include kan-chunup (*Thouinia paucidentata*), bob ché (*Cocoloba schiedeana*), zak-yab (*Gliricidia maculate*), bo'hom (*Cordia gerascanthus*), toxob (*Caesalpinia vesicaria*), chulul, sutsuk and mangrove tree are used. In Guatemala, crossbeams of pine have been observed (Wauchope 1938). Roof framing materials including rafters, beams and longitudinal poles are all made of similar materials. Kan-chunup, chacté, cholul, hol (*Hibiscus tubiflorus*), zabac-ché (*Exostema caribaeum*), bezinic-che (*Alvaradoa amorphoides*), pichi-che (*Psidium sartorianum*), pa-zak (*Simaruba glauca*), kuche (*Cedrela Mexicana*), zutup (*Ipomoea bona-nox*), and Elemui (*Guatteria guameri*) are used depending on local availability and length and thickness of straight pieces (Wauchope 1938).

Walls are constructed of vertical poles, 4 cm –8 cm in diameter, lashed together much like a stockade. Walls are usually separate from the main building construction, either being set in the ground, resting on the ground surface or on a stone foundation to prevent rotting, although, in some cases, the main walls are load bearing (Wauchope 1938). Some walls are coated in daub. Vertical wall poles are most common in the Maya area, although horizontal wall poles are present in the upper portions of the far ends of houses with saddle roofs (Wauchope 1938). Walls are made from almost any type of

wood, including species used the main building and roof framing. Additionally, guano and escoba palm are used, as well as bamboo in parts of Guatemala (Wauchope 1938). In the case of wattle and daub walls, small sticks are woven between the upright wall poles and mud is smeared over the outer surface (Wauchope 1938).

Thatching materials vary slightly with palm being the most common (Wauchope 1938). Guano palm (*Sanal japa*) is most common in Yucatan, with another variety chit palm (*Thrinax argentea*), a shorter fan like variety in the north. In Guatemala, palma coroz (*Attalea cohune*) is most common, with palma real used to a lesser extent. Chiapai, chichon and akté leaves are used in Chiapas. The Kekchi in northern districts use the cumumxan large fan palms. In Belize, cohune palm and cabbage palm are reported to be used (Wauchope 1938). Thatching with grass is most popular in Guatemala and is also used in northern Yucatan. Wauchope does not give details on the grasses used in Guatemala, but in Yucatan he reports three types of grasses used, including koxol-ac, a savanna grass, zuuc, a reddish field grass and kuk-zuuk, also called peccary grass. Other thatching materials observed by Wauchope include corn leaves and sugar cane leaves. Europeans introduced sugar cane, so its use would not go farther back than their arrival, but it does suggest the Maya make resourceful use of the materials locally available. Choice of thatching has little effect on the framing architecture of the house (Wauchope 1938).

In addition to housing structures, Wauchope, although in much less detail, reported the presence of miscellaneous structures, some related to household activities and non-domestic activities. Such structures include storehouses, kitchens, beehive shelters, chicken houses, granaries, ovens, shrines, sweat-baths, tanneries, washbowl and

wash-trough shelters and well houses (Wauchope 1938). Storehouses and kitchens are described as being of similar construction as house structures.

Beehive structures, Wauchope (1938), describes as being of similar construction as houses but lacking the walls. Within the beehive structures, large hollow logs stopped at both ends, serving as the beehives, are stacked in rows (Wauchope 1938).

Although chickens are a Spanish introduction to the Maya area, small animal pens are possible for the ancient Maya. Wauchope (1938) notes chicken houses made of stone and wood. Wooden chicken houses measure 1.85 meters square and 1.3 meters high and are topped with a small roof of thatch or palm (Wauchope 1938).

Granaries consist of narrow poles around 7 cm in diameter serving as support posts for a raised crib made of narrow sticks suspended by cross beams. The staging is suspended 1.35 meters above the ground surface. Maize ears are stored on top of this staging and covered with leaves. In addition to special purpose buildings, many buildings serve multi-purposes such as storing food in the rafters of the main house. Granaries are sometimes found within storehouses (Wauchope 1938).

Wauchope (1938) reports the presence of ovens as being separate structures from kitchens and houses. These structures often are constructed of masonry and adobe. Wauchope (1938) observed ovens as commonly being located away from the main house.

Shrines often are found within houses, but in some cases a separate structure is built for such purposes. Wauchope (1938) reports variability in shrine size from an unspecified small structure to as large as and of similar construction to a family house. The larger shrine Wauchope (1938) notes as being that of a religious secret society.

From Wauchope's observations, sweat baths are small buildings 1 meter high and 1.5 meters wide of masonry and wood and mud construction. The presence of baths is

not reported for Yucatan in Wauchope's observations; he notes they are most prevalent in the Guatemalan highlands.

The tanneries reported by Wauchope (1938) were built from plastered masonry. Three stations were involved in the tanning process. One station consisted of a stone platform where hides were scraped. The second station consisted of a plastered masonry tank with two bays, in which the hides were cleaned. The third and larger tank had three bays and contained the tanning solutions for the hides (Wauchope 1938).

Wauchope's (1938) description of washbowl and wash-trough structures is limited to stating their existence. Large ceramic bowls or dugout troughs are used as washbasins.

How reliable are Wauchope's observations regarding modern Maya structures in helping with interpreting Late Classic Maya structures? Arguably, his observations from the 1930s are likely more reliable than present day with the increased interconnectedness of globalization further influencing the modern construction methods and materials and activities within Maya households. The in depth discussion of Wauchope's work is a major contribution for this project in that he gives one of the only points of departure for analysis of the ancient wooden structures in Punta Ycacos Lagoon. His observations and measurements, not only of houses but also of ancillary structures, can be used with caution to assist in determining possible function of the salt production architecture.

In a more recent observation of Maya house construction, Michael Steinberg (1999) observes the Mopan Maya building practices in southwestern Belize. Steinberg notes the practice of harvesting house materials occurs during the phase of the full moon. By following this schedule, the plant material contains its maximum quantity of sap, making the wood more resistant to insects and rot. With the right harvest, roofing

material will last four to five years, posts will last 15 years and siding will last 10 years. Steinberg also reports on the materials used in house construction by the Mopan. Two species of palm, cohune (*Orbignya cohune*) and waree cohune (*Astocaryum mexucanu*) are used for thatch. Eight species of hardwoods are used for posts including quamwood (*Schizolobium paraphybum*), ironwood (*Dialium guianense*), black fiddle wood (*Bourreria mollis*), ceiba (*Ceiba pentandra*), bullet tree (*Bucida buceras*), rosewood (*Dalbergia stevensonii*), Santa Maria (*Calophyllum brasiliense*), and negrito (*Manilkara zapota*)(Steinberg 1999). For wall boards, Steinberg observes the use of quamwood and ironwood. Many of these observations are consistent with Wauchope's observations. The materials are available in the local environment.

Other studies of Maya buildings consider the entire living domain of a household called solares in Yucatan. Virginia Ochoa-Winemiller (2004) provides an in depth study of solares in 2004. A solar is a house lot. Solares tend to be rectangular in shape covering a surface area of 1217.39 square meters. The average solar contains six structures. In addition to a main house, there can be a kitchen, palapa, latrine, animal pens, a well and a roofed laundry area. Also within the solar, are shrub areas with orchard trees, gardens and refuse areas. Ochoa-Winemiller's study demonstrates the importance of studying beyond the main building structure to include the greater realm of the domestic domain. The main house is only a part of the built domestic environment. Maya construct buildings of wood and stone for a variety of purposes and many buildings serve multiple purposes.

### **Of Wood and Salt**

Wood has been found preserved in the archaeological context of salt making debris at the Punta Ycacos Lagoon sites. The apparent lack of household debitage



indicates activity at these sites was focused on salt production (McKillop 2005a). The presence of preserved wood has not been documented at other prehistoric salt making sites. By examining historic and modern accounts of salt making, the function of wooden features can be inferred. My earlier discussion in this chapter regarding the salt making process referred to the use of various wooden features and apparatuses, reported elsewhere in Mesoamerica. Although dimensions, construction materials and construction methods of wooden features are not the focus of these reports on Mesoamerican salt making, some data can be gleaned from their description. Wooden salt making apparatuses used in Mesoamerican salt making include *cajones*, *estiladeras*, *canoas*, *tepecos*, *tapeixtles*, and canoes (Andrews 1983; Reina and Monaghan 1981; Williams 1999). Additionally, landscape modifications used to build retaining walls, embankments, dams and canals for holding ponds, salt pans and other brine management features often include wood as portrayed in photographs and illustrations of salt sites described in reports (Andrews 1983; Reina and Monaghan 1981; Williams 1999).

Williams (1999) provides an in depth look at salt making sites (*fincas*) in Michoacan, Mexico. The *fincas* he describes are *sal solar* sites that evaporate brine leached from soil. In describing the salt production process Williams refers to a number of wooden features involved in the process. Soil is gathered and poured into an *estiladera*, a wooden funnel shaped structure about 1.5 meters in height. The *estiladera* sits atop a wooden block. In a photo provided by Williams (1999), the *estiladera* appears to be further supported by four posts forked at the top and supporting crossbeams in which the wooden funnel is contained (Williams 1999). The filtered water seeps into a *banco*, a wooden trough where the water is collected. The brine is further transferred into

wooden *canoas*, dugout wooden troughs between 6 meters and 10 meters in length where the brine is evaporated into granular salt (Williams 1999). The images provided by Williams show the wooden troughs raised off the ground with wooden supports. From a schematic of a *finca* provided by Williams (1999: Figure 3), the distribution of features can be observed. In the schematic Williams provides, the *finca* example has four *estiladeras* that vary in size from 5 meters in diameter to 2.5 meters in diameter judging from the plan view. The *finca* covers an area of roughly 4200 meters. Two groupings of *canoas* in parallel rows occur each near the two largest *estiladeras*. One grouping of nine *canoas* constructed of wood begins approximately 10 meters and 15 meters away from a single large *estiladera*. The second grouping of *canoas* include four, constructed of cement. These *canoas* are located closest (under 10 meters) to a second large *estiladera*. Another pair of smaller *estiladeras* does not have its own grouping of *canoas* but is situated closest (15 meters to 30 meters) to the grouping of cement *canoas*. Other features in the *finca* include a pair of wells, connected by canals for each *estiladera/canoa* combination. In photos included in Williams (1999) report, wooden posts are visible along the length of a canal. If their purpose is to assist in shoring up the embankment, hold up the barbed wire as a fence or both remains unclear. Additionally, an area of mounded leached earth labeled *tierra picada* occurs midway and off to one side of the two main *estiladera/canoa* activity areas. Although Williams' (1999) description, images and schematic are for *sal solar* sites in western Mexico, the general understanding of site layout and organization of activity areas is important to take into consideration when interpreting the site layout and distribution of wooden features in Punta Ycacos Lagoon.

A similar operation to Williams (1999) *finca* occurs at Sacapulas, Guatemala. Here a similar apparatus to the *estiladera* is called a *cajon*. It also is constructed of wood and raised up on wooden supports and mounded earth (Andrews 1983; Reina and Monaghan 1981). The *cajon* is shaped like a wooden box measuring 1.5 meters by 1.5 meters according to the example given by Reina and Monaghan (See image in Reina and Monaghan 1981 Figures 21, 23 and 24). Water is filtered through salt laden soil in the *cajon* and collected in a tray below, where the brine is not evaporated but instead boiled in ceramic vessels within a building (Reina and Monaghan 1981). The building at Sacapulas appears to be constructed of stone although, wooden structures may be possible in areas where abundant stone is not available for building construction. Reina and Monaghan (1983) report from local belief and documentary sources that the salt works at Sacapulas have considerable antiquity and may have pre-Hispanic origins (Reina and Monaghan 1981).

Both Andrews (1983) and Williams (1999) report on another salt production technique called *tepesco* that involves filtering brine through salt laden estuary soil in a raised wooden structure. The final product is then evaporated in solar pans (Andrews 1983; Williams 1999). Andrews (1983) indicates the antiquity of the *tepesco* method is unknown and the ability to prove otherwise would be difficult considering the high perishability of the wooden apparatus. Williams (1999) reports a nearly identical technique called *tapeite* that involves filtering water through salt laden estuary soil in a raised wooden structure occurring farther north along the western Mexican coast.

Andrews (1983) provides numerous photos of salt making operations from many parts of Mesoamerica. In many of these photos wood is depicted in salt making and as parts of landscape modifications. Rows of vertical wooden posts can be seen shoring up

the retaining walls of salt pans. The retaining walls tend to be rectilinear in shape with multiple salt pans lined up together. Also depicted in the images are wooden buildings, likely the salt sheds to which Andrews (1983) refers.

The accuracy of these data to make analogies with the past, like other ethnographic and ethnohistoric data, is challenged with time and years of blending between Mesoamerican and Spanish cultures. However the ancient Maya had to have some sort of innovation to manufacture salt as the imprint of ancient salt sites leave similar marks in the landscape. The most visible imprint of prehistoric salt making in the landscape that correlates with ethnographic and ethnohistoric sources are the mounds of leached soil scattered around salt source areas (Andrews 1983; MacKinnon and Kepecs 1989; McKillop 2002; Williams 1999). As a readily available resource in many parts of Mesoamerica, wood was likely involved in the infrastructure of ancient salt making operations. The reports where wood is noted or depicted as part of the salt making process will be considered in this analysis of the preserved wooden features at the Punta Ycacos Lagoon sites.

Preliminary studies of the wood found preserved in the mangrove peat of Punta Ycacos lagoon have identified the species of wood for the paddle as *Manilkara*, possibly *Manilkara sapote* (McKillop 2005a). *M. Sapote* is a durable hardwood that grows in rainforests also known for its sap called chicle, a component of chewing gum (McKillop 2005a). Aside from the paddle, species identification of the posts has yet to be carried out. Some are well preserved hardwoods and others resemble palm wood. Identification of wood species used in the architecture of the sites is expected and will be compared to earlier studies of wood used in Maya construction.

## **The Physical Context**

The archaeological ruins of the Late Classic salt making sites studied in this dissertation are located in Paynes Creek National Park in the Toledo District of southern Belize (Figure 1-7). Paynes Creek National Park was declared a nature reserve in 1994 and a park in 1999. The park is part of a conservation plan for the Toledo District called the Maya Mountain Marine Corridor or MMMC. The MMMC is a plan to protect a corridor of land stretching the breadth of eco-zones within the Toledo District from the peaks of the Maya Mountains in the west, through the coastal riparian plain and the hundreds of cays of Port Honduras to the Belize barrier reef of the Caribbean Sea in the east. The area hosts a diverse variety of habitats and very rich biodiversity of plant and animal life. The area also bears the imprint of thousands of years of cultural heritage including the coastal Maya sites in Punta Ycacos Lagoon, Wild Cane Cay, Frenchman's Cay, Green Vine Snake, Village Farm, Pork and Doughboy Point and Arvin's Landing among others (McKillop 1996, 2002, 2005b; Pemberton 2005; Somers 2004; Somers and McKillop 2005) as well as the larger inland ceremonial centers of Lubaantun, Nim Li Punit, Uxbenka and Pusilha among others (Hammond 1975; Leventhal 1990; McKillop 2002).

The slopes of the Maya Mountains and the downward flow of water are fed by a very moist tropical rainforest climate, Af, according to Köppen classification. The Toledo District receives an average annual rainfall in excess of 400 cm with seasonal variation. A brief dry season begins around March and ends around the beginning of June with the rainy season lasting from June through February. This is relative and quite variable from personal experience.

The Maya Mountains are a northeastern extension of the Sierra system of Central America originating from across the western Belize border in Guatemala (Dillon and

Vedder 1973). They are composed of clastic sedimentary rocks from the late Paleozoic with granitic intrusions formed during the regional uplifting of the crust and limestone from the Cretaceous. Granite and basalt from the Maya Mountains have been found in ancient Maya archaeological contexts elsewhere in the Maya region implying this area was an important source of these materials for the ancient Maya (Abramiuk and Meurer 2006). In addition to stone materials the Maya Mountains are the upland source for the six major watersheds of the Toledo District flowing from the mountains south and eastward to the Caribbean Sea.



**Figure 1-7:** Map of sites and landscape features of Belize and Central America.

The lower slopes of the Maya mountains and river courses are shrouded in broadleaf rainforest. This gives way in patches on the coastal plain to pine savanna as it does in northern Paynes Creek National Park. In the coastal zone, tide dominated river courses and the cayes, mangrove forest is the dominant vegetation.

Of particular importance to the context of my dissertation research is the complexity of the estuarine mangrove ecosystem of Punta Ycacos Lagoon. Little research on the ecosystem and paleo-environment of the lagoon has been reported. The lagoon is shallow and microtidal.

The lagoon system is believed to have once been part of the Monkey River deltaic system, but the river since avulsed to a more northern outlet to the sea (McKillop 2002; Wright et al. 1959). Today some freshwater input has been reported from Freshwater Creek in the northwest of the lagoon (McKillop 2002). Shifts in the fluvial system and succession of the mangrove forest of the lagoon are also likely, and require further inquiry. How these changes affected or were modified by human habitation of the area including the ancient Maya salt industry also requires further inquiry. Reports from research elsewhere in coastal Belize have commented on the mangrove ecosystem and paleo-environment of coastal Belize as a whole (Burke 1993; Dunn and Mazzulo 1993; Lighty et al. 1982; MacIntyre et al. 2004; McKillop 2002; Wright et al. 1959). McKillop (2002:135-174) summarizes research on sea-level rise along the coast of Belize adding new findings from southern Belize.

Global eustatic sea-level has been on the rise since the end of last glacial maximum 18,000 years B. P. Atlantic deep-sea cores have indicated sea level was an estimated 120 meters below present level (Chappell et al. 1996). Rates of sea-level rise have been variable through time with a rapid rise between 10,000 and 6000 B. P. and a

slowing since then (Lighty et al. 1982). In the coastal region of Belize, the first evidence of sea-level rise on the Pleistocene shelf is indicated from 18 meter vibro-cores recorded at Boo Bee Patch Reef in the Southern Shelf, as early as 8700 years B.P. (MacIntyre et al. 2004).

These vibro-core records largely consist of mangrove peat accumulation found to be a reliable medium of measurement. Mangroves are an intertidal tree species tolerant of saline settings. Red mangroves (*Rhizophora Mangle*) will grow in shallow coastal waters and will keep pace with rising sea level through deposition of detritus, which forms peat. Mangroves are the dominant coastal feature of Belize fringing nearly its entire coastal line, intercoastal lagoons and cays.

Isostatic sea-level rise has been uneven along the coast of Belize. The southern shelf is lower in elevation than the north and the effects of sea-level rise occur earlier in the north, around 8700 B. P. as indicated by the afore mentioned vibro-core at Boo Bee Patch Reef (MacIntyre et al. 2004). The northern shelf began to become inundated around 6100 B. P. (Dunn and Mazzulo 1993). Since initial inundation, rates of sea-level rise have varied through time and have been uneven between the northern and southern shelves.

In the north, evidence from Ambergris Cay (Dunn and Mazzulo 1993) indicates that after initial inundation around 6100 B. P. until 3000 B.P., the sea rose at a rate of 13.5 cm per 100 years. Between 3000 B. P. and 1000 B.P. the rate slackened to 2.5 cm per 100 years. Current sea level has remained unchanged since 1000 B.P. (Dunn and Mazzulo 1993).

In the southern barrier reef, the earliest inundation of the shelf began around 8700 B. P. However, the record was cut short as the deposition of mangrove peat ended likely



due to the rate exceeding the mangroves ability to keep pace with the rising sea (MacIntyre et al. 2004). The next earliest continuous record from the south comes from the Tobacco Cays with an early record of inundation beginning around 7000 B. P. (MacIntyre et al. 1995). Between 7000 B. P. and 3000 B. P., the rate of sea-level rise is estimated at 43 cm every 100 years. Since 3000 B. P. the rate has decreased and remains at 10cm every 100 years (MacIntyre 1995). The location of radiocarbon dated Late Classic archaeological deposits at 10 sites in southern Belize one meter or below sea level corroborates the actual sea level rise of at least one meter in the last thousand years (McKillop 2002).

The differential rates of isostatic sea-level rise are largely due to the complex nature of the Belize coastal geology. Tectonic uplifting may have caused a rise in the northern shelf (Burke 1993). Additionally, coastal subsidence due to the settling of deposits and the shelf bearing the weight of water from eustatic sea-level rise may have had a greater effect in the lower lying south (McKillop 2002).

Sea-level rise in the Belize region over the last 10,000 years has been variable through time. Initial inundation occurred earlier in the south beginning around 8700 B. P. and the entire Belizean Pleistocene shelf by 6100 B. P. During initial inundation of coastal areas rates were relatively rapid and slowed by 3000 B. P.. The rate of sea-level rise is greater in the south than the north. These differences have been attributed to tectonic uplifting and coastal subsidence. The growth of mangroves and deposition of their detritus along the entire coastline has allowed many coastal features and islands to remain, where sea-level rise would have otherwise inundated.

The location of the study area within the context of the mangrove ecosystem has provided benefits to research. The mangrove peat preserved organic remains such as

wooden posts and the canoe paddle dating to the Late Classic Period (McKillop 2005a). The inundated nature of the area also limited the effects bioturbation and trampling found in terrestrial sites, with the result that larger sherds were recovered than at nearby land sites (McKillop 1995, 2002).

All artifacts and wood features at Punta Ycacos Lagoon sites are found on top of or embedded in mangrove peat. This location implies that when sites were constructed the area was a wet mangrove estuarine environment or there was peat close to the ground surface into which posts were driven. This location offers several advantages for the Maya salt makers among which the most favorable being access to a readily available source of saline rich brine that becomes salt when boiled or evaporated. Additionally, as indicated by the presence of the canoe paddle, access to water affords an advantage for transportation of trade goods such as salt and materials needed by the Maya salt makers. The presence of peat also offers additional advantageous possibilities. When dried peat can serve as a source of fuel for fire as well as when burned, salt can be extracted from the ashes or be used to enrich brine (Andrews 1983). Salt saturated peat can also be used to filter brine as a method of enrichment as has been reported among modern salt works along west coast Mexico (Williams 1999).

A possible disadvantage of setting up a salt workshop in a mangrove environment would have been access to dry land. Dry land was important for the boiling process of salt rendering which seems to be the primary method employed by the Maya of Punta Ycacos Lagoon based on the dense scatter of briquetage and charcoal at the sites (McKillop 2002, 2005a). Access to dry land would have been necessary for building the fire to boil the water.

Although the relationship between settlement and sea-level rise in Punta Ycacos lagoon is not the focus of my dissertation, I will make several comments. All Punta Ycacos sites are seemingly constructed directly onto or into a surface of mangrove peat. Since mangrove peat forms in shallow coastal water it would seem dry land may have been a temporary situation or created by the Maya in the Late Classic. A question for future research is how did the Maya handle the dry land issue. Were they modifying the landscape through channeling water or building up land areas? Elsewhere, evidence that the Late Classic Maya employed sophisticated water management strategies is well documented (Adams et al. 1981; Culbert and Rice 1990; Culbert et. al 1990; Denevan 1982; Dunning and Beach 1994; Harrison and Turner 1978). Additionally, the deposition of household debris elsewhere in the southern Belize coast allowed Late Classic Maya to stay dry despite rising sea level (McKillop 2002:167). To answer questions regarding paleo-environment of the lagoon and the land/water management strategies of the ancient Maya at salt sites in Punta Ycacos Lagoon will require coring and/or other subsurface testing in order to be answered. Although compelling, these questions cannot be answered within the scope of my research.

## Chapter 2: Methods

My dissertation fieldwork was carried out in March of 2006 in Punta Ycacos Lagoon in southern Belize as part of the “Mapping Ancient Maya Wooden Architecture on the Seafloor” project. The project goals were to systematically survey underwater sites with wooden architecture found in previous field seasons for mapping and surface sampling as well as to expand our overall survey of the lagoon system for more sites with wooden structures. Among the sites investigated, a cluster of eight was chosen to examine architectural variability for my dissertation. The investigation of wooden structures of sites 46, 47, 48, 49, 51, 52, 53 and 54 included a flotation survey, mapping of flagged features and sampling of wooden, ceramic, lithic and botanical artifacts.

Sites 46, 47, 48, 49, 51, 52, 53 and 54 (here on referred to as, the study area, unless referred to specifically) were discovered in 2005 in a shallow cove of the main section of the Punta Ycacos Lagoon (Figure 6-1). Following discovery, a survey of the study area was conducted to distinguish individual sites and gather information on site size, age, presence/absence of wooden features and to record GPS coordinates of PVC markers sunk into the seafloor to mark each site. The results of the 2005 survey indicated site size varied between about 16-meters by 18-meters and 26-meters by 30-meters. All sites included wooden features. Briquetage was present as well as other ceramics and lithics. The study area was considered a high priority for a systematic survey to define wooden architecture and to compare with architecture elsewhere in the lagoon (McKillop 2005c, 2006b).

Retracing our journey through the Punta Ycacos Lagoon and using the GPS coordinates recorded in 2005, we pinpointed the PVC markers left to mark each site in the study area. Upon recovery of each site location we began a systematic flotation

survey of each site. Flotation survey is an adapted version of the pedestrian survey used by archaeologists on dry land except the survey team, an arms-length apart, floats along the lagoon surface, on research flotation devices (RFDs), systematically scanning the seafloor for archaeological material with their hands and the aid of a snorkel and mask (McKillop 2005a). The flotation surveyors including five other project team members and me, traversed back and forth in parallel lines. We made overlapping swaths across each site in the survey area with each swath beginning and ending where significant artifact concentrations dropped. This method has been adapted over previous field seasons in Punta Ycacos Lagoon (McKillop 2005a). Flotation reduces disturbance of the seafloor providing better visibility, protecting provenience, and preventing damage to artifacts.

As our team floated over each site, we marked features with flags sunk into the seafloor and extending above the water surface, providing an above water view of each site. Flags were color coordinated and marked with a permanent marker to correspond with different features encountered. Yellow flags were used to mark site boundaries, where detectable presence of surface features became minimal or nonexistent. What constituted minimal became a subject of discussion among crewmembers. In some cases, isolated artifacts were encountered beyond artifact concentration. In other cases, the absence of artifacts between sites was a few meters, or less. This discussion will continue until future subsurface investigation of the study area reveals more compelling evidence with which boundary delineation may be categorized.

Yellow flags were also used to mark ceramic and lithic artifacts considered to be indicative of temporal context, variety and interaction with the greater Maya area. The

yellow flags were marked with letters of the alphabet to discern individual finds. These artifacts were later collected for laboratory analysis.

Red flags numbered consecutively, were used to mark wooden posts. Wooden posts often were found within the context of other artifact material. The posts had characteristics that suggest intentional human modification and placement. The posts were vertical and extended below the seafloor. Samples of entire posts excavated from elsewhere in the lagoon exhibit pointed distal ends bearing the marks of cutting tools (McKillop 2005a). Other wood was found, but determined not to be cultural. Non cultural wood included modern mangrove, some still living as well as other wood embedded obliquely, or bent but without human modification. Removal of each post from the seafloor matrix to verify its cultural origin would have severely compromised the integrity of their current state of preservation. The features are too numerous to provide adequate long-term artificial preservation out of their present context. Our in the field criteria for designation of such posts considered if the wood descended into the seafloor in a straight vertical fashion and if they did not bear branches or rootlets.

Other wood included non-vertical features that demonstrated possible human modification or placement. The non-vertical wood included wooden materials with exposed ends exhibiting tool marks and straight pole or beam-like wooden elements that appeared to closely correspond to abutting or nearby vertical posts. Non-vertical wood was numbered with two flags of the same number and given A or B distinctions to specify each end, where possible, and specially noted to describe its non-vertical orientation.

Wooden wedges were found in close association with posts. Wedges were smaller in circumference and often angle slightly towards a larger post.

Posts and other wood were divided into two categories during survey and mapping. Wood consisting of solid, dense homogenous materials, was labeled “solid woods.” Wood with a hard shell-like exterior and a soft pulpy interior was labeled “pimenta” as the hard shell-like bark resembles that of the local pimenta palms found commonly growing in the modern landscape.

Additionally, diameter and circumference of wood were measured with a plastic measuring tape. Measurements were recorded in a field notebook to coincide with the corresponding number label marked on flags. The measurements were later incorporated into the location data collected during the mapping phase of the project.

After all sites in the study area had been systematically surveyed and flagged, the mapping portion of the investigation began. First a datum was established on the nearest stable, solid ground where all sites in the study area were visible. Finding such terrain in proximity of the study area was difficult. Much of the vicinity was dominated by a mangrove ecosystem and the “ground” consists of nearly entirely of mangrove peat with varying degrees of stability. The datum location chosen consisted of a hard, dense, consolidated peat covered with a thin veneer of sand that was exposed above the water surface except during the highest peak of tidal fluctuation.

Once an appropriate datum location was decided, establishing Datum 6 consisted of digging a hole, approximately one-meter deep, setting a one-meter long, two-inch diameter, PVC pipe and filling the hole with cement. The datum name, Datum 6 is derived from being the sixth datum we have established in the lagoon for mapping archaeological sites. After the cement hardened, a tripod, outfitted with a Topcon GTS 725 total station was centered and leveled over the marker.

Mapping began with tying in Datum 6 with previously established Datum 5, to the southwest, near the Eleanor Betty Site, investigated in previous field seasons (McKillop 2006b). Each site was mapped individually with a crewmember carrying a prism pole to each flag placed during the survey. The prism pole was placed on top of each post in the center. Posts were either flush with the seafloor or protruded a few centimeters above the seafloor. The Topcon GTS 725 total station was equipped with TopSurv software allowing for the recording of a database with descriptive attribute data for each point location measured. Attributes included the X, Y and Z coordinates of each location from Datum 6, the number or letter of feature measured, a label of artifact, solid wood or pimenta, diameter and circumference (unless recorded separately) and additional description such as horizontal wood. The software also allowed for a map view to be selected on the total station display window for in the field visualization of measurements.

At the end of each field day, completed map surveys of each site were downloaded at the Village Farm Field Station into laptop computers and backed up on external hard drives. Survey data was downloaded in the “job” format of the TopSurv software. This “job” format could be further processed using multiple user-friendly options. Opened in the TopSurv format, either directly on the total station or on the laptop “jobs” could be displayed in an AutoCad viewer and saved in a variety of GIS, database and design formats. By saving the map data in an Excel nez spreadsheet format (.csv) allowed for the greatest ease in adjusting the X, Y coordinate data into UTM coordinates. Previously established UTM coordinates for Datum 5 near Eleanor Betty were used to tie in Datum 6 and other points measured in the study area. These UTM corrected files were further processed to include the other descriptive field data gathered



and saved as Excel workbook spreadsheet files (.xls) forming the beginning stage of the GIS phase of the investigation.

Using Geomedia Professional 6.0™ to build a GIS for the study area, the Excel spreadsheets were loaded and projected according to the adjusted UTM Northing and Easting coordinates. The GIS construction phase began while in the field and continued into the post field season analysis phase of the project. In Geomedia, each site was further queried to delineate individual feature classes such as points described as solid wood from points described as pimenta, or artifacts, or site boundaries, or site markers. Each query formed a separate file allowing for the separate display of each feature class. Further queries of each feature class examined diameter and circumference of wood, location of horizontal wood and individual artifact types. Upon completion of mapping, each site within the study area was loaded into the GIS in this manner. This process allowed for same day GIS analysis of field data. This GIS analysis was used with some success to predict the possible locations of features not found in the initial survey based on patterns recognized elsewhere. When time allowed during the rigorous execution of other project activities, the team returned to previously surveyed sites to experimentally search for features where they seemed mysteriously absent based on patterns observed elsewhere. In the case of Site 49, an entire line of 58 vertical and horizontal pimenta posts was discovered along the site margin that had previously been missed by the systematic site survey.

Additional GIS processing of data included creating a range classification of post sizes by diameter based on ethnographic data, constructing templates for documented Maya architecture and a kernel density analysis using Arc View Spatial Analyst™. Each

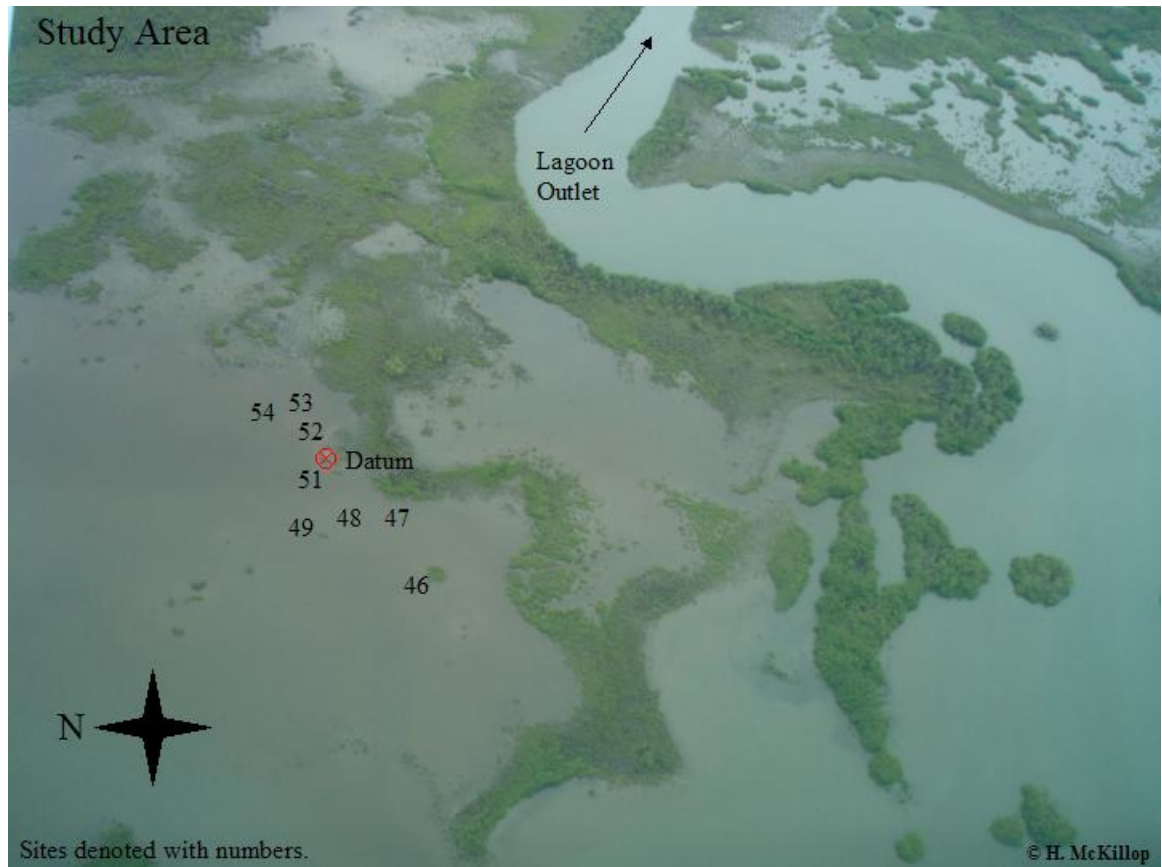
of these GIS processes will be described in greater detail in the analysis portion of this dissertation as it is tied in with the analytical aspect of this study.

After the mapping phase of fieldwork was completed, the team returned to the study area to collect samples. Sampling included retrieving all ceramic and lithic artifacts marked with flags and cutting samples from all solid woods. Few samples of pimenta wood were taken based on their fragile nature and the exceptional similarity and proximity from one pimenta to the next. Ceramic and lithic artifacts were recovered from their locations on the seafloor and placed in plastic resealable bags, labeled with site number, letter designation and date.

Samples of wood were acquired by cutting wedges from each post with knives. The ideal sample was a wedge shaped like a pie slice taken into the core of the wood post below where the most deterioration had occurred at the seafloor/lagoon water interface. The ideal sample was not always possible to acquire as the posts were in varying states of decay with some too hard to cut into with a knife and others crumbling to bits when handled.

### Chapter 3: Results of the Survey

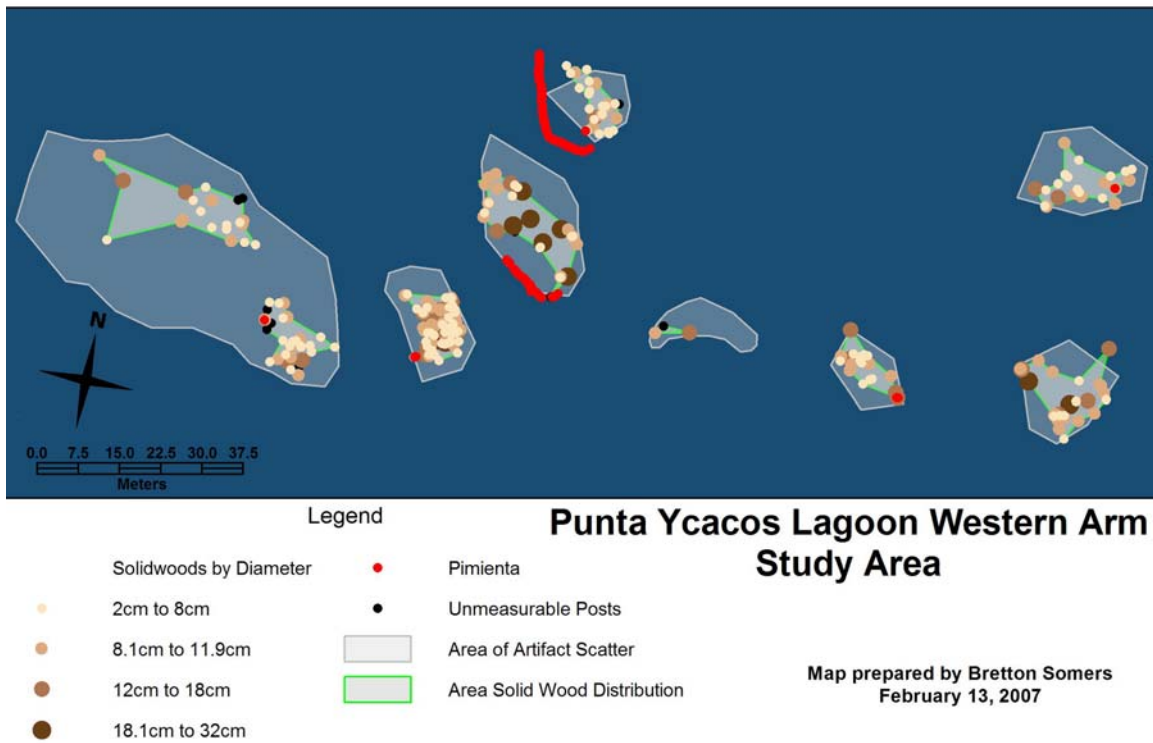
The survey of the study area covered an area of 16,800 square-meters. Within this area the eight sites discovered in 2005 and investigated for my dissertation are Sites, 46, 47, 48, 49, 51, 52, 53 and 54 (Figure 3-1).



**Figure 3-1:** Aerial photograph of study area (Photo by Dr. Heather McKillop).

As expected, the systematic survey revealed far more data on the sites than did the initial 2005 survey. A total of 372 wood posts was discovered. Of these, 130 samples were collected. A total of 280 posts were classified as solid wood ranging between 2 cm and 32 cm in diameter. In the GIS, the range in solid wood size for the study area was divided into 4 standardized size classes by diameter, as displayed in Figure 3-2, with small (white) being 2 cm to 8cm, medium (beige) 8.1 cm to 11.9 cm, large (brown) 12 cm to 18 cm and extra large (dark brown) 18 cm to 32 cm. The class intervals were

based on post sizes reported for the modern Maya wooden structures studied by Wauchope (1938). This size classification was to help determine patterns in construction layout based on placement of larger possibly load bearing elements versus smaller subsidiary elements and will be addressed in greater detail in the analysis chapter. Some of the solid woods were in such poor states of deterioration that either a measurement of diameter, circumference or both was impossible. These posts are indicated in black on Figure 3-2. In 18 cases, neither diameter nor circumference could be measured without excavation. There are 12 wooden posts where diameter only was measured and 12 posts where only a circumference was measurable. For these cases where only one measurement was recorded, the missing data were calculated if a strong relationship was determined between diameter and circumference within the measured population of wooden posts.



**Figure 3-2:** GIS display of study area.

In addition, 92 wooden posts classified as pimenta were detected within the study area. Two distinct tightly spaced curvilinear rows were found at Site 48 and Site 49. pimenta also occurred at sites 46, 47, 52 and 54 in smaller isolated occurrences and will be addressed in greater detail during the following discussion of results from individual sites.

Ceramic sherds were present on the surface of these sites as noted by the light blue shaded areas in Figure 3-2. The occurrence of the ceramic sherds extends beyond the area where solid wood features were present highlighted in light gray in Figure 3-2. At the two sites with rows of pimenta posts the ceramic scatter all but drops off approaching the rows from site center and discontinues altogether beyond (Figure 3-2).

### **Ceramics**

During the 2006 survey, a sample of 34 pottery sherds was recovered from the study area. A sample of 26 ceramics was recovered in the preliminary 2005 survey when the sites were discovered. This combined sample of 60 sherds is a fraction of the ceramic assemblage present on the surface. The ceramics from all the Paynes Creek sites are being studied separately. Here I provide a discussion of the study area pottery to present an overview of the variety, possible ancient activity and temporal association we encountered at the sites. The ceramics were classified according to the type-variety system based on surface finish and decoration. The type-variety system has been used extensively among Maya archaeologists for dating occupation periods of sites throughout the Maya area (McKillop 1987, 2001; Sabloff 1975)

The ceramic types found in this study compare to other ceramics found in the Port Honduras region in earlier research by Dr. Heather McKillop, for which she has developed a local type-variety scheme (McKillop 2001, 2002). McKillop's Port

Honduras type-variety format was adapted from Sabloff's analysis of ceramics from Seibal (Sabloff 1975). The Port Honduras collection has been compared with collections from other sites along the Belizean coast and elsewhere in the Maya area to recognize relationships with the greater Maya realm and to establish chronology (McKillop 1987, 2001, 2002). Names of ceramic types for McKillop's Port Honduras analysis have been derived from local toponyms.

The ceramic types in the sample from the study area include Punta Ycacos Unslipped, Mangrove Unslipped, Warrie Red, Moho Red and a few undetermined types, all of which are types associated with the Late Classic period. At this point, a brief description of each ceramic type found in the study area is necessary to understand some of the possible activities associated with the salt making sites in this study area. For a more in depth description of each ceramic type-variety specifications see McKillop (2001 and 2002).

Punta Ycacos Unslipped is the primary ceramic type associated with the salt making activity (Figure 3-3). The type is characteristically of a very coarse paste and sand temper from local materials and often poorly fired giving it a very rough and pitted surface finish with no slip and are often exfoliating. The majority of sherds examined in designation of this ceramic type are from jars with out-curved necks and direct rims. Also found among this type are bowls and dishes with round sides and direct rims (McKillop 2002:56). Among less common forms of Punta Ycacos Unslipped ceramics are candeleros and incense burners.

Associated with this ceramic type are vessel supports constructed of the same materials as the vessels for elevating the boiling vessels above a fire. This apparatus consists of clay cylinders or vessel support legs; spacers, shaped like disks and fitting

between multiple vessels; and sockets, forming a connective surface between jars and cylinders and an amorphous foot in which the support legs are set on the ground surface.



**Figure 3-3:** Punta Ycacos Unslipped rim sherd found at Site 46.

Punta Ycacos Unslipped appears to be the ceramic of choice for the boiling process of salt making (Figure 3-3). Punta Ycacos Unslipped ceramics are often found in association with a charcoal lens and charcoal fragments embedded within the ceramics

themselves (McKillop 2002:62). Other usages of Punta Ycacos Unslipped ceramics were likely multipurpose utilitarian with jars serving as storage or transport vessels and bowls and dishes serving open service purposes.

Punta Ycacos Unslipped has been found throughout the Port Honduras area and similar ceramic types have been found along coastal Belize at sites such as Placencia Lagoon (MacKinnon and Kepecs 1989), New River Lagoon (Valdez and Mock 1991) and the Marco Gonzalez site (Graham and Pendergast 1987). As mentioned earlier in the discussion regarding salt making technologies in Chapter 1, the ceramic technology of elevating jars with clay cylinders over fire was not uncommon throughout pre-Columbian Mesoamerica with evidence of salt making cylinders being found in coastal areas along the Pacific coast as far south as modern day Costa Rica (Coe and Flannery 1967; Andrews 1983).

Punta Ycacos Unslipped is by far the most ubiquitous ceramic type in the study area with its debris covering the majority of site areas (Figure 3-3). Punta Ycacos Unslipped debris is found in such extreme density that it forms a thick pebbly sand layer of rubble in some places often mixed with charcoal. The sample of 15 sherds taken from the study area is not representative of the quantity of Punta Ycacos Unslipped present at the sites. Only well preserved sherds exemplifying the characteristics of the ceramic type or possessing unusual Punta Ycacos Unslipped qualities were collected in this preliminary sample. Future project research involving subsurface testing may attempt addressing issues of quantifying the presence and distribution of Punta Ycacos Unslipped ceramics and others.

Mangrove Unslipped is another ceramic type-variety found in the study area (Figure 3-4). The main characteristics of this type is its unslipped surface, medium paste





**Figure 3-4:** Mangrove Unslipped rim and neck sherd found at Site 46.

with calcite temper and in its initial designation it is found as predominantly a jar form with out-curved and straight necks, direct or out flared rims and squared or round lips (McKillop 2002:72).

A few bowl sherds were also part of the initial Mangrove Unslipped classification indicating another form of this type-variety. In the initial sample examined by McKillop, occasional decoration included striations, score marks and an impressed fillet along the shoulder of jars. Also in the sample was a sherd with a rectangular stamp and another with vertical gouged lines (McKillop 2002:73). McKillop also observed some sherds were fire blackened. Mangrove Unslipped were likely used as utilitarian storage jars for water and brine used in the salt making process (McKillop 2002:77).

The presence of fire blackening on some of the sherds may indicate an occasional boiling function of the Mangrove Unslipped but may also be the result of a broken pot falling in the fire. The added effort of adding decoration as noted on a few sherds may indicate some elevated level of importance for the function of some of the Mangrove Unslipped jars.

Mangrove Unslipped is similar to Late Classic ceramic types found elsewhere in the Maya area notably at Seibal, Altar Sacrificios and Uaxactun (McKillop 2002). The sample recovered in this study includes 13 sherds.

Another type-variety collected in the sample was Moho Red. McKillop characterized this type-variety by an easily eroded red slip, a fine yellow paste tempered with ash that also erodes easily and occurs in the form of bowls or dishes with tripod supports and a basal angle or ridge on the exterior (McKillop 2002:87). Some Moho Red sherds exhibited incised decoration on the exterior wall with lines following the circumference of the vessel just below the rim and along the basal ridgeline as well as oblique incising and fluting.

A sample of 7 Moho Red sherds was collected from the sites in this study (Figure 3-5). Moho Red has been found at other Punta Ycacos Lagoon sites as well as Frenchman's Cay in Port Honduras and resembles the Late Classic Belize Red found at Lubaantun, Barton Ramie and Seibal (McKillop 2002). With Moho Red sherds occurring in bowl and dish forms these would indicate the need for some sort of open shallow vessel in the salt making process. Moho Red could be used for food service or preparation for the Late Classic Maya but in the absence of other domestic elements this function seems less likely. At the time of designation as a ceramic type Moho Red was

considered a rare fine ware of the Punta Ycacos salt works and may be more symbolic of interregional exchange of elite trade goods (McKillop 2002).



**Figure 3-5:** Interior of Moho Red dish sherd found at Site 48.

Another possible function may follow what Santley (2004) suggests of his interpretations from El Salado, where a set of stages in salt processing involved different ceramic vessels with a final stage of producing salt loaves performed in shallow basins. This use is another possible function Moho Red could have provided.

Warrie Red is also considered a fine ware among the salt workshops of Punta Ycacos Lagoon (Figure 3-6). A sample of 10 sherds of the Warrie Red type-variety was collected in this study.

The primary characteristics of this ceramic type are a red slip and made from a medium to fine paste with calcium carbonate temper or sometimes sand. Jars have a neck

and out-curving to out-flaring rim with a direct lip and bowls or dishes have out-curving to out-flaring sides with a basal break or ridge (McKillop 2002:77).



**Figure 3-6:** Warrie Red rim, neck and body sherd with comb stamping found at Site 49.

Some vessels exhibiting unit stamping, comb stamping and other impressed or incised decoration (Figure 3-6 and Figure 3-7). This decoration occurs on the exterior shoulder of some jars and the exterior of some bowls. At the time of classification unit stamp designs included motifs of monkeys, S shapes and circles with dots inside (McKillop 2002:77).

Warrie Red has been recovered from other sites in the Punta Ycacos Lagoon as well as from Wild Cane Cay in Port Honduras (McKillop 2002). Warrie Red is similar to other Late to Terminal Classic red slipped ceramics with unit stamping found at

Lubaantun, Seibal, Altar Sacrificios, Tikal, Lake Peten Itza, Aguateca, and the Belize Valley (Hammond 1975; McKillop 2002).



**Figure 3-7:** Warrie Red body sherd with unit stamping found at Site 48.

In his 1975 monograph on Lubaantun Norman Hammond observes differences in unit stamp designs from sites in the Rio Pasion drainage in Guatemala such as Seibal, Altar Sacrificios and Aguateca from sites in the Belize Valley with Lubaantun designs more similar to those of the Belize Valley (Hammond 1975). McKillop observes a closer association of the Warrie Red ceramics and unit stamp designs with that of Lubaantun, supporting Hammond's interpretation (McKillop 2002).

The discussion on unit stamp interaction spheres underscores its importance as a potential exchange commodity or idea for the Punta Ycacos salt workers. As functioning vessels the jars may have served storage purposes. McKillop notes some Warrie Red jars

had pour spouts suggesting their function may have involved transferring liquids. In this capacity, the Warrie Red jars although smaller may have served a similar function to that of the Mangrove Unslipped jars (McKillop 2002). The added décor and finer quality of the jars may have added and elevated status or symbolism to the function of Warrie Red vessels. McKillop (2002) suggests their possible involvement in salt rituals. In considering the complexity of salt production, differences in quality of salt produced elsewhere and ritual significance of pure salt the possibility exists to have different ceramics for rendering particular salt products.

A total of 14 ceramic sherds unrecognizable as type in the field were collected from the study area for analysis. These sherds do not appear to fall into the classification of the usual Port Honduras ceramics. One find of particular interest is a hollow pot leg (Figure 3-8) resembling forms from the northern coast of Honduras (Stone 1943), shedding light on further interaction possibilities for the Punta Ycacos salt works.



**Figure 3-8:** Unknown ceramic type vessel support found at Site 53, similar to forms found in Honduras.

## Stone Artifacts

Lithic artifacts were also encountered in the study area. A combined 2005 and 2006 sample includes 11 specimens. The sample includes chert stemmed unifacial points, bifacial adzes and chopper/pounder tools, obsidian prismatic blades as well as ground stone adzes. The sample suggests activities in addition or in association with salt making at these sites. The three chert unifacial stemmed points were likely hafted as knives or spears and could be used for hunting or fishing, as a weapon or a multipurpose cutting implement (Figure 3-9).



**Figure 3-9:** Chert Unifacial point found at Site 46.

The two-chert bifacial adzes may have been hafted or even hand held (Figure 3-10). These tools are normally associated with chopping. These adzes possess a wide sharp edge on one end that one would expect to be the proximal cutting edge. The adze tapers

toward a blunt point at the distal end. Analysis of the adze indicates that both ends and the edges in between appear to have been used suggesting the possibility that these may have been multi-purpose tools.



**Figure 3-10:** Chert bifacial adze found at Site 54.

Of the two chopper pounders, there are differences in their morphology. One looks strikingly similar to the chert adze on the wide cutting edge, but instead of tapering toward a distal edge it is more rounded and disk like. This tool may have been intended as an adze and broke and was reworked into a smaller tool. The sharp edge around the circumference would be more useful for chopping, cutting or scraping than pounding. The other chopper-pounder was more rounded on the edges (Figure 3-11). Use wear on the blunt edges suggests this tool had been used more as a pounder.





**Figure 3-11:** Chert chopper-pounder found at Site 52.

The source for the chert in the study area remains unknown. Although the possibility of a local source exists one has yet to be found. Considering the from far and wide acquisition of other materials found in the study area, the source for the chert could also have been acquired via long distance trade.

Obsidian prismatic blades have been found in a number of contexts throughout the Maya area (Figure 3-12). As a volcanic glass, the edge that can be created on blades are sharper than surgical steel and are indispensable as cutting tools. The blades have been associated with ritual bloodletting based on their being found in elite contexts. Their prevalence in more modest contexts suggests they were probably used for a whole variety of cutting needs. The wide distribution of these implements and the limited source areas has even larger implications for the extent of exchange interaction throughout

Mesoamerica. The two prismatic blades were visually sourced to the El Chayal source area in highland Guatemala (Heather McKillop, 2006 personal communication).



**Figure 3-12:** Obsidian prismatic blade found at Site 48.

The ground stone adzes found in the study area are both made from a grayish greenstone with a brownish discoloration from centuries on the seafloor (Figure 3-13). One of the adzes was broken at the proximal end. The other was smooth on one side and somewhat rough and chipped on the other possibly indicating use. The ground stone adzes would likely have been used in a similar fashion as the chert adzes for chopping and possibly hafted.

Greenstone has been also been associated with elite contexts and may have been symbols of status among the Late Classic Maya. This significance as a status symbol is

also a possibility for the salt workers of the lagoon. Nonetheless greenstone would have to have been acquired through long-distance as there are no local sources.



**Figure 3-13:** Greenstone adze found at Site 46.

### **Wooden Architecture By Site**

Separate distinct artifact scatters had first defined each site. Systematic survey revealed the presence of wooden features and a more detailed record of the variety of ceramics and lithics occurring in the artifact scatter. Each site, while sharing much in common with others in the study area, has distinct characteristics represented in the modern surface record.

### **Site 46**

Site 46 is the western most site of the study area (Figure 3-2) with surface features covering an area of 1632 square meters (Figure 3-15). The seafloor at site 46 consisted

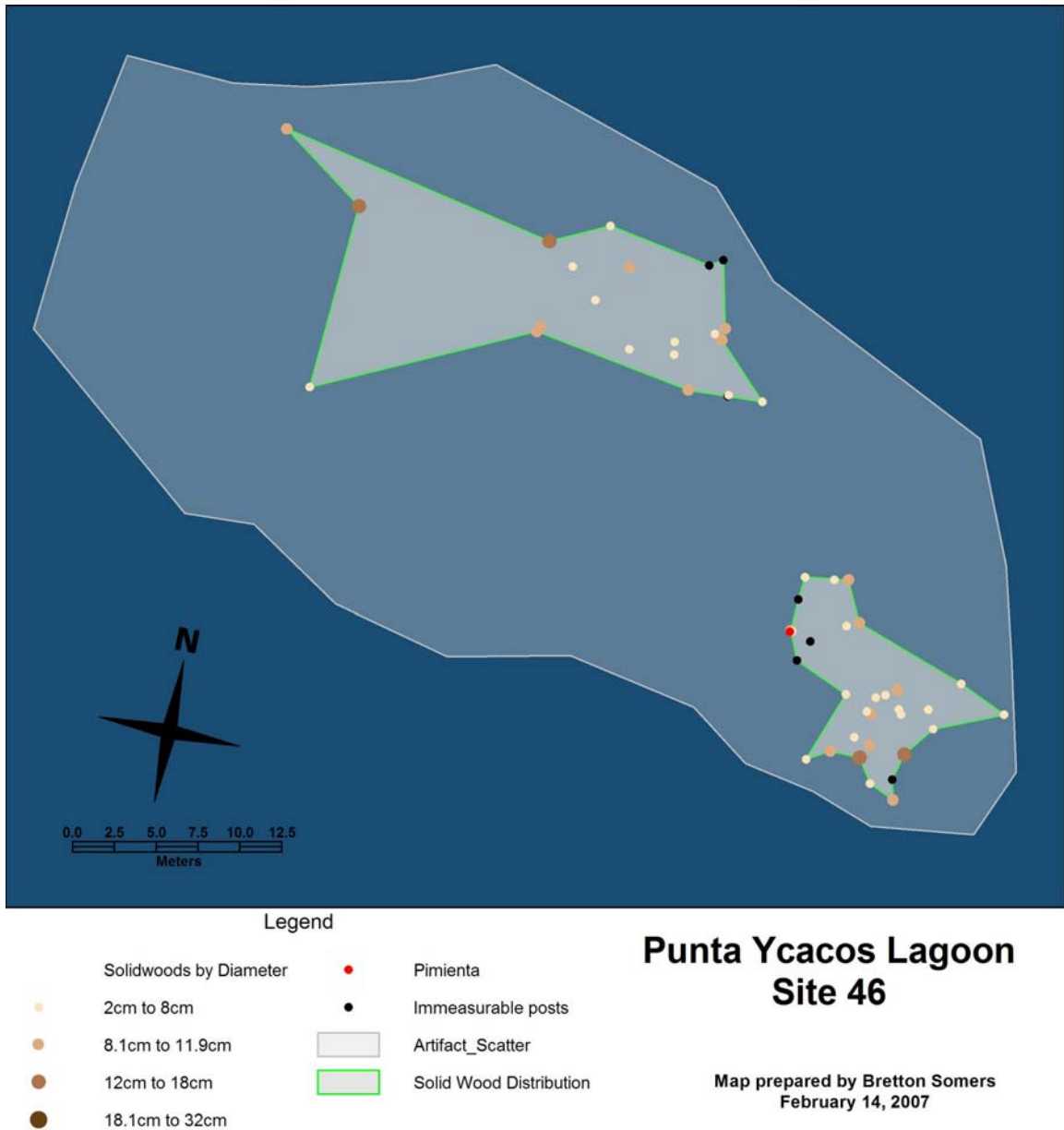
of a firm dense peat, such that it could support a persons weight standing on it without sinking. Covering the peat was a thin layer of sandy silt that could reach a maximum thickness of 4 cm in some areas. Slightly west of site center, an area of higher ground would become exposed during a very low tide (Figure 3-14), as experienced during a weather system known as a Norther in Central America. Artifacts mostly seemed scattered over the seafloor, but in some cases more deeply embedded artifacts seemed present, particularly in the eastern portion of the site.



**Figure 3-14:** Ceramic debitage at Site 46 exposed during a Norther low tide. Punta Yacacos Unslipped ceramic cylinder in the foreground.

Systematic survey discovered 55 solid wood posts and a single pimenta post. The pimenta post was in direct contact with another larger post with a circumference of 33 cm

along with two other smaller solid wood posts. These smaller wood posts surround the larger and are angled in slightly, suggesting they are possibly serving as wedges.



**Figure 3-15:** GIS display of Site 46.

The solid wood posts occur in two distinct clusters. One cluster of 20 solid woods occurs in the northern center of the site (Figure 3-15). A second cluster of 32 solid

woods was found in the southeast portion of site. A large mangrove clump (to the right of the site number in Figure 3-1) just south and east of the site center fills the better portion of the space between solid wood clusters. Outside of these two clusters three solid wood outliers lie in the western portion of the site. Of the solid wood features discovered seven are missing measurement data for both diameter and circumference, three features are missing only diameter measurements and three are missing only circumference measurements.

The sample of 11 ceramics collected from the site included three Moho Red sherds, three Warrie Red Sherds, two Mangrove Unslipped sherds and three Punta Ycacos sherds. Lithics collected included two chert uniface stemmed points, one chert pounder and two greenstone adzes one of which one was broken.

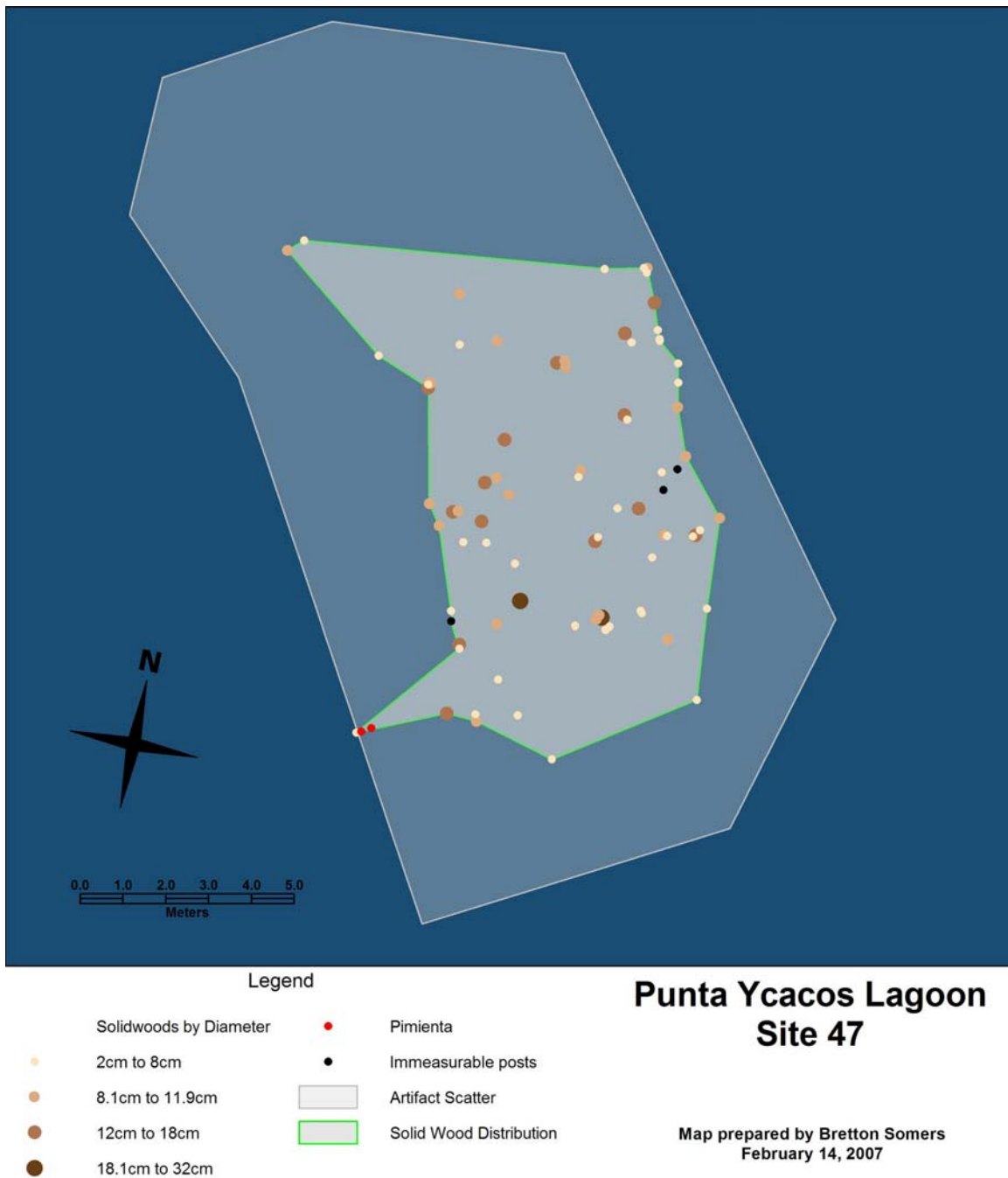
#### **Site 47**

Separated by a 9-13 meter space of minimal surface artifact scatter, Site 47 lies due eastward of Site 46 (Figure 3-2). The artifact area of Site 47 is dense and compact covering a surface of roughly 210 square meters (Figure 3-16). Where the density of ceramics does not completely cover the sea floor, the surface area is composed of a very thin layer of silt over a firm sandy peat.

A sample collection of four ceramic sherds was taken from the site. Among this collection were two Punta Ycacos Unslipped sherds, one Moho Red sherd and a sherd of unknown type. No lithics were collected in the artifact sample at Site 47.

Grouping toward the southeast margin of the 210 square meters and filling almost rectilinear spaces are 83 solid wood and two pimenta post features. Of the 83 solid woods, seven posts are missing data. The two pimenta are located on the extreme western edge of the site with a single outlying solid wood. Although tightly spaced, they

do not seem to have a wedge relationship as the pimienta at Site 46 seemed to share with the related solid woods.



**Figure 3-16:** GIS display of Site 47.

The extreme southeast edge of Site 47 borders a mangrove shoreline observable in the aerial view of Figure 3-1. The seafloor rises and peat becomes denser along this

margin possibly obscuring any continuation of the site from surface detection in that direction. Leading up to this edge, artifacts were more deeply embedded in the peat suggesting the possibility of the site extending into the mangroves under a layer of peat.

#### **Site 48**

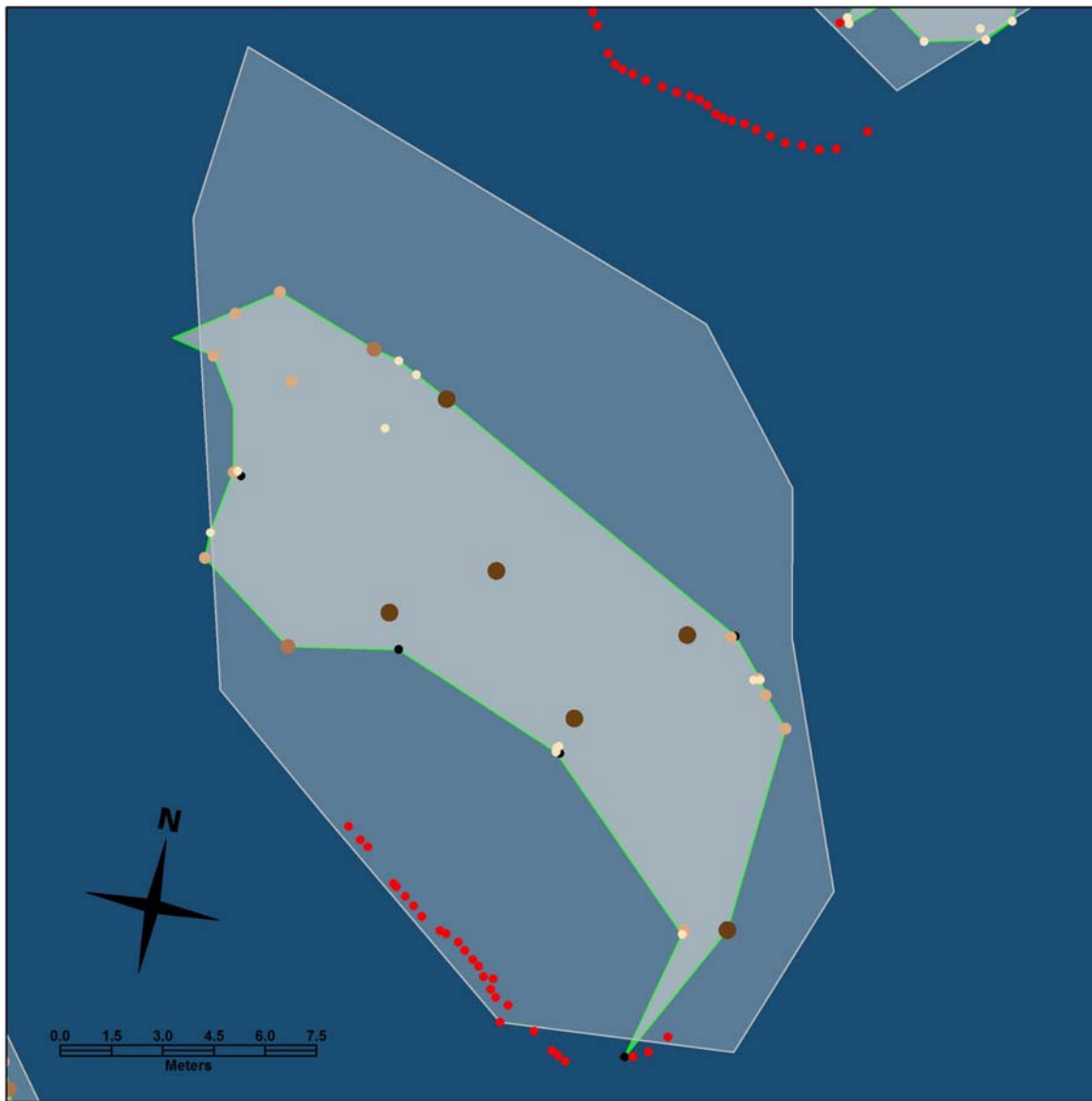
Covering an area of roughly 371 square meters, Site 48 lies to the northeast of Site 47, separated by an artifact void of 10 to 13 meters (Figure 3-2 and Figure 3-17). The sea floor at site 48 is of variable consistency. The northwest edge of the site borders a small mangrove clump, around which the seafloor rises. The peat is firm and is covered in a thin veneer of silty-sand. Artifacts in this area are embedded into the peat.

Toward the south and east of the site, the seafloor is covered in a sandy-silt layer increasing to 2-3cm in depth. Peat becomes less dense toward this side of the site and artifacts are both embedded and loose within the sandy-silt. An artifact sample collected at the site included four ceramic sherds and one obsidian prismatic blade. Of the ceramics, two Punta Ycacos Unslipped sherds, one Moho Red and one Warrie Red with a unit stamp was collected. The obsidian prismatic blade has been visually sourced as being from El Chayal.

Wooden features include 27 pimienta and 38 solidwoods at Site 48. Five of the solid woods are missing both diameter and circumference measurements, two are missing only diameter measurements and one is missing a circumference measurement.

All of the 27 pimienta wood posts form a nearly continuous 12.6-meters curvilinear row along the southwest margin of the site. Ceramic and lithic artifact surface presence ceases just beyond the pimienta row from site center. Part of the row toward the south exists outside of any ceramic or lithic presence.





**Figure 3-17:** GIS display of Site 48.

To the north west of Site 48, occurs a grouping of 17 solid wood posts with 3 lying outside the area where ceramic and lithic presence was detected. The remaining 31 solid wood posts lie dispersed or in smaller groupings toward the south and east. A

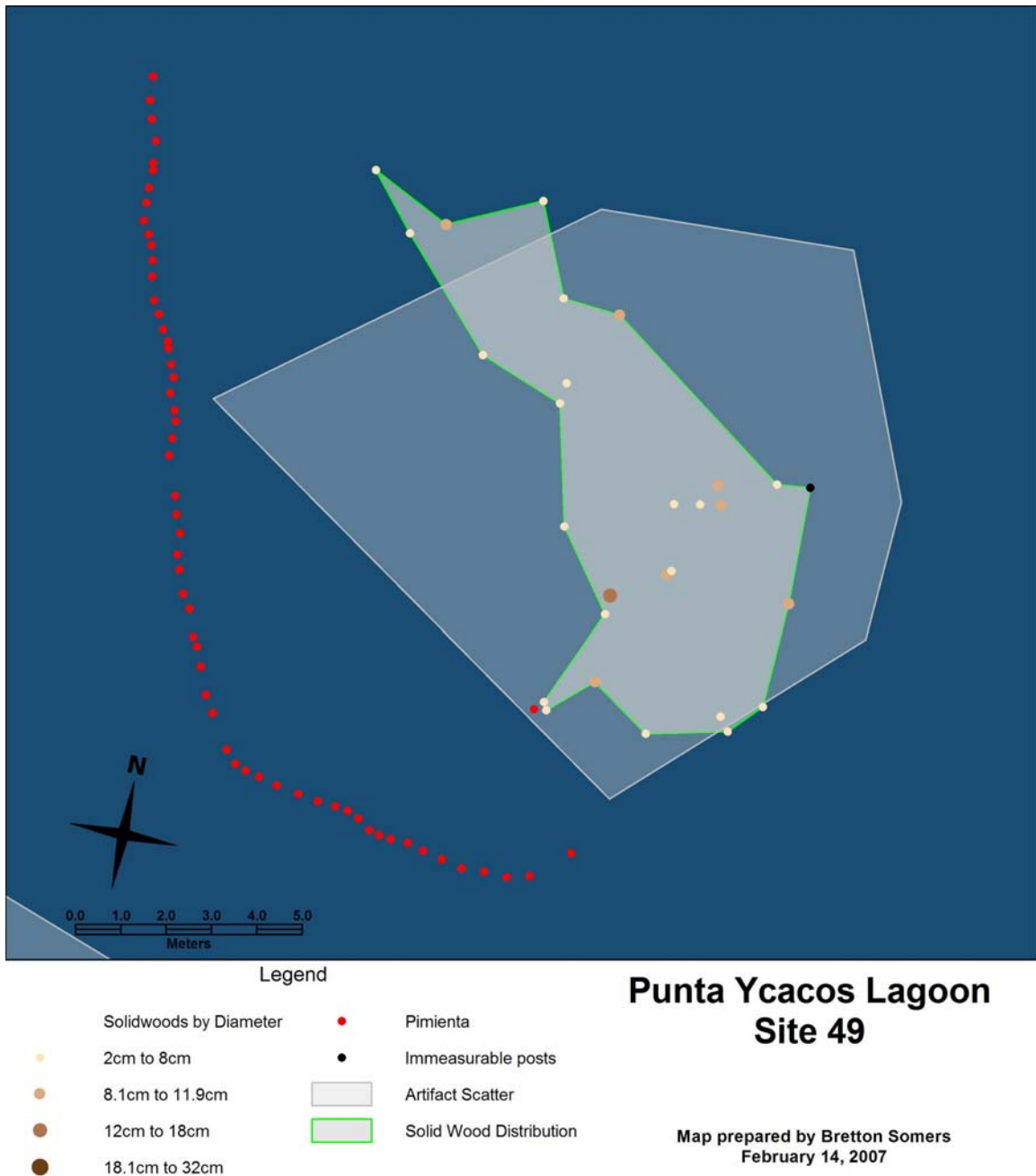
grouping of five solid woods occurs just south of the site center. In this grouping, four smaller solid woods of less than 22 cm circumference nearly encircle a larger post of a 35 cm circumference. The southernmost of the four surrounding posts was immeasurable but was noted as being angled toward the central post in a wedge-like fashion. The placement of this solid wood cluster has a support-like relationship similar to the cluster at Site 46 discussed earlier. Another cluster of three solid woods as well as a pair of solid woods on the east margin of the site also exhibit this post/wedge relationship.

The largest three solid woods in the study area with circumferences of 106cm (southern most dark brown point in Figure 3-17), 88 cm (northern dark brown point in Figure 3-17) and 75 cm (easternmost dark brown point in Figure 3-17) respectively, were discovered at Site 48. Additionally three other posts in the top ten largest of the study area occur at Site 48 including the two dark brown points near site center in Figure 3-17 and the northernmost dark brown point.

#### **Site 49**

Site 49 is located due north of Site 48 and is separated by a void of artifact presence of some 8-12 meters. However, a 23.6-meter long curvilinear row of 58 pimienta posts lies between them (Figure 3-2). This pimienta row has been included as part of Site 49 as it is in closer proximity and it seems to partially encircle the site (Figure 3-18). The pimienta row was found in a secondary survey effort, after early in-the-field GIS analysis of the study area and other sites in the overall project. Where rows of pimienta occur, a pattern seemed to arise in their location in the context of associated sites (MiKillop 2005c). The rows occur approximately two or more meters from areas of high artifact density and solid wood presence. In our initial systematic survey, the pimienta row was undetected, as this relationship had not become fully realized and it lies

a considerable distance outside the artifact scatter of both sites 48 and 49. In a later follow up survey based on this observation this row of pimenta posts was discovered. Other follow up surveys in this study area did not discover any further pimenta rows.



**Figure 3-18:** GIS display of Site 49.

Including the pimienta row, presence of solid woods and artifact scatter, Site 49 covers approximately 300 square meters. However, the artifact scatter is concentrated in an area of 120 square meters with six solid woods and the entire pimienta row outside of this area. The surface area of the site was a firm spongy peat and the silt and sand that forms a thin, easily dispersed layer over most of the study area was almost non-existent over Site 49. The ceramic briquetage and sparse lithic assemblage detected was mostly loose on the seafloor and only partially embedded. A sample of 10 Mangrove Unslipped water jar sherds was recovered along with a perforated disc made of a similar material. Among the ceramics seven Punta Ycacos Unslipped sherds were recovered including two support cylinders, one candelero, two bowl rims and two jar rims.

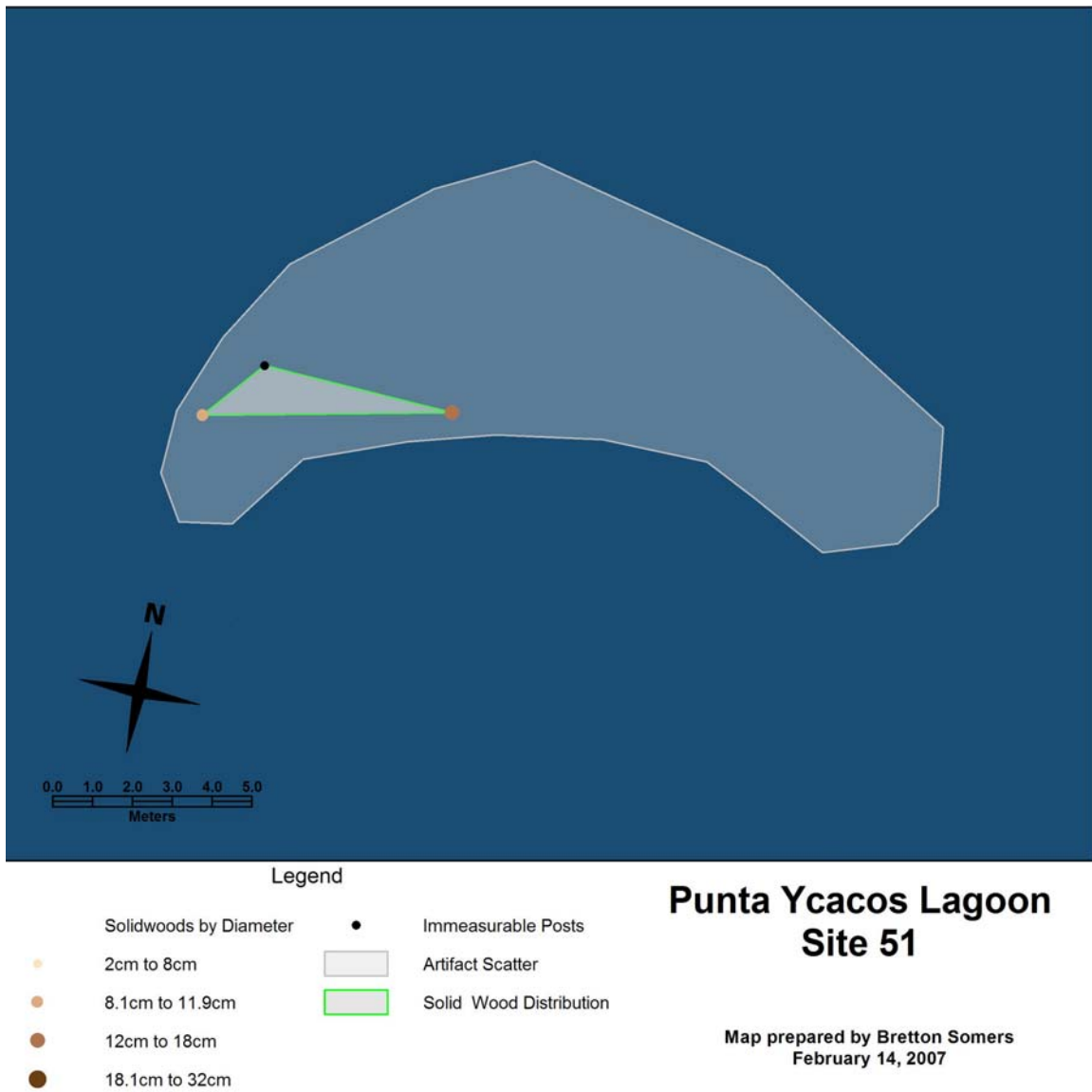
Warrie Red sherds were also recovered from the site, including two with decoration and three jar rims. A single Moho Red pedestal base and seven ceramics of unknown type were also collected at the site.

Most of the 28 solid wood posts of the site occur within the concentrated artifact scatter area east of the pimienta row (Figure 3-18). Some of the solid woods were in poor condition and taking measurements was not possible (points in black Figure 3-18). One of the solid woods is missing both circumference and diameter measurements, five are missing diameter measurements and two are missing circumference. Samples of 22 solid woods were collected from the site.

### **Site 51**

Site 51 is a small site compared with others in the study area with a semi-circular arc of artifact scatter covering approximately 106 square meters, west to east (Figure 3-19). The seafloor at this site was sandy with firm peat below the sand. Flotation survey of the site was made difficult as it lies in shallow water. The site borders the area of

exposed high ground upon which the datum is located. Artifacts are exposed and loose on the surface as well as embedded in the peat. Some loose ceramics have been washed up onto the higher ground but their presence does not extend beyond the waterline. The site may extend further southward however; the area of high ground obscures any surface indications of this possibility.



**Figure 3-19:** GIS display of Site 51.

Wood posts were found at Site 51, with three solid woods found in the western side of the site. One of the solid woods was in poor condition preventing an accurate measure of both diameter and circumference.

Ceramics at Site 51 predominantly consisted of the ever-present salt making briquetage found through out the study area. No artifacts were sampled at the site.

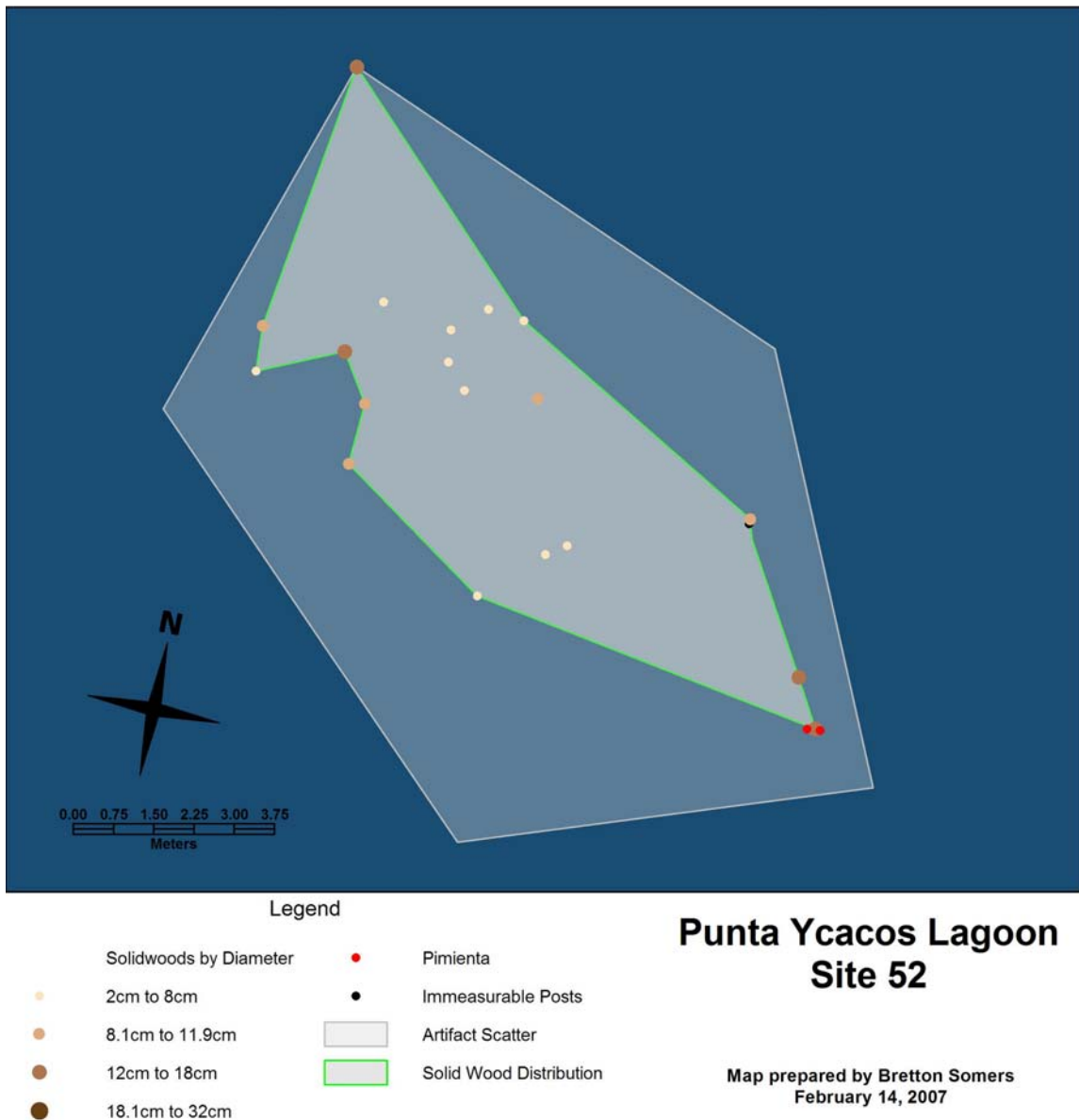
## **Site 52**

Site 52, located 15-meters east of Site 51, covers a surface area of approximately 116 square meters (Figure 3-2 and Figure 3-20). The surface area is composed of a firm peat covered with a thin layer of sandy silt. Undulations in the peat surface collect pockets of deeper sandy silt accumulations.

Artifacts at the site are mostly embedded into the peat. Briquetage is the predominant component of the artifact scatter. No ceramics were sampled at Site 52. The artifact sample collected consisted of a single chert pounder.

Wooden posts were discovered at Site 52 including 22 solid woods and two pimenta posts. Most of the solid wood posts clustered toward the north and west of the site center. One outlier occurred in the extreme north of the site. A row of five solid woods occupies the southeastern edge of the site. Of the solid woods, one was in an advanced state of decay and could not provide diameter or circumference measures, whereas three others could not be measured for diameter.

The two pimenta posts are located within 20 centimeters to the east and west of the solid wood in the far south east of the site. These two pimenta posts, although located in close proximity to either side of a solid wood, posts did not exhibit the wedge-like characteristics noted elsewhere.



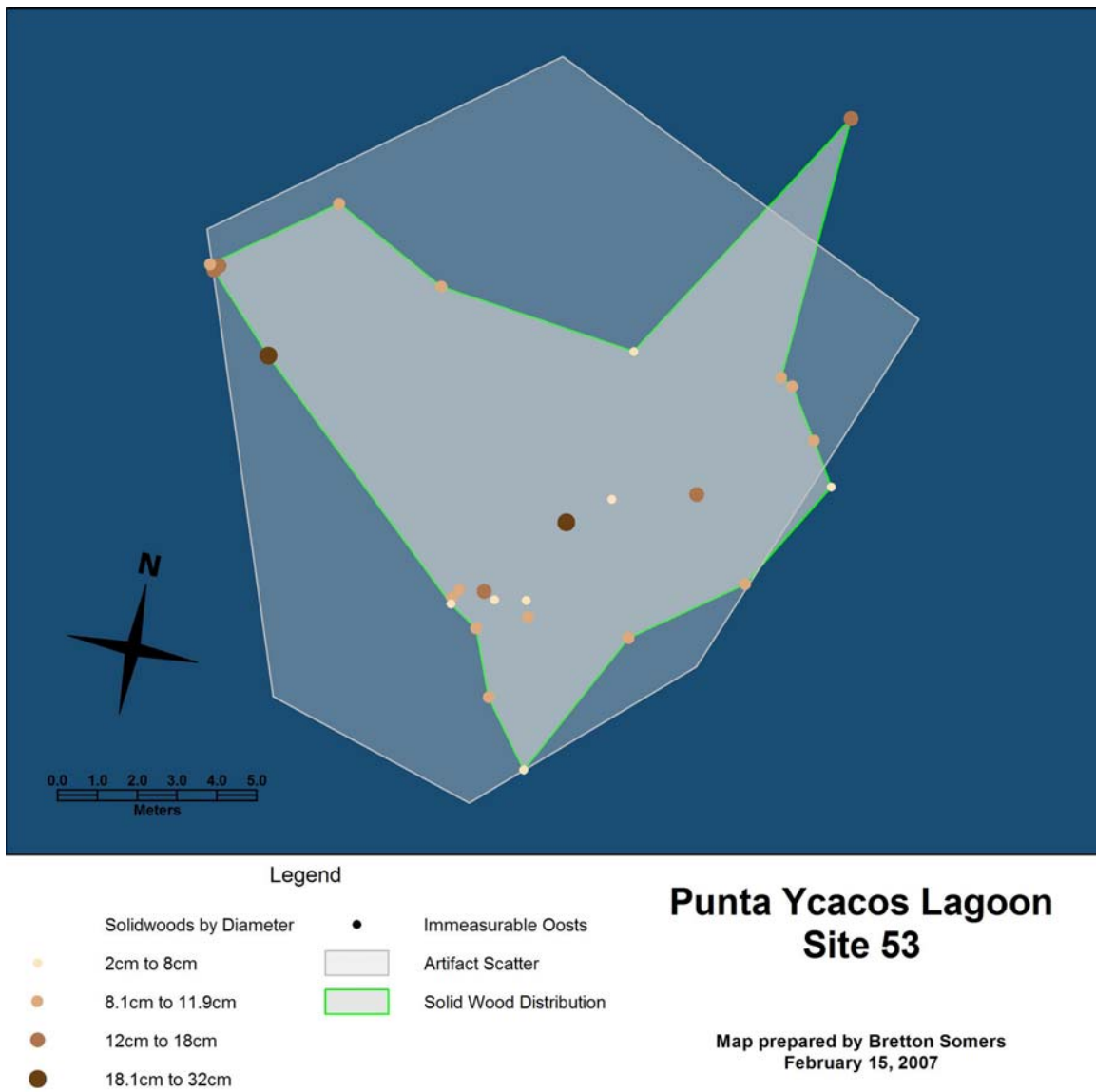
**Figure 3-20:** GIS display of Site 52.

### Site 53

Approximately 23 meters to the east of Site 52 lies Site 53 (Figure 3-2). The main artifact scatter of the site covers a surface area of 212 square meters with three solid wood posts lying outside this area (Figure 3-21). A total of 27 solid woods were mapped at the site. Circumference measurements were not possible for only two of these posts indicated as black points in Figure 3-21. Most of the solid wood posts were concentrated

in the southeast of the site with a few dispersed to the north and west. No pimienta was discovered at the site.

Ceramic artifacts were collected from the surface of the site. The ceramic sample included one Punta Yacacos Unslipped candelero with glyph-like motifs and the unknown hollow, conical pot leg resembling forms found in Honduras referred to above. For lithics a single broken chert adze was recovered.

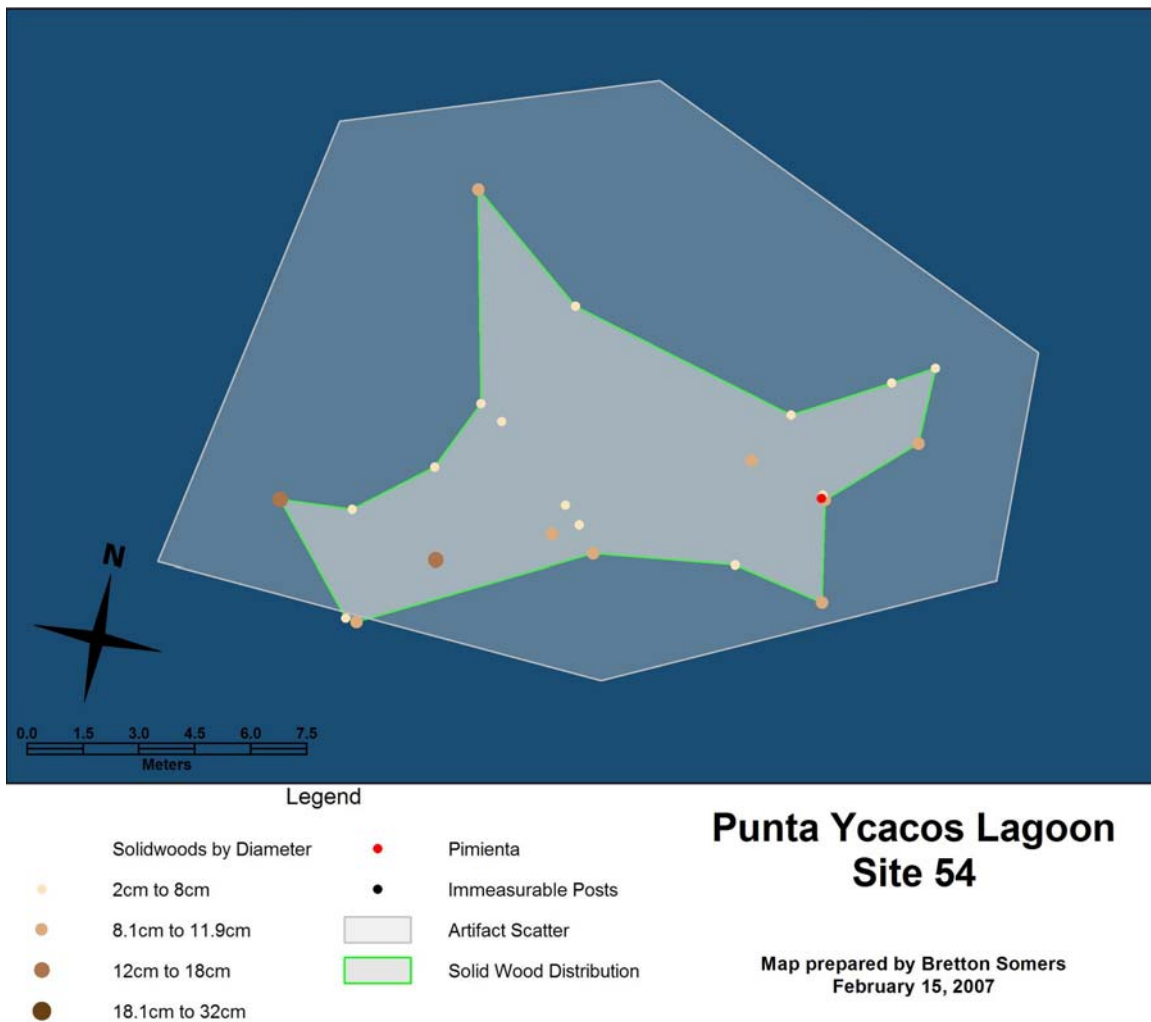


**Figure 3-21:** GIS display of Site 53.



## Site 54

Site 54 covered 265 square meters in the northeast of the study area approximately 23 meters to the north of Site 53 and 72 meters to the east of Site 49 (Figure 3-2 and Figure 3-22). The site lies on firm peat covered with a layer of silty-sand approximately three centimeters thick. Artifacts were exposed and loose on the seafloor as well as embedded in the peat.



**Figure 3-22:** GIS display of Site 54.

Ceramics collected in the sample at Site 54 included two Punta Ycacos rim sherds, one Moho Red bowl rim sherd, one Warrie Red body sherd with a circumferential

impressed stamp and incised vertical line, one Mangrove Unslipped jar rim and three unidentified sherds.

Additionally, lithics sampled included one obsidian prismatic blade, one chert stemmed unifacial blade and a complete chert adze.

Wooden posts at Site 54 included 23 solid woods and one pimenta post. Solid wood features are mostly located south of site center with only two lying toward the north of the site. The single pimenta post was found in close proximity to two solid woods forming an equilateral triangle arrangement with the posts spaced 10 cm apart.

The systematic survey employed in this research project was successful in relocating the sites discovered in the previous survey of the area in 2005. Additionally, the systematic survey found the presence of wooden posts was extensive with each site containing posts and a total of 372 discovered across the study area. Posts vary in girth and are distributed variably at each site. Artifacts discovered at each site within the study area are consistent with those found among other ancient salt making sites in Paynes Creek National Park area with a high density of briquetage and the presence of several types of Late Classic period ceramics (McKillop 2005c). Lithics were also present and represent activities requiring cutting tools as well as access to non-local resources from throughout the Maya area. The use of GIS in the field aided the survey process by allowing for the early visualization of relationships in post distribution contributing to the discovery of a row of 58 pimenta posts at Site 49.

## Chapter 4: Analysis

One would expect from the earlier discussions regarding wooden architecture and salt production to be able to examine the spatial distribution of wood posts at an archaeological site and determine familiar patterns in architecture form and site layout. If a house or building were present, one would expect the remains of a rectilinear arrangement of main posts surrounded by an exterior of smaller wall posts, if one were following Wauchope's (1938) description of modern Maya houses. Otherwise some other architectural pattern practiced by the Classic Maya would become observable. Unfortunately, in my study area posts of varying sizes are clustered together at each site and patterns are not immediately apparent. Given the complexity of salt production to serve a variety purposes, tastes, medicinal and spiritual needs and multiple stages and means of processing the final products, these posts could represent a variety of salt workshop structures and apparatuses. What is certain at Punta Ycacos Lagoon sites is that wood was purposefully selected, cut into posts and sunk into what is now the lagoon floor in select areas. The posts are now found among a dense scatter of Late Classic briquetage on the lagoon floor. Without an existing model for the spatial patterning of a Late Classic Maya salt workshop, I looked for structure patterns reported elsewhere from historical and modern sources. The structures include houses and out buildings described at length by Wauchope (1938) and salt making apparatuses such as *estiladeras*, *cajons*, *tapeixtles*, *tepecos*, *canoas*, retaining walls, canals and dams described by Andrews (1983), Reina and Monaghan (1981) and Williams (1999). The analysis of the wooden posts in the study area will proceed from the known to the unknown, combining these reports from earlier researchers with the data recovered from the lagoon. The 2006 comprehensive surface survey of the study area recovered a cumbersome body of data.

The first step in this analysis was to organize the data into a format from which observations could be made.

### **Data Reconstruction**

Among the wooden posts encountered within the study area were 42 posts missing measurements for diameter, circumference or both. These missing measurements are due to the extent of decay in which these posts were discovered. For 18 of the posts found by the survey neither diameter nor circumference could be measured. In an effort to fill in the missing diameter data, the measurement records were analyzed to determine if there was a relationship between the diameters and circumferences of the posts in the study area. In general, the relationship between diameter and circumference in a circle is pi and in general, tree trunks are circular in girth. For my study area wood posts, I tested this relationship as the circumference of trees is not necessarily a perfect circle. Furthermore, due to deterioration, there may have been significant errors in measurement to negate making this assumption. To determine if the relationship between diameter and circumference was significant the measurements of solid wood posts were subjected to a bivariate correlation test. Using SPSS™ statistical software, the diameter and circumference of posts in the population were found to have a Pearson Correlation of 0.812. A Pearson correlation of 1 represents the strongest relationship between two variables. A Pearson correlation of 0.812 is significant at the 0.01 level, suggesting the relationship of post diameters to circumferences is significant. The significance of the relationship between diameter and circumference for the posts justifies the use of pi to fill in missing post measurements by multiplying the corresponding diameter by pi to calculate circumference or dividing the corresponding

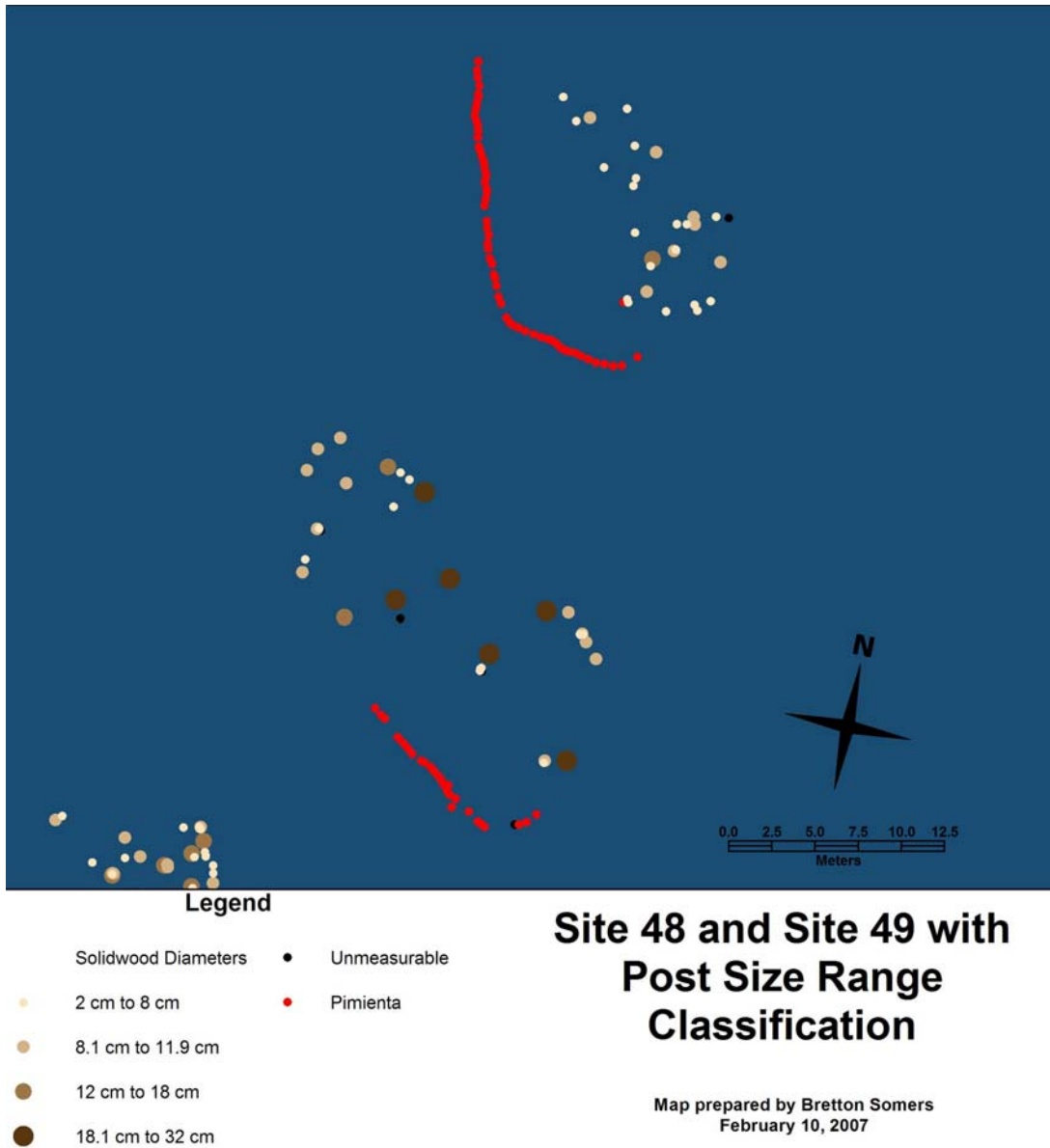
circumference by pi to calculate diameter. The result of examining this relationship allowed for adding 24 missing measurements to the wood population for further analysis.

From the wooden posts in the study area, I will suggest possible architectural forms. One such distinction includes the separation of solidwood features from pimenta. The decision to separate solidwood and pimenta wood into a separate categories (feature classes in the GIS) stems from their separate areas of occurrence and the nature of how they occur. Within this study area and elsewhere in the lagoon where pimenta occurs, it tends to form distinct curvilinear rows separate from clusters of solid woods by distances exceeding two-meters as they do at Sites 48 and 49 (McKillop 2005c). Although pimenta posts tend to occur in curvilinear rows, the solid woods cluster together in a seemingly less organized fashion. Occasionally, an isolated pimenta will be found among solid woods but this occurrence is rare. Only seven pimenta of the 372 wooden posts discovered in the study area were not part of a curvilinear row that was separated from clusters of solid wood features. The seven pimenta that were found among solid wood clusters are located toward the edge of clusters. In a single occurrence, a solid wood occurs in line with a row of pimenta. The spatial distinction and nature of how solid wood and pimenta occur warranted the separation of the two into distinct feature classes.

### **Solid Wood Post Classification**

Wauchope (1938) report details the dimensions of various wooden architectural features he encountered in his study of modern Maya houses. One such feature dimension, important for determining what possible architectural forms or elements are present, is post size. The largest wooden buildings Wauchope encountered among the modern Maya were houses. For houses, he provides dimensions for main posts as being between 12 cm and 18 cm in diameter. For wall posts, he provides diameters of between

4 cm and 8 cm (Wauchope 1938). Unfortunately, no other reports were found to support, refute nor add to the post dimension data provided by Wauchope (1938).



**Figure 4-1:** Example of post size range classification.

Main posts are the primary load-bearing element for the buildings described by Wauchope (1938) and as a result tend to be the largest posts. By examining the post sizes in this study I investigated whether similar load bearing architectural features are present.

Furthermore, examining the distribution of post sizes based on Wauchope was done to reveal other patterns among architectural elements to assist in determining what types of buildings or apparatuses were associated with the salt making sites. Wauchope (1938) also provides detailed data for a variety of other architectural elements mostly in the superstructure of houses, which were of little use in this study as all the wood features encountered in this study area are posts.

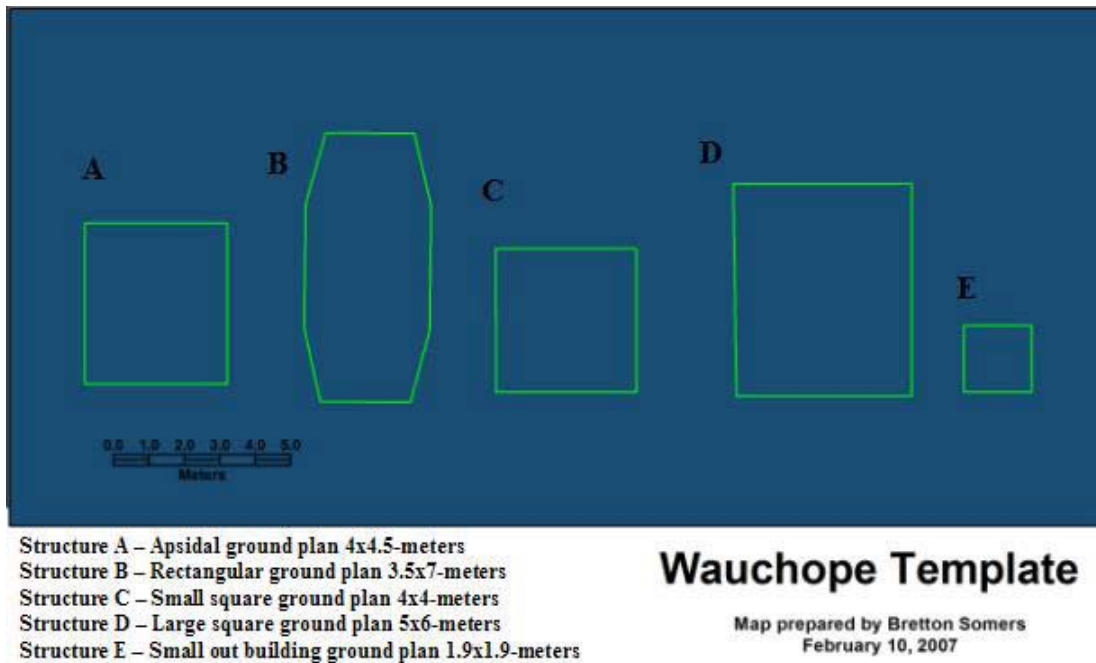
In Geomedia 6.0™, all of the solid wood posts were classified into a range of size categories according to diameter measurements. Diameter was chosen for range criteria to remain consistent with Wauchope's dimension scheme. Size categories (see Figure 4-1) included posts 2 cm through 8 cm following with Wauchope's 4 cm through 8 cm dimensions for wall posts. The smallest size category was the most numerous with 127 posts. A single 2 cm post was lumped into the category. The next ascending size category includes 83 posts from 8.1 cm through 11.9 cm in diameter.

There were no data found for architectural elements of this size range in Wauchope's report or elsewhere although there are a great many wooden architectural elements reported without dimensions. The 12 cm through 18 cm post diameter category follows suit with Wauchope's main post dimensions with 33 posts falling within this range. Above the main post category are the remaining largest posts of the study area from between 18.1 cm and 32 cm in diameter. A total of 10 posts fall within this category.

### **Template Development**

In addition to using post sizes to look for patterns in the architectural features of the study area, the analysis also combined reported data on building and salt making apparatus sizes. Wauchope (1938) provided the dimensions of several buildings

including approximate spacing of main posts in his report on modern Maya houses. For houses, he describes apsidal, rectangular and square houses as well as smaller square out buildings. Using his dimensions, a template feature class was created in Geomedia 6.0™ with scale polygons for each building (Figure 4-2).



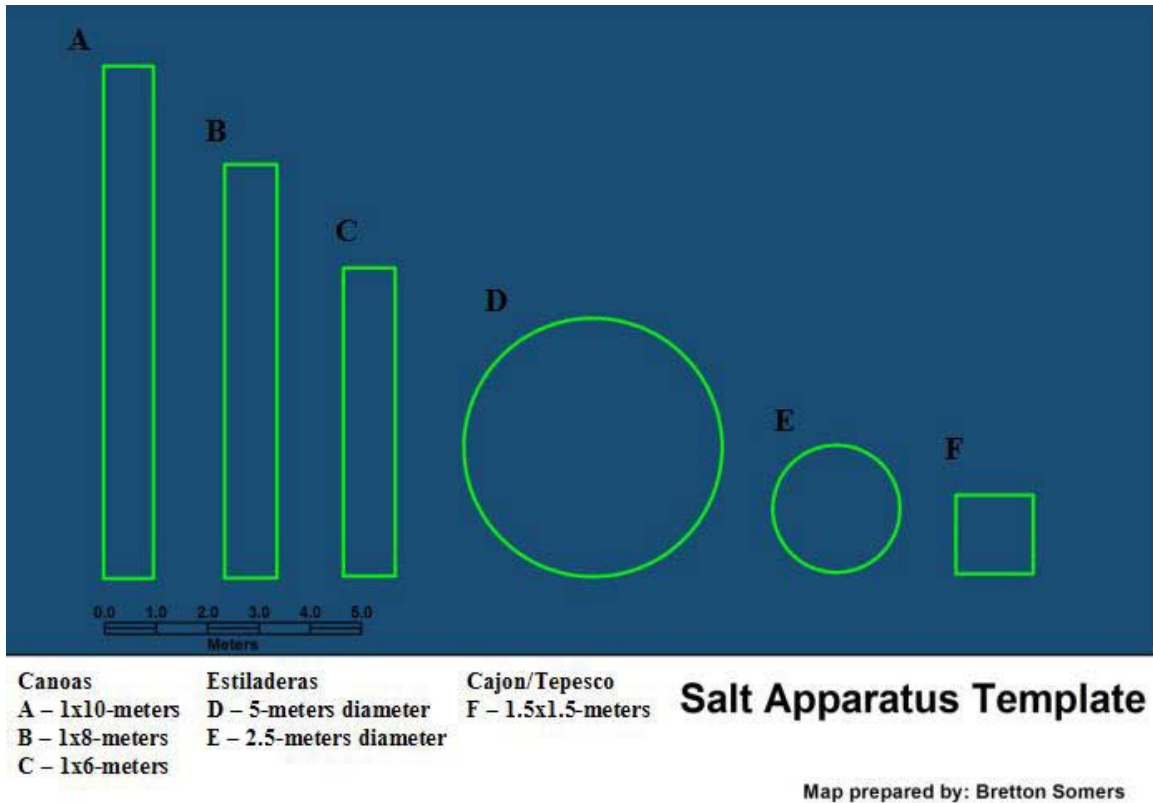
**Figure 4-2:** Wauchope template feature class with structure dimensions.

In the Wauchope structure template feature class, five polygons representing buildings were created. For the apsidal building, described by Wauchope as the most common house type in the Maya area, an 8-sided polygon was created. A 4-meter by 4.5-meter polygon was created for rectangular buildings. For square buildings Wauchope provides two dimensions for which two polygons were created, one polygon is 5-meters by 6-meters and the other is 4-meters by 4-meters. In the Wauchope structure template feature class each of the vertices on the polygons represents a post location.

Similarly, an additional template feature class (Figure 4-3) was created in Geomedia 6.0™ for salt making apparatuses described by Andrews (1983), Reina and



Monaghan (1981) and Williams (1999). Polygons in the feature class for salt apparatus templates included *estiladeras* and *canoas* with approximate dimensions measured from Williams (1999:405) site layout schematic.



**Figure 4-3:** Salt apparatus template feature class.

For the *estiladeras*, two circles were created with diameters of 2.5-meters and 5-meters. Williams (1999) mentions a range of 6-meters through 10-meters in length for *canoas*. Williams (1999:405) does not mention a width for *canoas*, but from the site schematic they appear to be approximately 1-meter wide. To represent *canoas* three polygon templates were created measuring 1-meter by 6-meters, 1-meter by 8-meters and 1-meter by 10-meters. A polygon template for a *cajon* was also created with the dimensions 1.5-meters by 1.5-meters derived from Reina and Monaghan (1981:24).

The intended use for these templates was to look for patterns in the clusters of posts that match the dimensions of the building or salt apparatus polygons. To find these

patterns, template polygons were selected with the move tool in Geomedia 6.0™ and superimposed over each site to look for matching patterns.

By rotating the axis of polygons further assisted the search for patterns. The dimensions of the templates were considered loosely to allow for variations among structure dimensions. The correspondence of template features with patterns in the post distributions was not to serve as definitive proof that these exact architectural features were present during the Late Classic, but instead to offer a connection with documented architectural features from modern and historical periods to the possible architectural features of the past. Furthermore, the design of the templates into two separate feature classes was not to imply the occurrence of these features must also be separate. The creation of two separate templates is based on the sources of supporting data for their dimensions. The possibility of some combination of the templates occurring among the sites was as possible as their separate occurrence. In some cases, the analysis suggested multiple possibilities with the study area dataset.

To narrow down the template search for architectural features, a cluster analysis of the study area was conducted to look for density patterns in the distribution of solid woods. The cluster analysis was performed using Spatial Analyst™ an extension of Arc View 3.3™. The cluster analysis calculated post distribution densities using the kernel density analysis method. Kernel density assumes a continuous surface area for a study area with each location having a density value despite whether an actual occurrence of chosen criteria exists for a location (O'Sullivan and Unwin 2003). To create a continuous surface a grid is interpolated for the entire study area. Grid cells closer to occurrences or a value of chosen criteria will have higher density values. The result of this analysis is a continuous surface where areas with the highest value or most number

of occurrences nearby of chosen criteria will have a higher density value than those areas with smaller values or less number of occurrences (O'Sullivan and Unwin 2003). This continuous surface can be displayed with contours highlighting the areas of highest density (O'Sullivan and Unwin 2003).

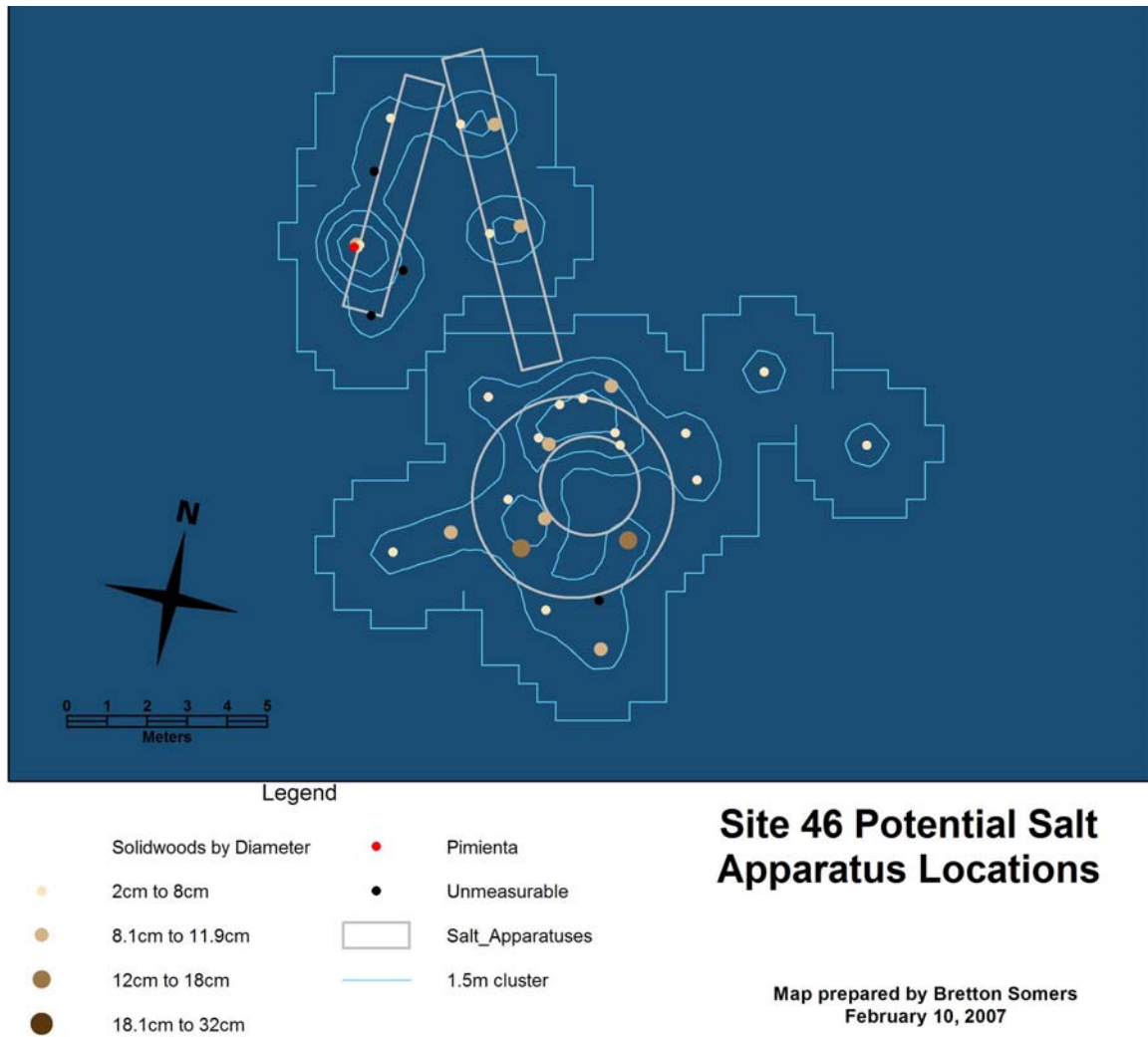
In this study the chosen criteria was the occurrence of solidwood posts. Kernel density analysis requires the analyst to set a bandwidth or search radius from which continuous density values are calculated for each grid cell within the study area (O'Sullivan and Unwin 2003). Multiple densities of post locations were calculated using different search radii. The search radii were selected based on the dimensions of building and apparatus sizes. For example, the dimensions of a *cajon* as reported by Reina and Monaghan (1981) is 1.5-meters square. By calculating the kernel density of post locations with a search radius of 1.5-meters, I estimated in the study area where the likelihood for the highest density area of posts occur within 1.5-meter areas. Where these areas of highest areas of densities occur would be a likely area to search for a possible location of a *cajon* or another structure of that size. Kernel density calculations were performed for search radii of 1.5- meters, 3.5-meters, 4.5-meters and 5-meters based on the dimensions of structures in the suite of templates created for the analysis. For each of the density clusters created from each search radii, contours were created using Arc View 3.3™ and Spatial Analyst™ to illustrate the gradation of density strength in the study area. These contours were converted into shape files and transferred back into Geomedia 6.0™ with the rest of the study area data to be used in the analysis. These contours were superimposed over the study area to help narrow down the search areas for possible building and salt apparatus locations by illuminating where the highest densities of posts occur for search radii corresponding to the different building sizes.

The search for potential building and salt apparatus locations considers all three of the aforementioned criteria. Do the posts found in the density clusters meet the appropriate diameter size range for where they correspond to the template? For the Wauchope templates, corresponding patterns of posts should fit load-bearing criteria and have diameters in the 12 cm to 18 cm diameter size range. The largest post-size category 18.1 cm diameter and above will also be considered load bearing posts. For salt apparatus templates, post-sizes will not be a major factor in the analysis, as dimensions for structural elements are not reported. Judging from photographs and descriptions the salt apparatuses in need of the most load-bearing structural support would be the *estiladeras* due to its function as a filter for salt laden soil. The following discussion examines the findings of this analysis.

### **Solid Wood Analysis**

At Site 46, four possible matches occurred for salt apparatuses in the southeastern portion of the site. Judging from the range in dimensions of salt apparatuses the analysis began with the smallest corresponding kernel density cluster contours of 1.5-meters and worked upward. The most helpful contours were the 1.5-meter and 5-meter kernel density cluster contours, a trend that continued throughout the study area. At Site 46 a potential location for the 1-meter by 6-meter *canoas* (Figure 4-4 left *canoas*) occurs in a post density area among 8 posts including 1 isolated pimienta and follows a linear row of posts on its western edge. Among the posts 3 were immeasurable due to their deteriorated state, 3 posts are in the 2 cm through 8 cm diameter size range and 1 larger post is in the 8.1 cm through 11.9 cm size range. The presence of this *canoas* should be considered loosely. Existing posts do not indicate support for all sides of the *canoas* and their distribution is haphazard possibly a result of missing data lost to deterioration.

Although it is still unclear exactly how *canoas* were constructed, the potential location for the 1-meter by 8-meter *canoa* (Figure 4-4 right *canoa*) is more convincing with two pairs of parallel posts as possible supports. The dimensions of the *canoa* could just as easily be as small as 3-meters to be supported by these pairs of posts.

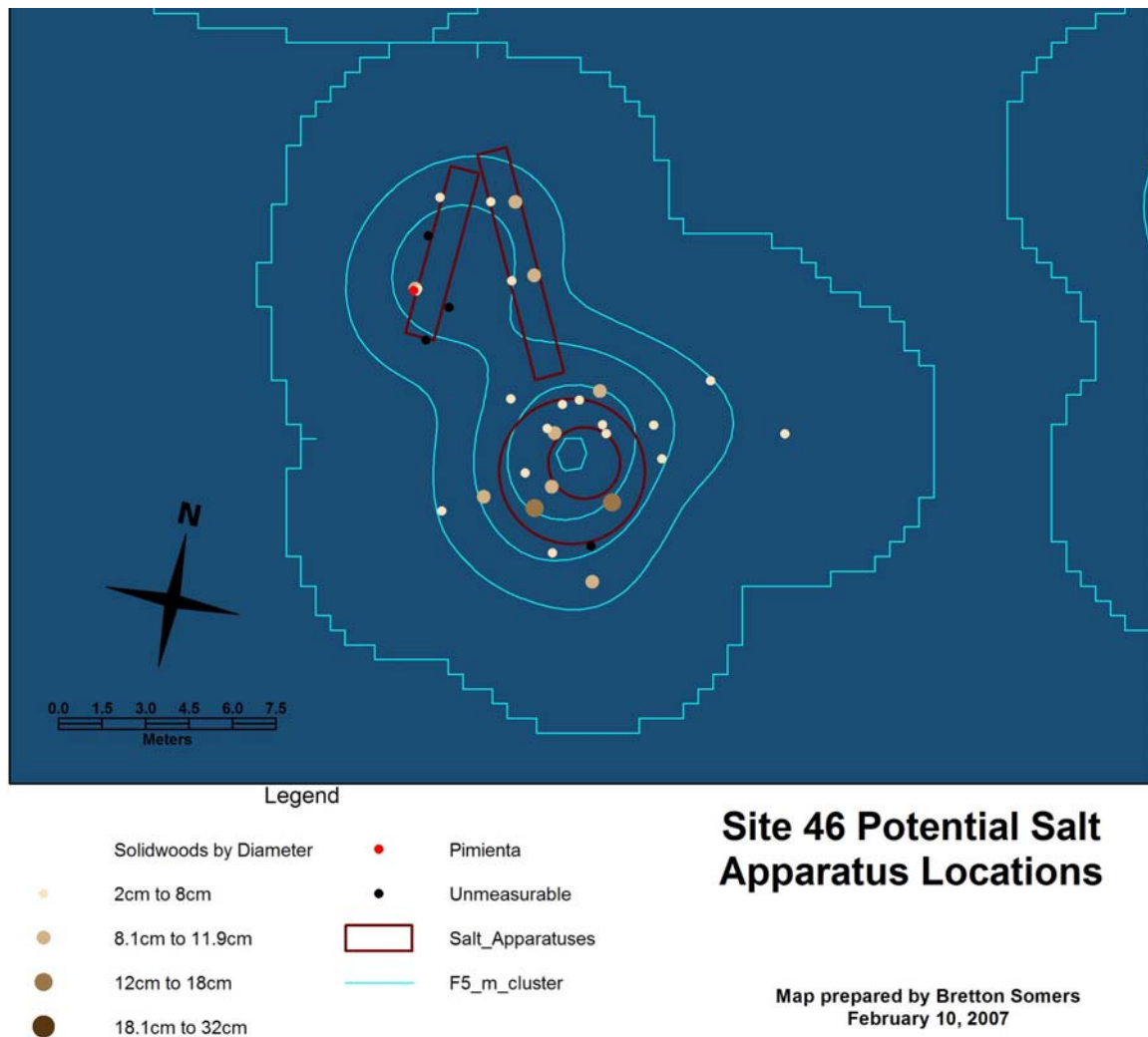


**Figure 4-4:** Site 46 potential salt apparatus locations within 1.5-meter density clusters.

The load-bearing strength appears to be greatest among the eastern posts in each supporting pair however upon closer examination these posts are each 9 cm in diameter, the southwestern post is 8 cm in diameter and the northwestern post is the smallest at 6

cm in diameter. The relationship looks lopsided due to the range classification but on closer examination 3 of the 4 posts are only a centimeter of diameter in difference.

The potential location of two *estiladeras* occurs inside the southernmost 1.5-meter density cluster. The location also falls within the 5-meter density cluster (Figure 4-5).



**Figure 4-5:** Site 46 potential salt apparatus locations within 5-meter density clusters.

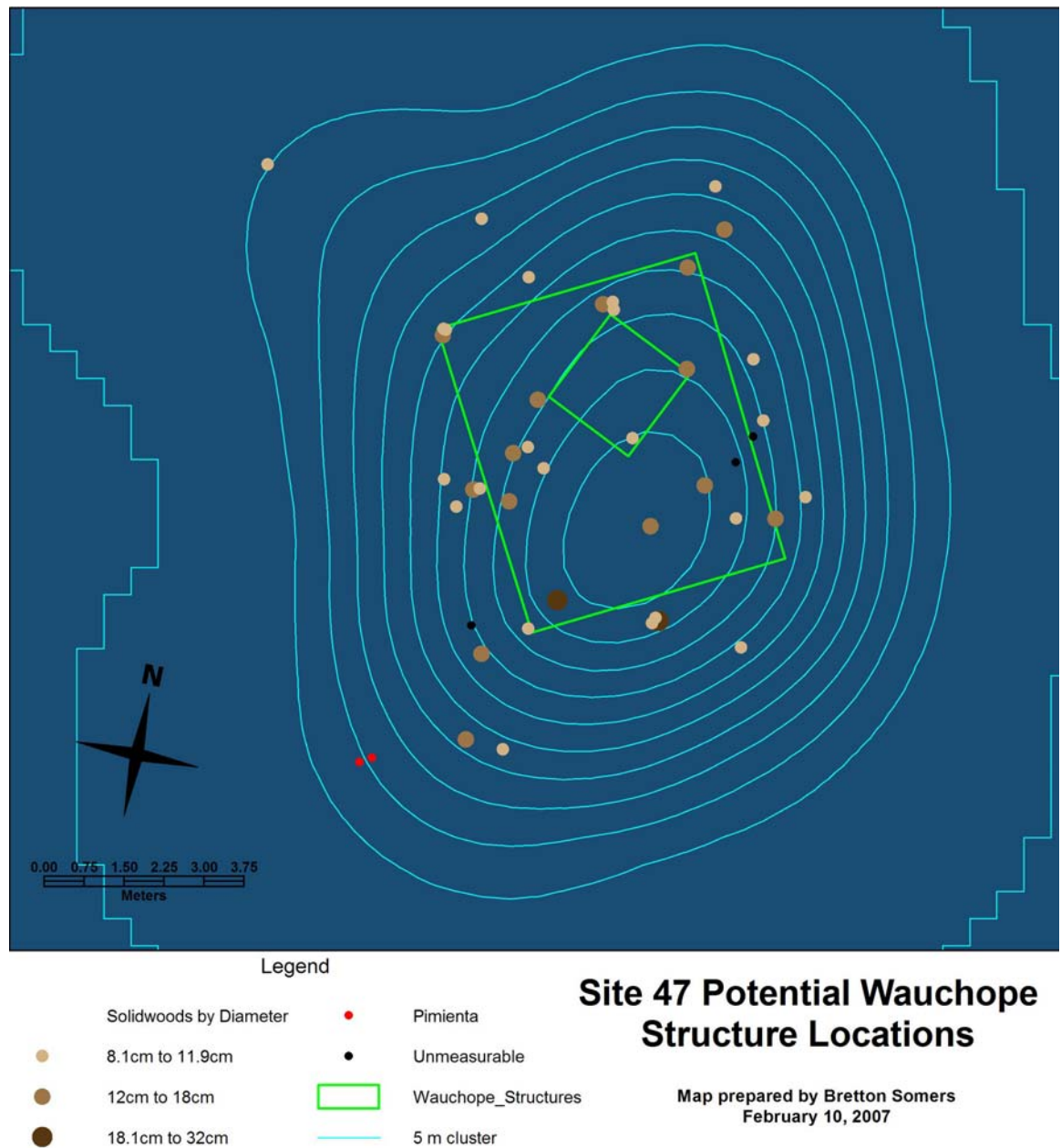
The two possible *estiladera* locations are nested within one another. A total of 10 posts roughly enclose an empty space in this density area. From photographs in Williams (1999) report it appears at least some *estiladeras* are supported by a square or rectilinear frame. Within the cluster of posts within the *estiladera* circle templates there are a

number of possibilities for such a frame. The only weakness in the potential for the location of these *estiladeras* is the variability in post sizes within this cluster. Only 2 posts fall within the load-bearing main post range, 12cm through 18cm diameter, and would require another pair to form a square or rectilinear frame.

Other smaller posts do occur in the vicinity of where supporting frame posts should occur. Multiple smaller posts may form load-bearing support in lieu of the more stout main posts, however, further confirmation is necessary.

Analysis of Site 46 with the Wauchope structure templates was unsuccessful in finding potential locations for architecture. On visual inspection many rectilinear relationships can be seen among posts but the post size ranges do not support the possibility of forming viable structures.

The analysis using Wauchope structures at Site 47 was more successful at identifying potential locations of architecture. Site 47 has the largest number of posts among sites in the study area with 85 posts densely clustered in an area of 210 square meters. Straddling the area of highest post density calculated with a kernel density search radius of 5-meters lies the potential location for the frame of a 5-meter by 6-meter square structure. This location is a loose fit with the two northern main posts fitting closely with 12cm through 18 cm diameter posts and the southern main posts showing a weaker relationship. A post fits closely with the southwestern location but it is only 9cm in diameter, which is outside Wauchope's main post size range. A larger post 20 cm in diameter lies 0.8 meters to the inside of this post and may be related. On the southeastern corner of the 5-meter by 6-meter template a main post does not coincide with the corner although a 13cm diameter post lies 0.9-meters toward the northwest along that side of the polygon.



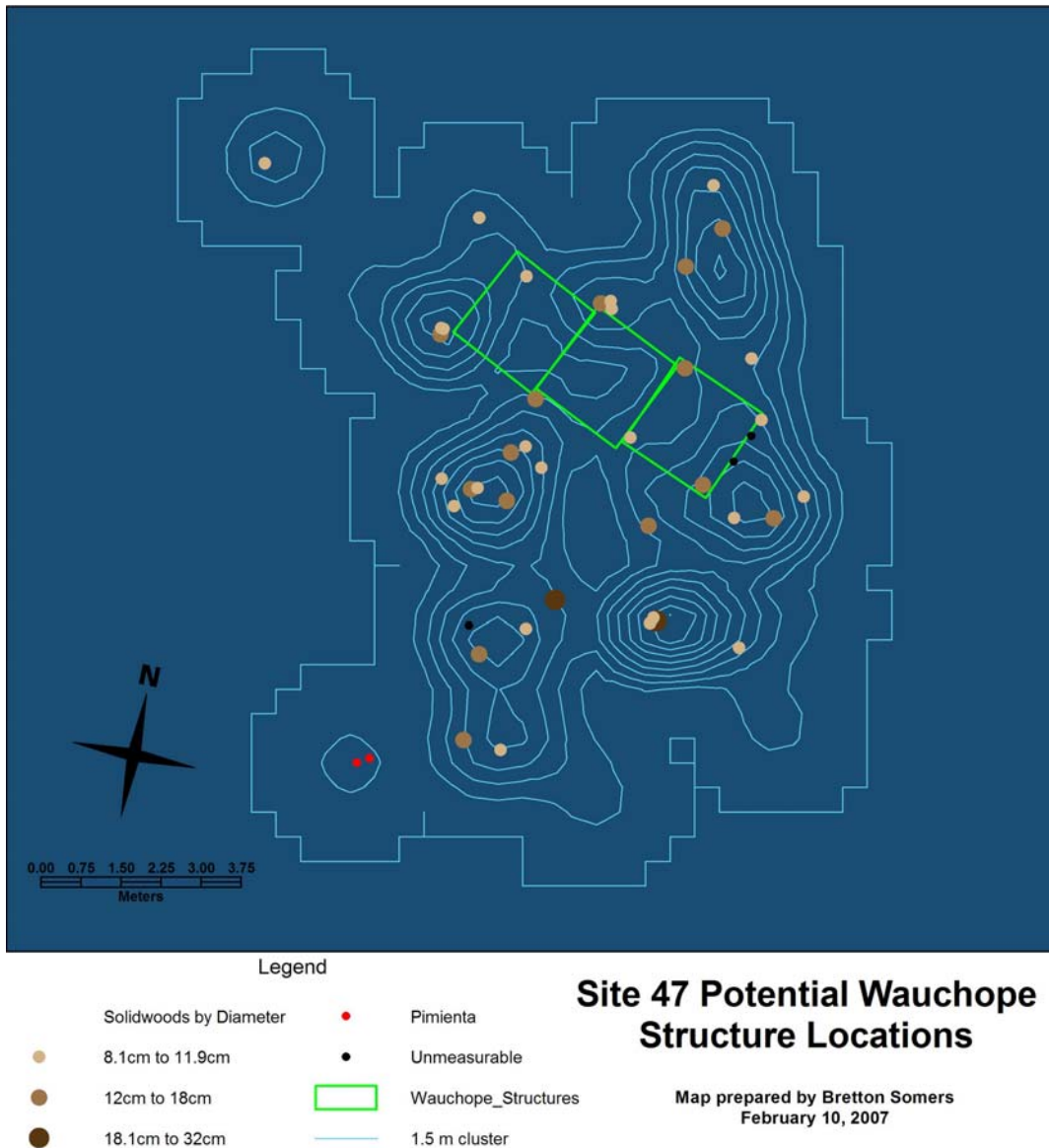
**Figure 4-6:** Site 47 potential Wauchope structure locations within 5-meter density clusters.

Nestled inside the 5-meter by 6-meter Wauchope template is a potential location for a smaller 1.9-meter square Wauchope out building structure. This structure has posts falling within the main post range on three corners. On the fourth southernmost corner a smaller 10cm diameter post lies near where a post should occur. As a smaller structure it



is possible the load-bearing requirements are not as necessary as they are for the larger buildings described by Wauchope (1938). Wauchope (1938) does not describe post dimensions in his out building synopsis.

In examining Site 47 with the smaller density cluster contours another pattern in potential Wauchope structures became visible (Figure 4-7).



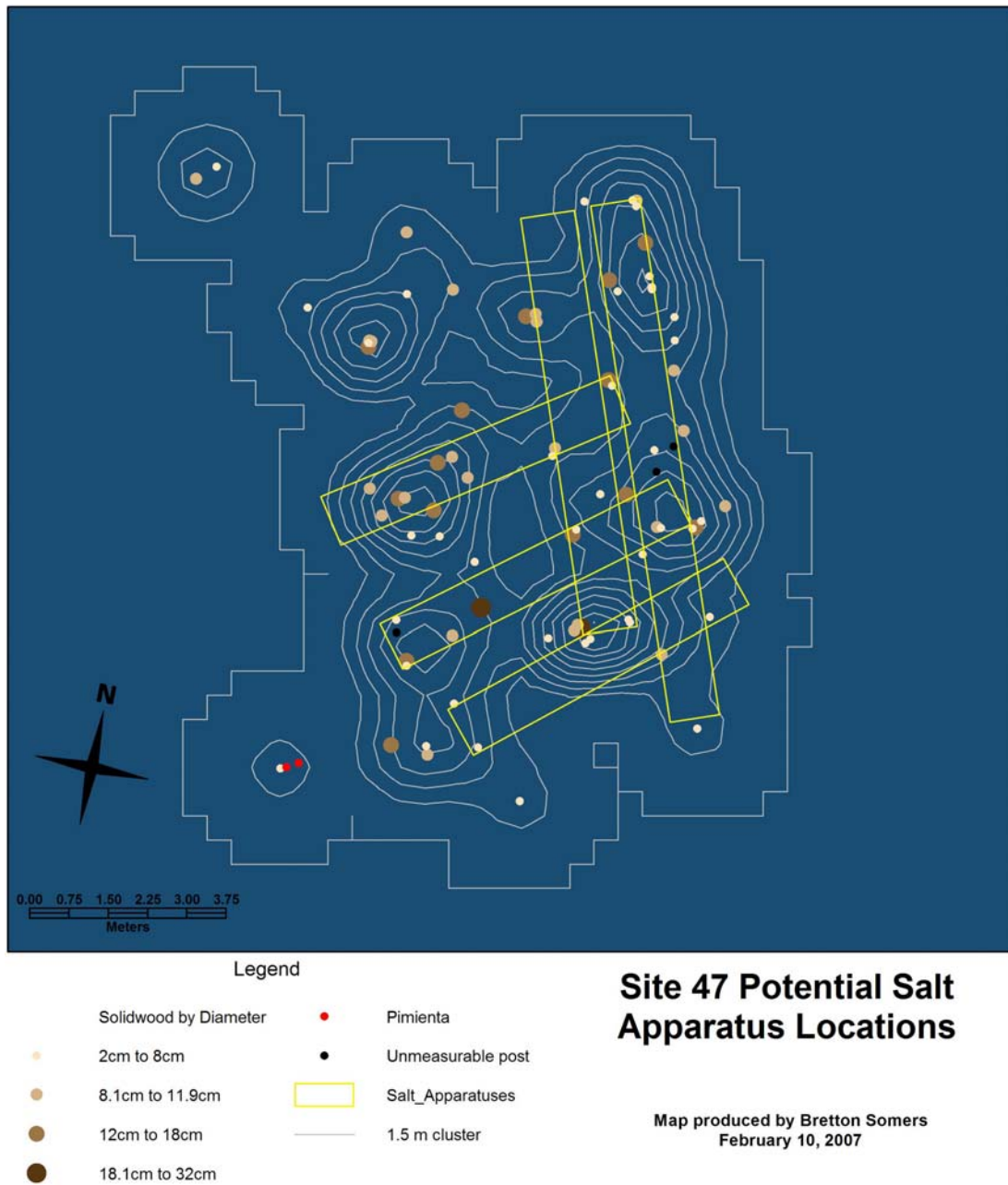
**Figure 4-7:** Site 47 second potential Wauchope structure locations within 1.5-meter density clusters.

The outbuilding structure from Figure 4-6 appears as the center of a complex of 3 outbuildings. The southeastern structure of the complex has a close relationship of 4 for each corner. Two of the posts are smaller than the main post size range but if allowing for some leniency with regard to load bearing for smaller structures this is a convincing fit. The northwestern structure possesses three main posts but a fourth is missing from the northern most corner. A smaller 10cm diameter post lies 0.5 meters inside of the corner, possibly completing the square.

Site 47 provides several possibilities for the locations of salt apparatuses. Using the 1.5-meter density cluster contours patterns in post distribution revealed the possible location of post supports for five *canoas* (Figure 4-8). Two of the *canoas* lie side by side, aligned north/south along the eastern side of the site. The two *canoas* share an edge with 4 posts in common, suggesting the possibility that multiple *canoas* may be linked together or that only 1 of the *canoas* could be possible in this situation despite the pattern. The other three *canoas* lie perpendicular to the first two. The southern perpendicular *canoas* straddles a density cluster with two pairs of posts spaced a meter apart on the western end and extending out toward another pair of posts toward the east. An additional three posts occur in no particular pattern along the perimeter of the template.

The middle of the 3 west/east aligned *canoas* spans 2-density clusters. A variety of posts of differing sizes occur along the perimeter of the template as possible support members. An additional 4 posts occur in no particular pattern within the template. The northern most of the three west to east lengthwise *canoas* represents a different possible scenario for searching for *canoas*. Given that the template width is derived from an estimation from Williams (1999) site schematic multiple possibilities should be considered. Straddling a 1.5-meter density cluster are two pairs of like sized posts that fit

within the *canoas* template. The support framing for *canoas* may occur toward the inside of the apparatus instead of along its perimeter. Alternatively, as *canoas* vary in length they may also vary in width. Other posts of varying size also occur within the template outline.



**Figure 4-8:** Site 47 potential salt apparatus locations within 1.5-meter density clusters.

In all five of the potential *canoa* locations there does not appear to be a uniform size classification for the posts involved. The variability of post sizes for each of the *canoa* templates would suggest a very piece meal construction of these features which would seem uncharacteristic behavior for the Maya considering the reports on wooden architecture from Wauchope (1938) and salt making from Andrews (1983), Reina and Monaghan (1981) McKillop (2002) Valdez and Mock (1991) and Williams (1999). This variability may be representative of multiple occupations or a recycling of materials in the upkeep of the salt works. Alternatively, the template relationships may not occur in the cluster patterns.

Other possible salt apparatus relationships include a 2.5-meter diameter *estiladera* and a *cajon* (Figure 4-9). The *estiladera* conforms with the same location as the Wauchope out building in Figure 4-6 and has the same support member situation of 3 main posts and a smaller 10 cm providing a fourth support member. This fourth support member occurs with an additional post 7 cm in diameter adding to the potential load bearing capacity.

In addition to the 2.5-meter *estiladera* the *cajon* template also fits into a pattern of post distribution. The *cajon* straddles a 1.5-meter high-density cluster. A variable collection of posts span the perimeter of the *cajon* template. However, corner posts are not well represented.

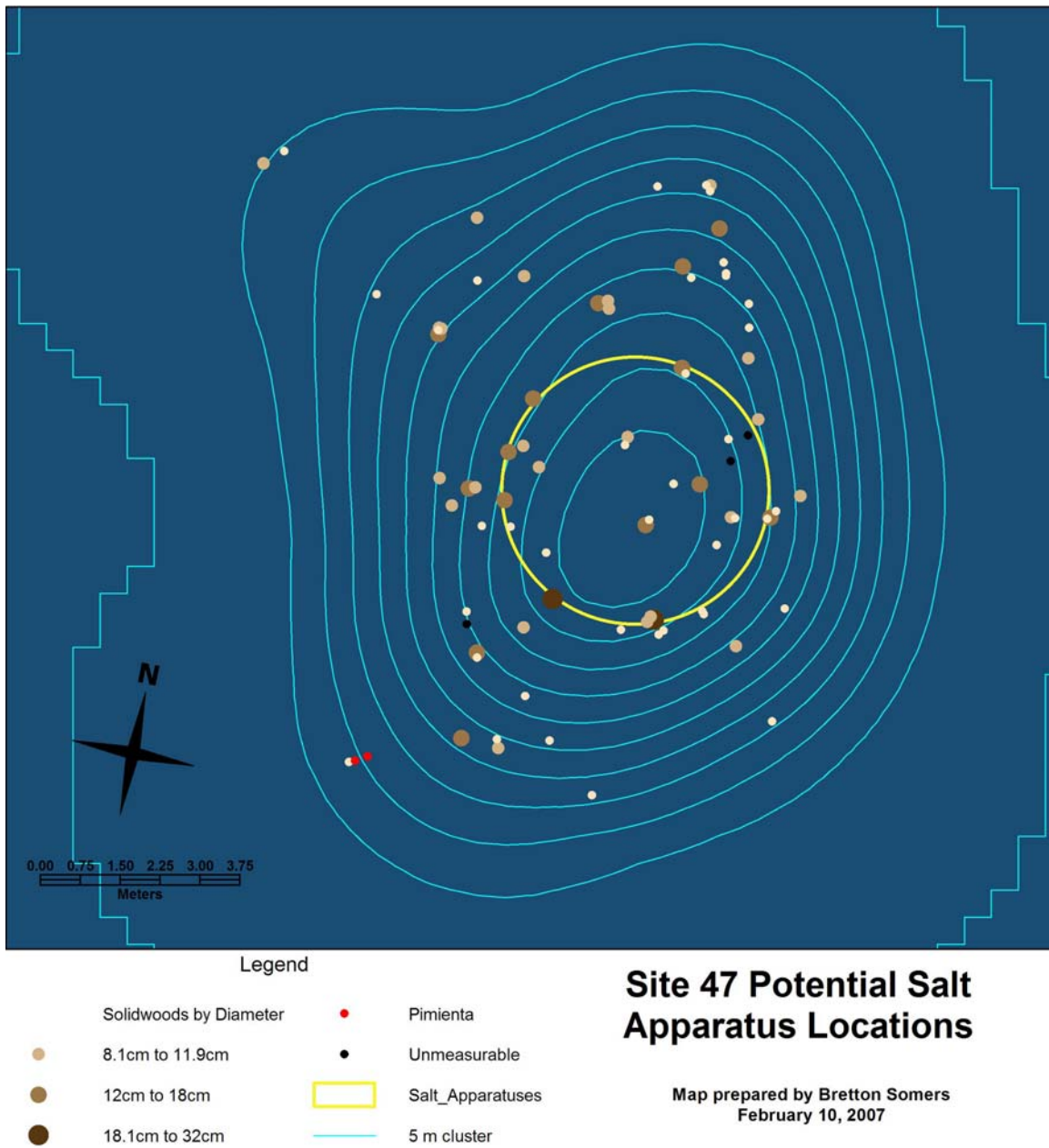
In an analysis combining the 5-meter density cluster contours and the salt apparatus templates, a relationship was detected with the 5-meter *estiladera* and a pattern of posts (Figure 4-10). In this relationship, 7 posts of main post size class and larger occur along the perimeter of the template among several smaller sized posts.



### Site 47 Potential Salt Apparatus Locations

Map prepared by Bretton Somers  
February 10, 2007

**Figure 4-9:** Site 47 Second potential Salt Apparatus locations within 1.5-meter density clusters.

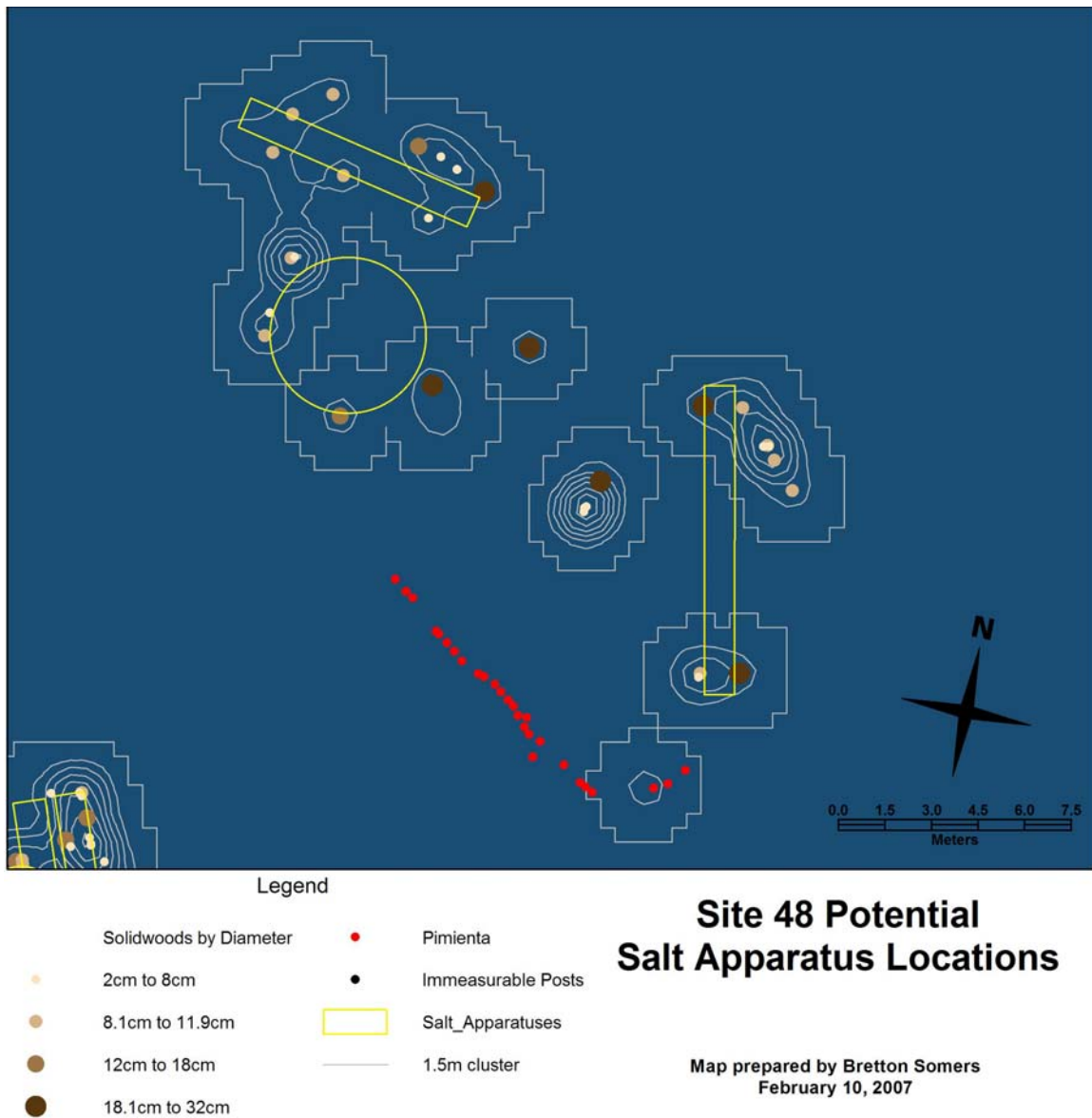


**Figure 4-10:** Site 47 third potential salt apparatus locations within 1.5-meter density clusters.

Depending on construction design there are an adequate number of posts to support such a structure in this location.

Several possible locations for the suite of architectural templates used in this study were discovered during analysis of Site 48. Three locations for salt apparatus

templates were identified from concentration areas revealed with 1.5-meter concentrations (Figure 4-11).



**Figure 4-11:** Site 48 Potential salt apparatus locations within 1.5-meter density clusters.

Toward the eastern side of the site, a 1-meter by 10-meter *canoa* spans two post cluster areas and fits between two pairs of posts. The posts in this relationship are not uniform in size range including posts in the largest and second smallest size range. The

southwestern post in this relationship occurs with a smaller 6cm-diameter post possibly as reinforcement for more load bearing capacity.

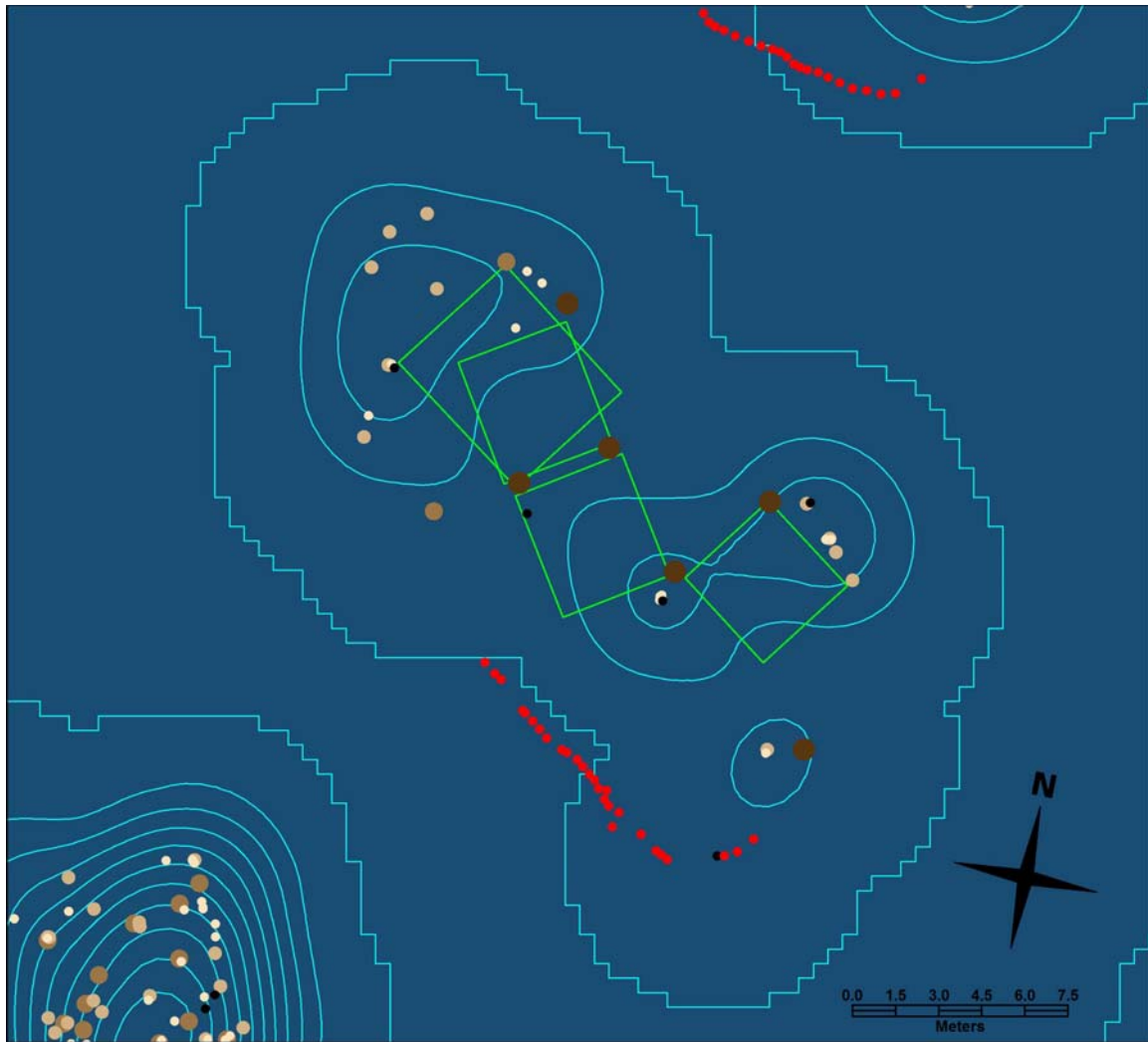
A second 1-meter by 8-meter *canoa* occurs at the northern end of the site. This *canoa* also spans two areas of 1.5-meter post concentration. The possible supporting posts for this *canoa* are also variable in size ranging from 4 cm in diameter to 20 cm in diameter. This does not reflect a uniform construction strategy.

Another salt apparatus loosely fitting into the post cluster at Site 48 is the 5-meter *estiladera*. This relationship is weak at best with the entire range of posts involved as possible supports. A support for where the northeastern edge of the circle lies was not recovered in the survey. Although this relationship may not be strong the possibility for an architectural feature requires further inquiry.

Analysis of Site 48 revealed patterns suggesting the possible locations for four Wauchope templates (Figure 4-12). The 5-meter by 6-meter structure fits a potential location supported on three sides with posts in the main post range, a larger post and a tight cluster of 3 posts on the northwest corner. The tight cluster at the northwest corner of the 5-meter by 6-meter template includes 3-posts with diameters of 8 cm, 9 cm and an immeasurable post. These posts are all within 20 cm of each other and if used together could possibly form a load bearing support.

Overlapping the location of the 5-meter by 6-meter template are two potential locations for 4-meter by 4.5-meter templates aligned end to end (Figure 4-12). The northern most of these two templates coincides with two large supporting posts on its two southern vertices. A third large post occurs just beyond reach of the northeastern corner of the template. A support near the northwestern corner of the template was not discovered in the survey.





Legend

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: #f5deb3; border-radius: 50%; margin-right: 5px;"></span> 2cm to 8cm</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: #d2b48c; border-radius: 50%; margin-right: 5px;"></span> 8.1cm to 11.9cm</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: #8b4513; border-radius: 50%; margin-right: 5px;"></span> 12cm to 18cm</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: #333; border-radius: 50%; margin-right: 5px;"></span> 18.1cm to 32cm</li> </ul> | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: #ff0000; border-radius: 50%; margin-right: 5px;"></span> Pimienta</li> <li><span style="display: inline-block; width: 10px; height: 10px; background-color: #000; border-radius: 50%; margin-right: 5px;"></span> Unmeasurable</li> <li><span style="display: inline-block; border: 2px solid #00ff00; width: 20px; height: 10px; margin-right: 5px;"></span> Wauchope_Structures</li> <li><span style="display: inline-block; border-bottom: 2px solid #00ffff; width: 20px; margin-right: 5px;"></span> 5 m cluster</li> </ul> |
|--|--|

### Site 48 Potential Wauchope Structure Location

Map prepared by Bretton Somers  
February 10, 2007

**Figure 4-12:** Site 48 Potential Wauchope structure locations within 5-meter density clusters.

The second 4-meter by 4.5-meter template also exhibits only 3 support posts. This template shares two of the large posts from the northern template of the same dimensions. The southeastern corner of the template corresponds with another large post. For each of these 4-meter by 4.5-meter templates further investigation is required to

determine if a fourth support member exists to make the structures feasible. If confirmed these templates may be evidence for a combined larger structure.

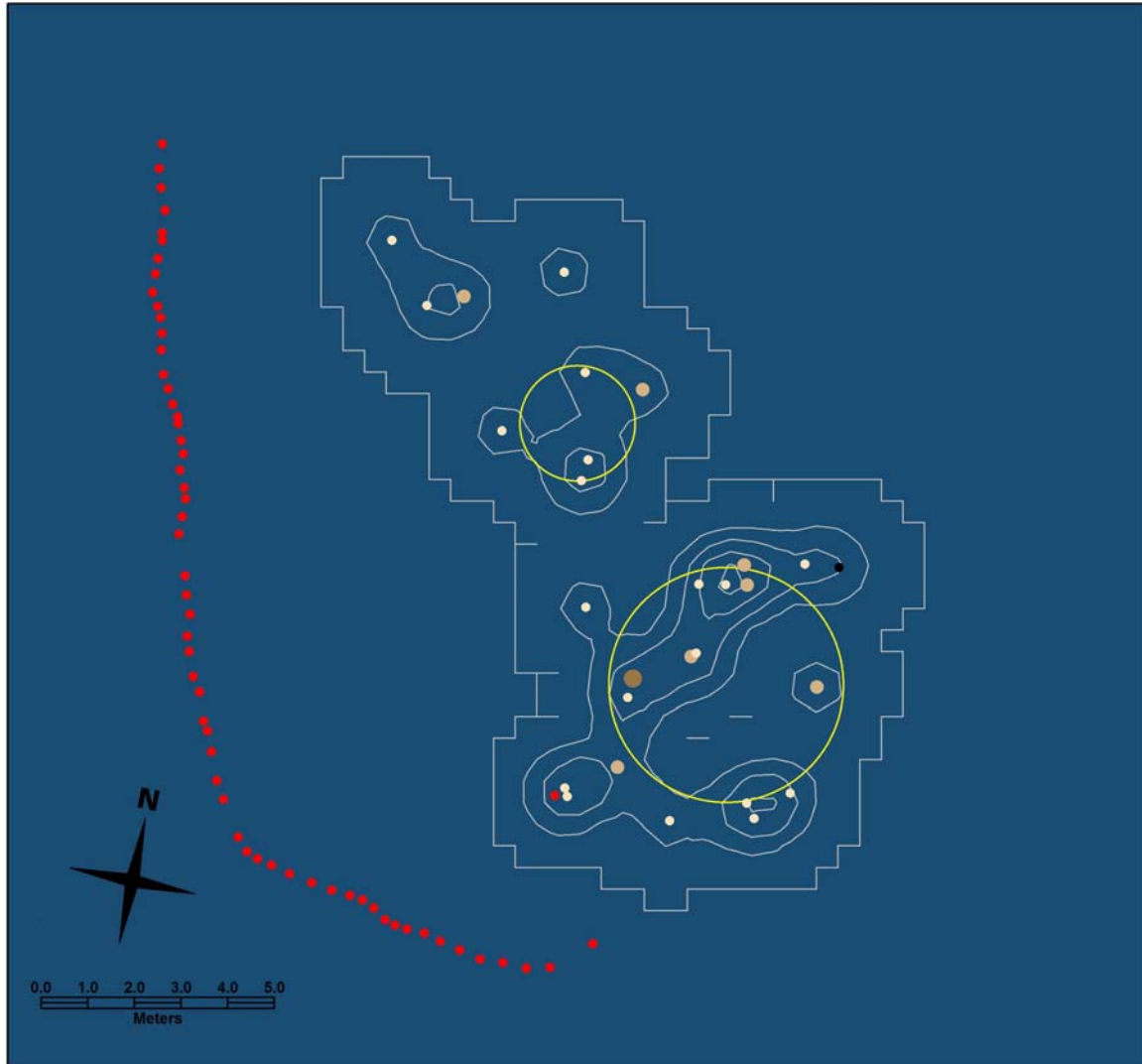
The 4-meter square template also shows a potential correspondence with the 5-meter density cluster on the eastern side of the site. The strongest argument includes 2 large posts corresponding with the northern corners of the template. The relationship becomes weaker with no posts corresponding with the southwestern corner of the template and a smaller 9 cm diameter post on southeastern corner.

At Site 49 two relationships were found with patterns in the post clusters (Figure 4-13). Both relationships involved *estiladera* templates. The smaller 2.5-meter *estiladera* loosely corresponds with a post cluster just north of site center. All of the posts involved are less than 11 cm in diameter, suggesting limited load bearing capacity if *estiladeras* do require such criterion. The arrangement of posts, although fitting with the general outline of the template, does not show any other apparent relationship.

The larger 5-meter *estiladera* also fits loosely into a larger density cluster of posts toward the southern end of the site. The variability of posts in this relationship does not indicate a uniform construction pattern. Further analysis at the site and of *estiladera* construction is needed to confirm this relationship.

No relationships were found with Wauchope templates and the posts at Site 49. Wauchope structures are larger and are reported to have main posts between diameters 12 cm and 18 cm at least. Site 49 only has one post falling into that range, limiting the possibilities for a potential relationship.

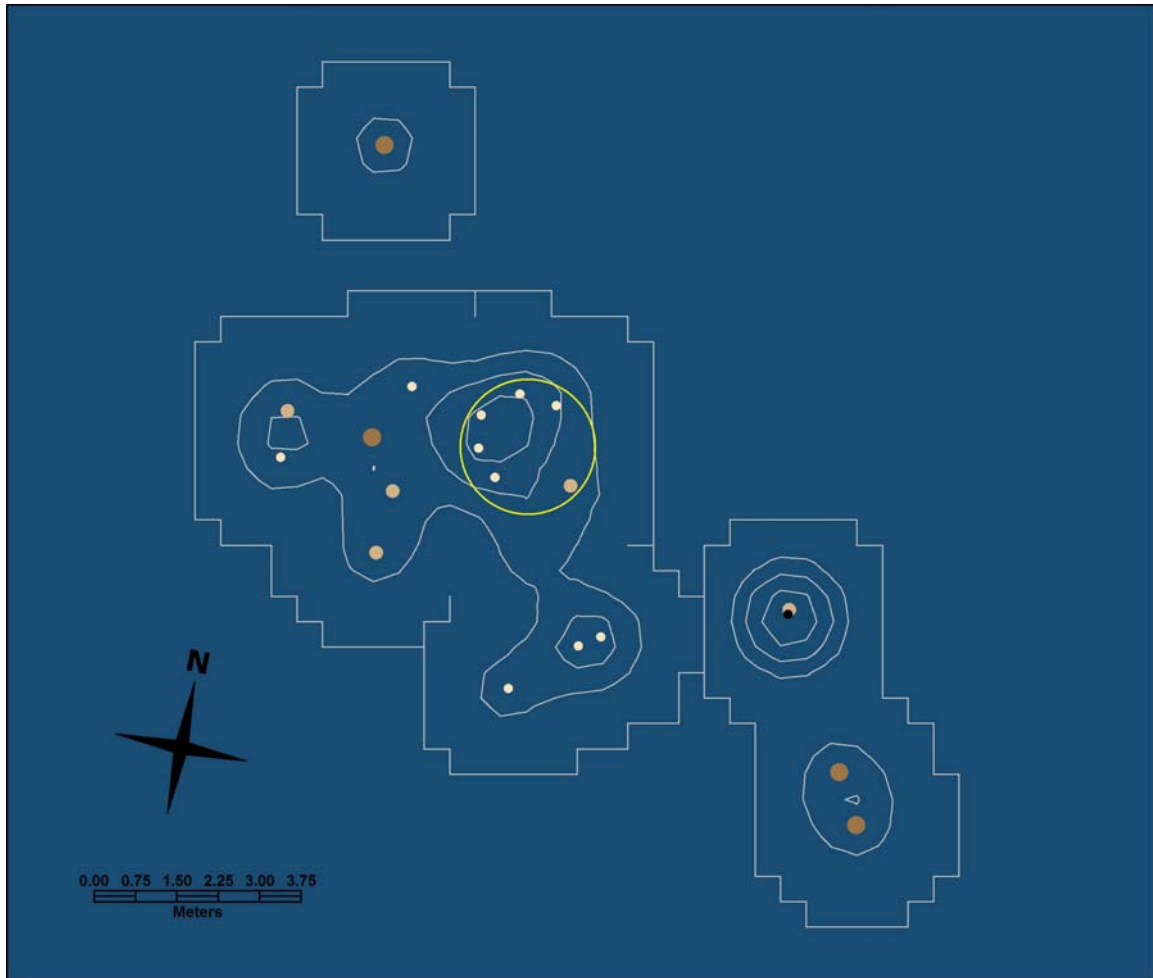
Only three posts are present at Site 51. No relationships were found for any of the templates. Much of Site 51 lies embedded under sand and peat. Further investigation below the lagoon floor will be required to determine if any potential architecture exists.



**Figure 4-13:** Site 49 Potential salt apparatus locations within 1.5-meter density clusters.

Analysis of Site 52 indicated the potential location for a 2.5-meter *estiladera* (Figure 4-14). The template fits around a pattern of 6-posts illuminated in a 1.5-meter density contour. The posts range between 6 cm and 9 cm in diameter. Although these

overlap two post-size classifications the difference is close enough to suggest a possible relationship in size selection. Although these posts are the greatest in load bearing potential, the size of a possible structure is small enough to not require larger posts.



Legend

- |                        |                      |
|------------------------|----------------------|
| Solidwoods by Diameter | ● Pimienta           |
| ● 2cm to 8cm           | ● Immeasurable Posts |
| ● 8.1cm to 11.9cm      | □ Salt Apparatuses   |
| ● 12cm to 18cm         | — 1.5 m cluster      |
| ● 18.1cm to 32cm       |                      |

**Site 52 Potential Salt Apparatus Location**

Map prepared by Bretton Somers  
February 10, 2007

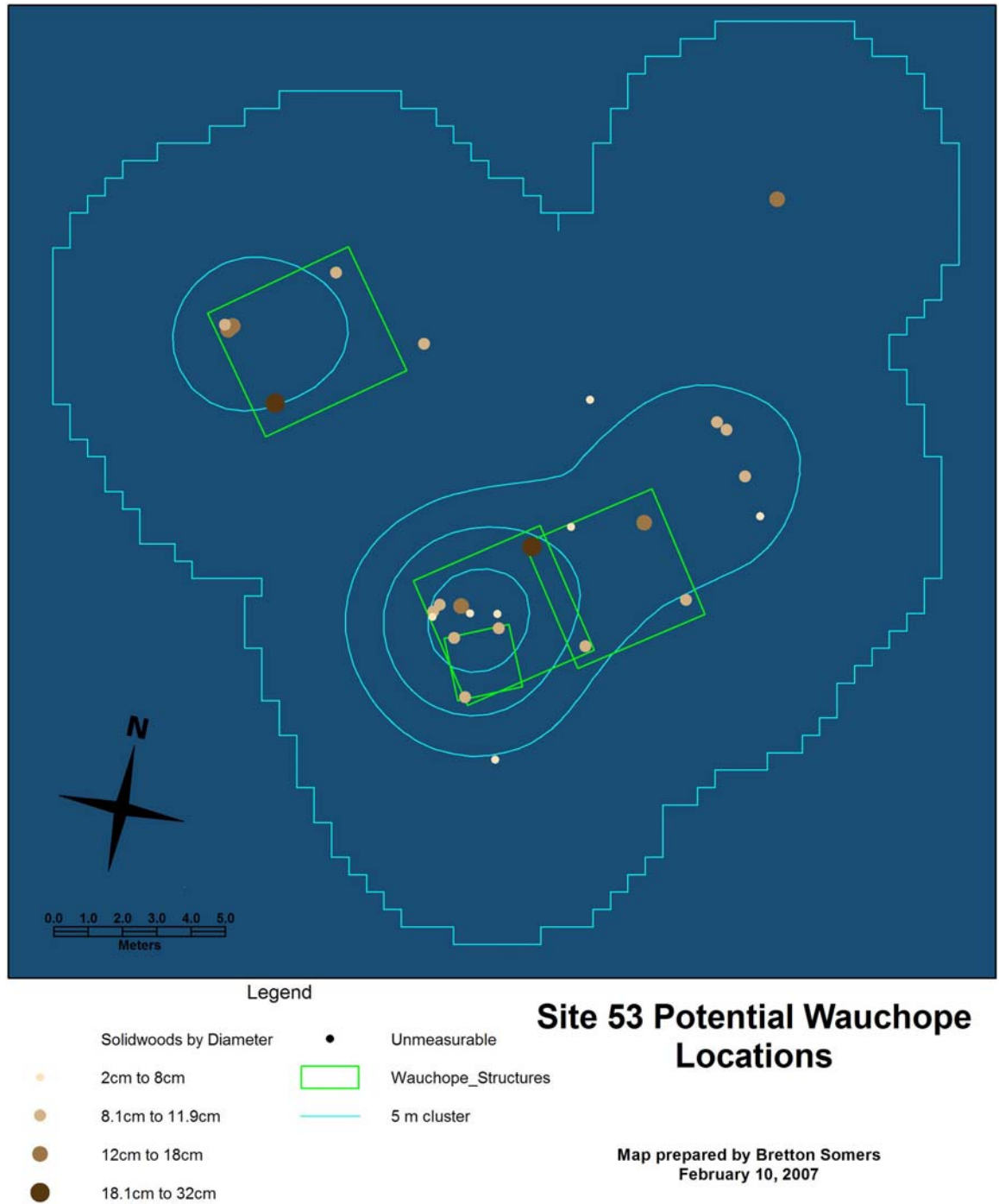
**Figure 4-14:** Site 52 Potential salt apparatus locations within 1.5-meter density clusters.

At Site 53, relationships among post patterns occurred among Wauchope templates and salt apparatus templates. Using the 5-meter density contours in the map window, four Wauchope structures loosely fit into patterns of post clusters (Figure 4-15). Toward the northwest of Site 53, a post cluster occurs with a rectilinear pattern. The cluster loosely conforms to the 4-meter by 4.5-meter Wauchope template, although smaller in dimensions. Although the posts do not match with the corners of the template, the Wauchope template was placed over the cluster to illuminate the potential for a structure, perhaps of smaller size.

Another larger cluster of posts occurs south of the site center and offers three potential locations for Wauchope architecture (Figure 4-15). A 1.9-meter square outbuilding structure with 3 posts, each 9 cm in diameter conforms closely to the corners of the template. A future search for a fourth post would offer more strength to this potential relationship.

Within the same southern density cluster of Site 53, two more potential Wauchope templates loosely exhibit potential relationships with posts. The 4-meter square template has two potential overlapping locations. The eastern most of these locations contains 4-posts that do not conform perfectly to the square. These posts are variable in diameter from 1-large post, 1 main post and 2 smaller posts. The second 4-meter square template toward the east shares a large post and smaller post in common with its eastern counterpart and a third smaller post in its southwest corner. A cluster of posts of varying diameter also falls within the square template with no apparent structural relationship with the template. For all of the Wauchope templates at Site 53, the relationships with the posts are not perfect matches but do reveal possible rectilinear

patterns in the posts that may conform better to structures of different dimensions not presently reported.



**Figure 4-15:** Site 53 Potential Wauchope structure locations within 5-meter density clusters.

Site 53 also revealed potential locations for salt apparatus templates (Figure 4-16). Where the 1.9-meter square Wauchope out building template had a loose fitting potential relationship with three 9 cm posts, the 1.5-meter square *cajon* fits inside of these posts.



### Site 53 Potential Salt Apparatus Locations

Map prepared by Bretton Somers  
February 10, 2007

**Figure 4-16:** Site 53 Potential salt apparatus locations within 1.5-meter density clusters.

The 2.5-meter diameter *estiladera* also shows a potential relationship with these 3-posts. All of these relationships with these 3-posts are contingent on discovery of a fourth post, perhaps more poorly preserved than the others.

The 5-meter diameter *estiladera* shares a relationship with the same 4-posts as the eastern 4-meter square Wauchope template. The variability of post sizes involved suggests an uneven load bearing potential for a structure at this location which may not have been an important factor for certain architecture.

At Site 54 there were no relationships found with the suite of templates used in this analysis. Of the 24 posts at the site, no relationships were found among the clusters of posts and range of post sizes that were consistent with the templates. Through observation no other patterns could be discerned that may suggest an architectural feature other than those suggest by the templates.

### **Pimenta Posts**

For the two curvilinear rows of pimenta posts at Sites 48 and 49 (Figure 4-1), there are three hypotheses. One hypothesis is that the curvilinear rows are the outer shell wall of a building as described by Wauchope (1938), with the solid woods forming the framing. The pimenta posts averaging five centimeters in diameter do fall within the 4 cm through 8 cm diameter range Wauchope reports for wall poles. Wauchope also reports the posts are lashed together suggesting they are tightly spaced together. The spacing of pimenta at Sites 48 and 49 average 0.4-meter. The walls described by Wauchope are often structurally independent of building framing and spaced up to a meter outside of main posts depending on how far the eaves extend out from the buildings. The pimenta row at Site 48 is at its closest over 3 meters from the nearest solid wood and at its farthest



pimenta posts are up to 6.5 meters from the closest solid wood. The curvilinear row at Site 49 also comes as close as 3.1 meters but curves out to a distance as far as 8 meters away from the nearest solid wood and 9.7 meters from a solid wood in the range Wauchope would categorize as a main post. Judging from the average 0.4 meter gap in pimenta posts and the distance range of 3 meters through 9.7 meters from the solid wood clusters, the curvilinear rows do not likely represent the external wall of a building.

A second hypothesis suggests these curvilinear rows are the remains of a palisade. A stockade could be used for a number purposes, for defense, as an animal pen as a property marker. With only the preserved remains of the pimenta posts found embedded in the peat the extent of the posts above the surface is unknown. Demarest et al. (1997) describe defensive palisades as having enclosed numerous Late Classic sites in the Petexbatun area of Guatemala. From post molds, these palisades are described to be “heavy, widely spaced posts” (Demarest et al. 1997). The palisade posts were reinforced by stonewalls and possibly lateral crossbeams. For the pimenta post rows in the study area, poor preservation is a limiting factor in determining their extent. Whether the curvilinear rows once extended beyond the remaining posts found, to enclose the solid wood clusters or some other area remains to be seen. With an average diameter of 5 cm and spaced an average of 0.4-meters apart, the use of the rows of posts would have been ineffective as a palisade for keeping people or animals in or out. The pimenta post rows are not found in association with an embankment or stonewall although lateral crossbeams may have been possible. Additionally, among the artifacts recovered there is nothing to suggest warfare, keeping animals or anything outside of salt making was an activity at the study area sites.

A third hypothesis is that the rows of pimenta are the remains of landscape modifications to assist in the salt making process. Although little documentation exists regarding the construction of saltpans, images in Andrews (1983) clearly display the use of wooden posts forming retaining walls holding up the edges of saltpans. Additionally, Williams (1999) includes images of the *fincas* he describes showing wooden posts as part of an embankment for a canal. Another possibility may include the need to build up or secure an area of dry land for the Maya to boil brine for collection of salt. During the Late Classic period, the study area was a part of a mangrove ecosystem as it is today. All of the wooden features are anchored into the mangrove peat suggesting intertidal water was not far away if not ever present at these sites. With *sal cocida* definitely employed based on the briquetage present, the need to construct sites on dry land to build a fire would have existed.

## **Discussion**

For many of the potential locations for Wauchope structure and salt apparatuses revealed in the analysis there are issues making the locations problematic. In some cases, a missing support post does not occur in the vicinity necessary to complete the polygons suggested by the template models. The dataset is likely incomplete based on preservation of the wooden posts. Missing posts in the template relationships may be due to the poor preservation of the necessary members to complete the structure. The dataset is also based on the results of a surface survey. The remains of more posts may lie deeply buried in the peat. Further research involving test excavation may confirm missing post locations or suggest other relationships in the dataset.

In some cases, a post lies in the vicinity of where one should lie but is off by up to a meter. These potential locations are still worth consideration as variation in building

dimensions and design likely occurred. The basis for these potential locations is based on what has been reported for wooden structures in the Maya area. Through time and space variability certainly occurred.

The patterning of posts in the study area often fits more than one template in the kernel density analysis. Some internal posts may represent internal features such as tables, benches and other fixed domestic furniture. Additionally, the often-confusing clusters of posts may represent multiple occupations and repairs of aging structures. The average lifespan of wooden buildings has been reported to be 10-15 years (Wauchope 1938; Steinberg 1999). Further research involving excavation may illuminate the time span of site occupations as well as periodicity of multiple occupations and reconstruction phases of wooden architecture.

The number of templates included in the analysis limits this study. A future study with a more diverse array of possible templates for architectural forms may find more potential matches with the distribution of posts in the study area. By visiting other modern, historic and historic salt making sites throughout Mesoamerica in and ethnogeographic study with attention toward recording the form, function, dimensions and variability of sites and architectural elements may provide additional data to build more templates according to a greater range of criteria.

It may also be possible to improve the potential of this study in the comforts of a computer laboratory by creating automated test templates and using them to find relationships within the study area. Instead of manipulating templates individually with options provided in the GIS toolbar, it may be possible to develop a supplemental program to the GIS that automates a search in the study area for the best possible matches according to adjustable template sizes, orientation and post size criteria. These results

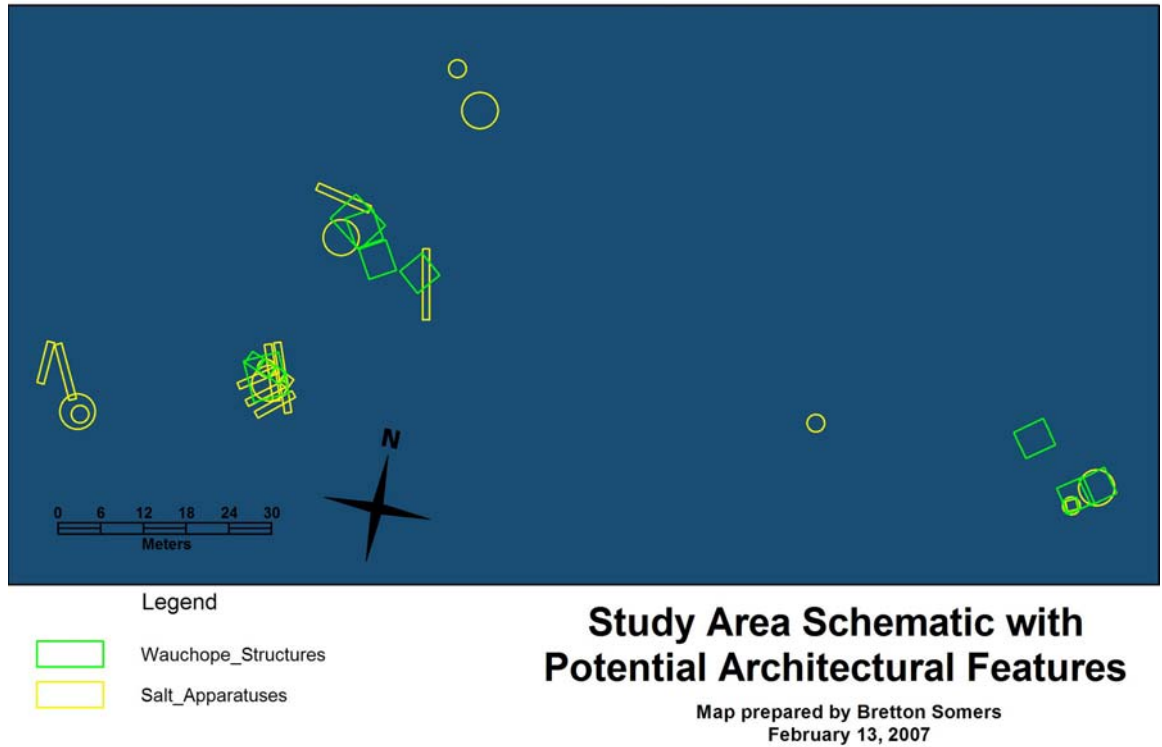
may be statistically provable as well as removing the limitations of a single analyst's observations.

Another limitation with template relationships found in the analysis is the lack of consistency with post sizes among related members in cluster areas. Wauchope's (1938) report emphasized some degree of uniformity in building construction for modern Maya structures. Part of the importance for such uniformity would be to ensure even structural integrity. This consideration may not have been important for the salt workshops of Punta Ycacos lagoons. Access to building materials, repair of aging structures and variety of structure types are possibilities for a seemingly piecemeal construction of the lagoon architecture. More data concerning the dimensions of native wooden salt apparatuses in Mesoamerica as suggested above may improve these interpretations. Despite these limitations the results of the analysis provide a wide range of architectural scenarios for the study area. Figure 4-17 exhibits the entire study area with potential architectural features.

My analyses reveal that the study area may have supported a variety of buildings and salt apparatuses. A greater potential for salt apparatuses occurs among five of the sites with the most potential in the western portion of the study area. Wauchope structures show potential locations at three of the study area sites. Among sites, there is no recurring pattern to the layout or design to post placement or potential architectural locations.

The discovery of a row of 58 pimenta posts after the initial survey of the site makes a compelling argument for using GIS for in-the-field analysis and prediction. By identifying that pimenta rows occur over two meters from solid wood clusters and near or beyond the presence of artifact scatter in the GIS, it was deemed important to return to

sites to check for their presence. This combined with the template analysis may help future research predict the location of missing posts and improve the dataset.



**Figure 4-17:** Study area schematic with potential architectural features.

## **Chapter 5: Summary and Conclusions**

My research reports and analyzes preserved wooden features from the Late Classic Maya period. This study falls within the beginning stages of an on-going project “Mapping Ancient Maya Wooden Architecture on the Seafloor.” In the first chapter of this study, the question of describing and explaining the presence of wooden posts amid Late Classic salt workshops in Punta Ycacos Lagoon was introduced. Earlier research has suggested that the Late Classic Maya presence at other sites in the Punta Ycacos Lagoon were primarily salt production sites. Evidence for long-term habitation has yet to be confirmed. Based on the surface analysis conducted, this study identifies with the non-habitation site assessment. In such a situation where the Maya were not living at the sites, the need or purpose for wooden architecture is unclear. This research was an attempt to illuminate some possibilities.

Like many scholars before me, my research combined archaeological field methods and data, ethnographic and ethnohistoric accounts with geographic spatial analysis methods. My research examined the spatial distribution of wooden posts at Late Classic Maya salt workshops with GIS in an attempt to explain what these posts represent in the ancient Maya relationship with the coastal lagoon environment of Punta Ycacos Lagoon. In the process of this analysis my research uses salt production examples from the pan-Maya lowlands and Mesoamerica to look for similarities with documented sources from the greater region. Following in the footsteps of a long history of anthropogeography in the Department of Geography and Anthropology at LSU my dissertation was intended to continue in this tradition under the recently formalized concentration in anthrogeography.

Past research regarding Late Classic Maya wooden architecture is plagued by the poor preservation conditions for organic materials in the Maya area. Although a few examples are present in the form of lintels and beams amid stone masonry at sites such as Tikal in the interior of the Maya lowlands, the use of wood is more often suggested by assumptions regarding housemounds and post molds found in excavations at archaeological sites.

Ethnographic and ethnohistoric research examining wooden architecture among the Maya and elsewhere in Mesoamerica provides possible examples of what the ancient manifestations may have been. In the discussion regarding salt-making and the Maya the evidence for the use of wood for architecture, landscape modification and various apparatuses are abundant.

Systematic survey of the eight sites in this dissertation revealed distinct areas of artifact presence exist within the study area. Artifacts include ceramics, lithics and wood. Within these distinct areas of artifact presence are wooden posts deemed to be architectural in nature based on their post-like design and purposeful placement.

Analysis of the ceramics at each site has revealed these sites were in use by the Maya sometime during the Late Classic period, a span of some 300 years beginning around A. D. 600. As mentioned earlier, the overwhelming presence of briquetage and shortage of more domestic artifacts at the sites studied here are consistent with earlier reports on salt making sites in the area that they were primarily workshops and not habitation sites (McKillop 2002, 2005a). This primary focus on salt production appears to be on a scale larger than household need and is likely to have been for trade purposes. A sample of finer non-salt boiling ceramics with decoration at these sites are also found

elsewhere during the Late Classic period and suggests influence and interaction with the greater Maya realm.

Interaction with the greater Maya realm is further supported by the lithics recovered at the sites. Obsidian and greenstone are non-local materials and would have to have been acquired via contact with an outside network of exchange. Chert may occur locally although, a source of similar quality to the chert tools found in the study area has yet to be discovered. The lithic tools recovered suggest cutting, chopping and pounding were in some way involved in the activity of the salt workshops. Future research comparing tool marks on the wooden posts with the cutting edges of the lithic tools such as the chert adzes found in the study area, may reveal a connection between tool use and the wooden architecture at these sites.

The presence of wood posts among these scatters of predominantly salt boiling ceramics and lithics provides conclusive evidence that some form of wooden architecture was involved in the process. Analysis of the distribution of wood features at sites has revealed the occurrence of two distinct patterns in the placement of wooden features at sites. Pimenta posts occur in curvilinear rows separated by distances in excess of three meters from clusters of solid wood features. This distinction has several implications. Whether or not pimenta rows and solid woods are part of the same architectural entity such as a building, they serve separate purposes in the design.

Pimenta post rows occur near the edge of sites where the density of ceramic and lithic scatter drops off from site center and as in the case of Site 49, ceases altogether. Judging from the distance the pimenta rows occur from the solid wood clusters and spacing between posts, the function as a building wall is unlikely when compared to ethnographic description (Wauchope 1938). The cessation of artifacts beyond the



pimenta row does suggest an end to activity involving lithics and ceramics extending out from these sites. Although a building wall seems unlikely, a retaining wall for a salt pond as depicted in Andrews (1983) and Williams (1999) may serve as a possibility. The opposite may also be true of a retaining wall, in that instead of containing water, it may secure areas of dry land in an otherwise inundated situation. Another possible function may include the use of pimenta posts as some form of fence or stockade such as those reported by Demarest et al. (1997), however the slight diameter (5 cm average) of the pimenta posts and lack of any evidence of warfare does not strongly support use as a defensive measure.

Analysis of solid wood features revealed fewer discernable patterns and a greater number of less certain possibilities regarding architectural forms and function. Using templates derived from reported dimensions of wooden architecture in Mesoamerica and examining density clusters of posts classified into size ranges revealed several possible matches, discussed in detail in Chapter 4, each with its own limitations. Reasons for these limitations are numerous, most prominent of which is a limited data set. Posts may be missing by not having been preserved in the archaeological record or may have been missed during the survey.

In –the-field GIS analysis has proven that by identifying relationships among posts while still in the field can assist in secondary searches to fill in missing data. Using templates and considering other relationships such as those between solid woods and pimenta will prove to be useful in future research.

The presence of wood posts in the archaeological record at these sites is a rare and remarkable phenomenon for the tropical environment of the Maya area. Test excavations at these sites may reveal more posts or post molds further filling out the data set and

revealing more patterns and relationships of architectural elements. The analysis used in this study may serve to assist in determining areas to investigate for possible missing elements.

Future test excavations at these sites may also clarify patterns in occupation of these sites. The sites in this study area may have been a palimpsest of multiple generations of salt production in Punta Ycacos Lagoon, each of which involved the construction of new architecture or repair and modification of old features. To an observer today, finding patterns in these clusters of solid wood posts is confusing if considering they represent a single moment in time.

Another challenge for this study was a limited body of reported information regarding specifications of wooden architectural features in the Maya area. Refining this study with a larger body of ethnohistoric and ethnographic data pertaining to the dimensions of wooden architectural features in the Maya area particularly, from salt making sites, may allow more possibilities for patterns to become apparent.

From the existing body of data and through comparison with reported examples of wooden architecture in the Maya area, the salt production sites in the study area were not standardized in layout or design. Further analysis of a larger sample of the salt making briquetage will be required in order to determine if the actual salt making ceramics involved in the process were standardized as has been reported for the vicinity (McKillop 2002). Outside of the aforementioned limited wood dataset, the seeming lack of standardization in architecture may speak more toward the nature of exploitation of the resource. The salt workshops may represent opportunistic exploitation of the high saline brine present in this area of the lagoon. Distribution of sites may coincide with favorable locations near the ancient source not immediately apparent in the modern landscape. The

distribution of sites and wood at sites may be suggestive of landscape modification strategies to effectively maximize salt production efforts. Standardization may be better measured by other means than through consistencies in the observable architectural patterns.

This approach attempts to draw comparisons to what has been reported for Maya wooden architecture, which is primarily modern. Perhaps more will come from comparison to other models or new data. We may find that there are recurring patterns in post distribution among the sites studied in this dissertation and others in the Punta Ycacos Lagoon that differ or are not found elsewhere. The Punta Ycacos salt works may share similarities with salt making elsewhere but have local permutations on the technology.

This research, although perhaps providing more questions than answers regarding the wooden architecture of salt production sites in Punta Ycacos Lagoon, helps lay the groundwork for future investigations of sites in the study area and others. The methods used provided an effective means for systematic survey and mapping of sites in the often-challenging context of an inundated study area.

The GIS analysis offers an effective interactive medium from which to investigate and test patterns in the dataset. The GIS also demonstrated effective in-the-field potential for investigative decision making. Through identification of the pattern of pimenta posts within sites using GIS, the decision to investigate sites beyond the original extent of survey revealed an additional pimienta row at Site 49. The use of GIS in fieldwork may serve to direct efforts in a more effective and efficient manner, maximizing the output of often-limited time in the field.

Additionally, exploring ways to improve the GIS technology to automate searches with adjustable template sizes and orientations may reveal relationships among posts beyond the scope of the current study and/or would not be revealed by further collection of ethnographic or ethnohistoric comparison.

As part of the initial phase of the on-going research project investigating the salt production sites in the Punta Ycacos Lagoon, combining future data and analysis with that presented in this dissertation will serve to further our understanding of the local salt production industry and its role in ancient Maya society.

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## Appendix: Glossary of Recurring Spanish Terms Described in the Text

*Cajon*: A wooden box measuring 1.5 meters by 1.5 meters raised up on wooden supports and mounded earth. Water is filtered through salt laden soil in the *cajon* and collected in a tray below, where the brine is then transferred to ceramic vessels and boiled within a building (See image in Reina and Monaghan 1981 Figures 21, 23 and 24). See Page 40 in this text for description of the *cajon* as it is used in modern salt production.

*Canoa*: dugout wooden troughs between 6 meters and 10 meters in length where brine is evaporated into granular salt (Williams 1999). The images provided in Williams (1999:406,408) show the wooden troughs raised off the ground with wooden supports. See Page 39 in this text for description of the *canao* as it is used in modern salt production.

*Estiladera*: a wooden funnel shaped structure about 1.5 meters in height. The *estiladera* sits atop a wooden block. In a photo provided by Williams (1999), the *estiladera* appears to be further supported by four posts forked at the top and supporting crossbeams in which the wooden funnel is contained. For photos and depictions see Williams 1999:405-406. See Page 39 in this text for a description of the *estiladera* as it is used in modern salt production.

*Sal cocida*: rendering salt from brine through boiling. See pages 14 through 21 in this text for a description and examples of the *sal cocida* method.

*Sal solar*: rendering salt from brine through evaporation. See pages 12 through 14 in this text for description and examples of the *sal solar* method.

## Vita

Bretton Michael Somers was born in Nashua, New Hampshire, to Roger and Eileen Somers on December 16, 1972. Inspiration drawn from several family R. V. vacations lead to Bretton's desire to travel and study the world and its people. In 1994, he completed his Bachelor of Arts degree in communication with minors in geography and art at the University of New Hampshire. For several years Bretton managed a restaurant in York, Maine, using his earnings to fund several backpacking excursions around the world. In 2000, with a reinvigorated interest in geography and anthropology, Bretton enrolled in continuing education classes at the University of New Hampshire with the eventual goal of attending graduate school. After participating in the Belize Valley Archaeology and Reconnaissance field school in Belize, directed by Dr. Jaime Awe, Bretton's interests became focused on using GIS and mapping sciences in combination with archaeology to study ancient settlement patterns. In 2002, he was accepted into the geography graduate program at Louisiana State University and moved to Baton Rouge, Louisiana. He completed his master's thesis *Hidden Landscapes of the Ancient Maya: Transect Excavations at Arvin's Landing, Southern Belize* in December 2004. Bretton was subsequently accepted in the geography doctoral program at Louisiana State University where he has since worked toward completion of the requirements for the geography doctorate with concentration in anthrogeography. During his period of enrollment at Louisiana State University, Bretton met Virginia Louise Ruyle to whom he will be married on May 20, 2007.