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INVESTIGATING THE ANCIENT MAYA LANDSCAPE:
A SETTLEMENT SURVEY IN THE PERIPHERY OF PACBITUN, BELIZE

by

JENNIFER WEBER

Under the Direction of Dr. Jeffrey Glover

ABSTRACT

This thesis presents the results of research conducted at the ancient Maya site of Pacbitun. The site, located in the foothills of the Maya Mountains in the Cayo District of Belize, offered a unique opportunity to investigate the relationship between the site core and various caves located in its 9 km² periphery. The landscape was a critical component of ancient Maya religion. The earth and all of its topographic features were considered to be alive and, as living beings, to interact in human affairs. Caves were seen as portals to the underworld and homes to deities. Pilgrimages to these sacred places influenced and were influenced by settlement patterns and socio-political relations. Particularly targeted in this study is the causeway system, which connects the site core to a ritually used cave, and is analyzed through the application of predictive modeling. Since analysis of the intermediate area between sites and caves has been rare, this research makes a substantial contribution to our understanding of the ritual landscape.

INDEX WORDS: Archaeology, Maya, Survey, Caves, Landscape, Settlement, GIS

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A SETTLEMENT SURVEY IN THE PERIPHERY OF PACBITUN, BELIZE

by

JENNIFER WEBER

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Masters of Arts

in the College of Arts and Sciences

Georgia State University

2011

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Jennifer Weber
2011

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A SETTLEMENT SURVEY IN THE PERIPHERY OF PACBITUN, BELIZE

by

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Office of Graduate Studies

College of Arts and Sciences

Georgia State University

May 2011

DEDICATION

Für meine Mutter

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1 INTRODUCTION

This thesis presents recent settlement survey research conducted at the ancient Maya site of Pacbitun. The site, located in the foothills of the Maya Mountains in the Cayo District of Belize (Figure 1-1), presents archaeologists with the unique opportunity to investigate the relationship between the site core and various caves located in its 9 km² periphery. For the past two seasons, the Pacbitun Regional Archaeological Project has been investigating these cave sites, trying to enhance our knowledge of the role of caves at the local and regional level. Prior to this research little attention over the past 25 years at Pacbitun has been given by previous investigators to the caverns that were located up to four kilometers away from the site core.

1.1 Purpose of the Study

In ancient Maya religion the sacred landscape played a critical role, as the earth and all of its topographic features, especially caves and mountains, were considered to be alive and, as living beings, to interact in human affairs (Stone 1995:21). Caves were seen as portals to the underworld and homes to deities. Pilgrimages to these sacred places influenced, and were influenced, by settlement patterns and socio-political relations (Stone 1995). The recording of natural and cultural features situated in this area will help us to better reconstruct various aspects of ancient Maya society at Pacbitun. For example, recorded features, like housemounds, water sources, and constructed causeways provide clues about the socio-political and cosmological environment. Particularly targeted in this study is the causeway system, which connects the site core to a ritually used cave. Through the application of ArcGIS's least cost path analysis tool, I systematically assess and discuss to what extent testable predictions can be made about the causeway routes linking the site of Pacbitun to its hinterland caves.

1.2 Expected Results

To date, most archaeological projects in the Maya area predominately have concentrated on the analysis of either settlement areas or caves. Analysis of the intermediate area between sites and caves has been rare to non-existent. Therefore, this research makes a substantial contribution to our understanding of how ritual behavior and pilgrimages influenced settlement patterns or visa versa. In addition, I explore the broader implications of predictive modeling techniques for our understanding of the ritual landscape in the Maya area in Belize.



Figure 1-1: Map of Belize
Source: ambergriscaye.com

2 THEORETICAL APPLICATIONS

2.1 Introduction

Settlement studies concentrate on the material traces of people's presence on the land and provide great insight into past societies at various scales. The distribution of buildings and artifact scatters can provide information about socio-political, religious, as well as economic situations (e.g. Ashmore 2004). In this chapter, I track the changing theoretical perspectives and conceptual frameworks that have influenced the interpretation of settlement data in Mesoamerica during the Culture Historical period prior to the 1950s, the Processual period, the Post-Processual period, and the Contemporary period (Trigger 2006). I then discuss various interpretive methods which are employed by archaeologists conducting spatially engaged research. In the last segment of this chapter, I outline the theoretical orientations I have employed in this thesis. I begin with an overview of practice-based agency theory which is employed by many Maya Archaeologists, studying settlement patterns today. I continue with a brief critique of some agency based concepts. Following the philosophical concepts of DeLanda (2006) and Deleuze (2004) I argue for a perspective that attempts to analyze the cultural and environmental setting by assigning agency to materials as assemblages. Material remains here are transformative entities that were created and manipulated based on changing ideologies of past human agents.

2.2 The Development of Settlement Theory in Mesoamerica

Prior to the 1960s, settlement pattern archaeology in Mesoamerica usually focused on monumental centers of differing size within a single region (Fox 1996:797). A major change in the development of settlement pattern studies in Mesoamerica was initiated in American

Archaeology by Gordon Willey. Willey, along with James Ford, set out to conduct the first regional settlement study conducted in the Americas. Thus, they had to develop new field and analysis methods, as well as new ways to interpret the regional reconstructions (Billman and Feinman 1999:1). As archaeologists started to look beyond culture history and towards the study of cultural processes, regional settlement analysis become more important and was increasingly applied by other archaeologists. Settlement survey soon became a major tool to answer anthropological questions like the origins of agriculture, the causes and consequences of warfare, social stratification, and the development of centralized institutions (Billman and Feinman 1999:1).

2.2.1 Culture History

Prior to the 1950s, Maya Archaeology was mainly focused on exploratory investigations and large scale projects primarily concerned with establishing cultural chronology. Archaeology during this “Descriptive Period”, (Johnson 1999:19) or the “Carnegie Period”, - (since it was the Carnegie Institute of Washington that sponsored many investigations at the time, amongst others) - focused on describing the natural and cultural world of the Maya, and the investigation of architectural chronology, through excavation programs (Garrison 2007:58). One of the first archaeologists to conduct a settlement pattern study was Edward H. Thompson in 1892, who identified small mounds as private homes at Labna, due to the fact there were so many of them. This argument has been marked as the “Principle of Abundance”, as it is based on the concept that the most common settlement type represents the houses of ordinary people (Ashmore and Willey 1981; Garrison 2007). One of the first intersite surveys was conducted by Alfred M. Tozzer in 1913, who noticed mounds in between major centers at the Classic site of Nakum (Ashmore and Willey 1981; Garrison 2007). As mentioned, in general, settlement data collection

in Mesoamerica at the beginning of the 20th century concentrated on small mound research (Ashmore and Willey 1981:6). This changed in the 1930s when the Carnegie Institution funded major excavations at sites like Chichen Itza, Uaxactun, and Mayapan (Ashmore and Willey 1981:7). It was also at this time, prior to World War II, when the first settlement studies were undertaken. As Kantner (2008:38) notes, Julian Steward's research of societies the Southwest and Basin areas of the United States in the 1930s was one of the first influences leading to regional archaeology investigations in the Americas. In his studies, Steward employed an ecological approach that explicitly considered the relationship between environmental characteristics, human populations, and patterns of regional settlement (Kantner 2008:38). Alfred V. Kidder, who was a leading Carnegie archaeologist at the time, brought into motion the first aerial photography and taxonomic system of ceramic classification (Ashmore and Willey 1981; Garrison 2007:62).

2.2.2 *The Processual Period*

According to Ashmore (2009:183), ecological and cultural evolutionary theory, together with favorable funding potentials, sparked opportunities for extensive landscape and settlement surveys after World War II. A number of these archaeological regional studies in the 1940s and 1950s were influenced by Julian Steward's research emphasis on entire landscapes rather than just individual sites (Kantner 2008:38). As Joyce (2004) states, Willey, a former student of Julian Steward, approached Mesoamerica from the perspective of Julian Steward's cultural ecology, a theoretical model which argued that different levels of cultural complexity were linked in regular, but not deterministic, fashion to environmental conditions. He then further developed the regional approach to archaeology, in order to obtain the kind of information that would be

necessary to employ this approach. In 1946, he set out to conduct a study of the Virú Valley, Peru, actually coining the phrase “settlement survey” (Ashmore and Willey 1981:10). It was the first time that settlement survey took as its focus a region, not a site. All the sites in a region were considered to be part of a system of interlocked economic and social units. Differences in the size of sites would be indications of differences in economic power within a region, as well as of social prominence and political authority. Settlement patterns provided the basis for selecting sites for excavation that then allowed the archaeologist to explore the full range of social activity (Joyce 2004:35). Following his success in Peru, Willey excavated several sites in the Belize Valley (e.g. Barton Ramie, Spanish Lookout, Baking Pot, and Melhaldo) (Chase and Garber 2004), but it was Willey’s Belize Valley Project at Barton Ramie that was the first to systematically collect settlement data within the context of a goal-oriented research program, that had explicit theoretical underpinnings. The project, begun in 1954, set out to examine the relationship of settlement occupation to the natural environment, to shed light on (1) the nature and function of buildings composing habitation communities, (2) understand form, size, and spacing of these communities in relation to others, and (3) consider these problems from a chronological perspective (Ashmore and Willey 1981; Garrison 2007:65). This approach differed greatly from the site-oriented surveys that had been conducted by the earlier CIW projects. In addition, through focusing on the analysis of common Maya households and living areas, instead of elite architecture, Willey was one of the first people to investigate the lower stratum of Maya society (Chase and Garber 2004:9).

Following Willey, William T. Sanders also used an ecological approach in his settlement pattern research in the Basin of Mexico in the early 1960’s, by viewing cities and towns as part

of a society's adaptation to the natural environment (Garrison 2007; Kantner 2008). Studies during this period became increasingly influenced by a scientific orientation that was part of a new approach in archaeological theory. Labeled as the “new archaeology” or processualism, focus in the mid-1960s shifted from descriptive archaeology to describing and explaining culture change (Garrison 2007:56). The new archaeology was strongly concerned with scientific methodologies and new analytical tools that had a strong impact on the formal approach, as archaeologists became increasingly aware of some of the methodological and analytical limitations of definitions and concepts utilized in settlement pattern studies (Kantner 2008:39; Parsons 1972:132).

By the late 1960s, a clear distinction between the settlement pattern, reflecting empirical observations by archaeologist, and the settlement system, representing theory-bound interpretations of the patterning, had emerged (Kantner 2008). As Garrison (2007) states, Norman Hammond, who worked on projects in Belize during the 1970s, was the first to incorporate data derived from natural resources and topography into his settlement pattern work. This led the way to further surveys integrating external data like geological and soil surveys, along with aerial reconnaissance and new technologies like radar mapping (Garrison 2007:71). From then on, environmental- and subsistence farming data were integrated in almost all settlement studies in the Maya area.

2.2.3 The Post-Processual Period

Towards the end of the 1970s, a number of archaeologists became increasingly dissatisfied with the materialism in processual archaeology (Johnson 1999:103). They argued for a more humanistic approach to archaeology that concentrated on the past individual and the

symbolic meaning of things, instead of employing a systems-evolutionary framework (Ashmore 2009). As a major advocate, Ian Hodder, proposed contextual archaeology in order to integrate the humanistic aspects of cultures into archaeological interpretation and thus, critiqued the excessive use of scientific methods (Garrison 2007; Johnson 1999). An example of such an approach was the Copan Mosaics Project, under the direction of William Fash of Harvard University in 1985, which was the first to integrate iconographic and textual data with archaeological data, striving for a more holistic analysis (Garrison 2007).

In regards to settlement survey archaeology, post-processualists wanted to address cognitive and ideological aspects of culture and not just focus on the relationship between settlement and environmental factors (Garrison 2007:57). With the increasing inconsistency amongst settlement surveys, it was Wendy Ashmore (1981) who created a summary of geology, topography, soils, climate, hydrology, flora and fauna, and ceramic phases, demonstrating an increased awareness of the importance of all environmental factors and their relationship to settlement. She addressed issues of methods and theory in different regions and created a typology for settlement patterns (Garrison 2007:79). Other than the settlement studies during that were founded in ecological and evolutionary perspectives during the processual period, here landscapes and settlements were seen, not only as displays of political and economic actions, but in addition as ritual expressions and cosmological meanings (Ashmore 2004:170; Ashmore 2009:185). For Maya archaeology, this meant viewing landscapes and settlements as they were created and inhabited by social agents who animated their world by drawing on natural and naturalized elements (Ashmore 2004:186). I will further discuss this view of the ancient Maya landscape in Chapter 6.

2.2.4 *The Contemporary Period*

Marked by the gradual incorporation of new highly technological tools into the methodological approaches of projects, the approach to settlement and landscape archaeology is still a holistic one. Together with these technological advances, guiding settlement and landscape analysis, a focus on ecology and land use, social history, ritual expression, and cosmological meaning persists (Ashmore 2009:184). An example of this is recent research on water ritual and management in Mesoamerica, illustrating the integration of scientific and humanistic approaches in landscape archaeology (Ashmore 2009:186).

Geographic Information Systems, Global Positioning Systems, remote sensing technologies, and airborne light detection have been increasingly incorporated into settlement pattern studies over the past years. These modern technologies provide great improvement for large scale surveys and research analyses. For example, the recently conducted LIDAR survey at the site of Caracol in Belize revealed an array of both, previously mapped, but also previously undiscovered structural groups, agricultural fields, and causeways that made it possible to identify features throughout its entire 200 km² area (Chase et al. 2011:391). Being able to accumulate data from full coverage surveys, like the one conducted at Caracol through LIDAR, can contribute to our understanding of the nature and composition of ancient Maya social structures, their political organization, and even over the causes behind the Classic Maya collapse (Chase et al. 2011:387).

As mentioned, other than the technological advances, today, the study of settlement archaeology and landscape analysis has been marked by theoretical and methodological diversity

(Ashmore 2009). Here, Ashmore (2009:186) mentions two prominent emerging research foci, addressing climate change and landscape degradation, as well as an increased input by indigenous communities, informing ancient ritual landscapes and political cartographies.

2.3 Interpretive Techniques to Settlement Data

Given the spatial nature of settlement pattern- and landscape analysis, as well as this research, it is important to review a few interpretive techniques that archaeologists in Mesoamerica employ when analyzing their data. Settlement studies, population estimates, and state complexity are intertwined and all display components of this thesis. In addition, site typologies and power relations between ancient states are still debated in Maya archaeology to this day, including the archaeology in the Belize Valley (see Chapter 3). Therefore, I will briefly discuss some aspects of the debated Maya state models, including centralized and decentralized hierarchical models, as well as ethnographic analogies.

2.3.1 Centralized vs. Decentralized Models of the ancient Maya State

After conducting survey work in the Petén in 1958, William Bullard (1960) was one of the first people to address Maya political organization and classify settlement remains (Garrison 2007:65; Iannone 2004:276). Bullard (1960) proposed a three-tier typology for Maya settlement: (1) house ruins, (2) minor ceremonial centers, and (3) major ceremonial centers. This typology was then organized into a hierarchy of clusters, zones, and districts (Ashmore 1981, Bullard 1960; Driver and Garber 2004:288, Garrison 2007: 65; Iannone 2004). Since Bullard's settlement investigations, a much more complex picture of the sociopolitical relationships has emerged and various, more detailed, typologies for ancient Maya settlement have been proposed

(e.g. Driver and Garber 2004:289; Iannone 2004:276). In addition, trying to define a hierarchy of settlements ultimately led to the discussion of how autonomous, populous, and centralized some of these ancient polities might have been (e.g. Fox et. al 1996:795).

In the centralized state model, states are defined as class-based societies with a minimum of two classes, elite and non-elite, that are not subject to kinship. Here, the elite rulers act as a full-time bureaucracy and are interested in territorial control, which they pursue with armed forces. Centralized states display a higher level of specialization as well as a complex administrative hierarchy (e.g. Ball and Taschek 1991:154; Fox et. al. 1996:801; Glover 2006, McKillop 2004:118). Employing ethnographic and ethno-historical research, decentralists argue that kinship played a key role in social and political organizations. In this case, power is dispersed among centers resulting in political redundancy where members have greater independence and thus fewer full-time craft specialists (Ball and Taschek 1991; Fox et. al. 1996:801, Glover 2006, McKillop 2004:118).

2.3.2 *Ethnographic Analogies*

In archaeology, ethnographic analogies are often used to try to interpret various social organizations of the Prehispanic past (Normark 2006). Sanders (1999) mentions that, while the modern cultivation he encountered during his settlement pattern project in the Teotihuacan Valley had destroyed much of the ancient architecture, due to the long practiced form of subsistence farming in the area, he was able to use the present-day settlement patterns, cultivation practices, and resource utilization as models to reconstruct the prehistoric agricultural patterns (Sanders 1999:13). This is a good example of how ethnography can aid archaeological

reconstructions. Since archaeologists frame hypotheses around recovered material remains of past processes, anthropological observation can help specify these general hypotheses into observable outcomes that can be expected to appear in the archaeological record. Thus, observation of contemporary processes can provide bridging arguments necessary to assign meaning to past material remains (Thomas 1999:162).

However, despite all the contributions to archaeological research, ethnographic analogies should still be handled with care. Cardoso (2003) agrees by stating that ethnoarchaeology and actualistic studies can be used to reconstruct past events and phenomena by analogy, using information derived from the present to explain data from the past. However, relations between material and behavior must be invariant if they are to serve as timeless, spaceless rules of reconstruction (Cardoso 2003:62). In other words, the suggestion that we can compare present human behavior to past human behavior would suggest that human behavior does not change. Certainly, archaeology must rely on clues, which includes ethnography, but correlations between material culture and behavior indicate what happened in the past but not necessarily why (Cardoso 2003:62).

2.4 Theoretical Orientation of this Thesis

For the results of my settlement research at Pacbitun, I employ agency theory, in order to analyze the relationships between the past agent and the built environment on a macro-level. On a micro level scale, I follow Normarks (2004, 2006, 2008) concept of polyagency while employing the philosophical concepts of Deleuze (2004), as interpreted by DeLanda (2006), and Normark (2004, 2006). More specifically, I apply an assemblage theory perspective; where

the material remains are the focus of the initial research process, not presumed concepts like practice, cosmology, or ethnography.

2.4.1 *Agency Theory*

Many archaeologists over the past decades, embracing a practice-based approach, have turned from macro-level to micro-level analyses, emphasizing past human individuals or agents (e.g. Dobres and Robb 2000; Normark 2006). Practice theories can be defined as theoretical constructs and their applications, which posit a dynamic notion of culture as being constituted through the dialectical relationship between structure and agency (Lopiparo 2005:1). In other words, and stated in a simplified way, cultural knowledge shapes peoples practices while at the same time these practices reproduce or transform culture (Ortner 2001:271). As McAnany states (2010:307), practice theory is a way to reconstruct the past in a manner that begins to approximate the deeply ritualized, and fundamentally agentic, experience of ancient Maya life that is indicated by archaeological remains. Those employing practice-based approaches often turn to Bourdieu's theory of practice or Giddens's structuration theory which highlight the dialectic relationship between an *agent*, an individual who can alter structures through practice, and *structure*, the settings and conditions that result from ongoing relationships between individuals, in order to discuss this agency (Dornan 2002; Glover 2006; Normark 2006). In agency theory, people are not uniform automatons, merely reacting to changes in the external world, but instead play a generative role in the formation of the social realities in which they participate as "human agents" (Dornan 2002).

Bourdieu's theory of practice examines how a human agent moves about within a field and a structure. Practices are only understandable in relation to structures behind the agents that

are incorporated in the body as “habitus” (Normark 2006). Habitus is based on the memories of past practice which unconsciously shape future action. It is an explanation of structured, structuring and durable dispositions internalized in humans which are produced historically. The habitus is shaped by the “doxa”, or field of knowledge, which is created through non-discursive practice and the interaction between fields and habitus (Normark 2006). Thus, individual action is primarily determined by unconsciously internalized structures (Dornan 2002). These structures make asymmetrical social relationships seem self-evident and undisputed, creating a “the way things are” themed social environment (Glover 2006). In Giddens’ structuration theory, agency is constituted by its involvement in practice, which in turn reproduces structure (DeLanda 2006:10). Here, agents have the capacity to reflect on their actions and identities, and act according to their intentions.

To what degree agents actually act according these reflections and intentions is discussed in different practice theories. For example, Lopiparo (2005) has labeled the two poles of practice theory “Practice Theory Light” and “Practice Theory Dark”. Practice theory light emphasizes free will, agency, change, and dynamism, while practice theory dark emphasizes constraint, structure, stasis, and the status quo (Lopiparo 2005:2). In her discussion about the agency of actors and the constraints of the structures that influence and are influenced by these actions, Joyce (2004:5) contends that actors are always knowledgeable and act with intentions but that these actions often have unintended consequences (Joyce 2004:5). For example, early monumental platforms in ancient Mesoamerica might have not been intended as burial places but later were utilized as such, due to social transformations and changing ideologies (Joyce 2004:15-16). The discussion of unintended consequences is another example of how complex

and difficult it can be to try to analyze the relationship between agent and structure, especially since the reflexivity between individuals and structures is an essential and transformative element of the social process (Normark 2006). For this thesis, I employ the mix of both poles of practice theory for the analysis of the built environment in the Pacbitun periphery and its past inhabitants.

2.4.2 *Considerations for Practice-Based Theories*

At this point I address two issues associated with practice/agency theory, concerning (1) the conception of a human agent and (2) the interpretation of material objects. As Ortner (2001:272) states, the value of using a theory in which human intentionality matters, seems evident. With this however, the problem of confining past human actors to the concept of agency arises. As Normark (2006) states, when human agency is used as basis for archaeological studies, there is reason to be cautious, as it cannot be known when it first occurred in the form(s) known today. Further, Shennan (2004) notes:

Our desire to see people in the past as the active, knowledgeable agents we believe ourselves to be, means requiring all material culture variation to result from self-conscious identity signaling and all change to be the outcome of the conscious choices of individuals with existentialist mentalities who walk clear-sightedly into the future.

Ortner (2001:272) on the other hand argues, that while one must be cautious of the concept of agency, because of its tendency to slide into the Western concept of bourgeois individualism, it is a general characteristic of all human beings, as everyone has agency and thus agency is, by definition, everywhere in the archaeological record (Ortner 2001:272). Further, she suggests that instead of looking for instances of agency, it should be presupposed. While I agree with Ortner's argument that everyone has agency, this statement has two shortcomings: (1)

simply presupposing agency still ignores the un-recoverable spectrum of thoughts, emotions, motivations, and many other invisible aspects of the past human agent and; (2) it does not accredit agency to anyone or anything but people. It seems to me, that trying to find direct relations between past human actors and the material and built environments they left behind does not only falsely simplify complex processes but also creates the danger of ignoring more diverse analyses. In addition, I find that agency should not be confined to people but instead be extended to material objects, architecture, animals, and the environment in general, since all material and non-material objects and subjects influence and are influenced by each other. Hutson (2010:12) speaks of an agency of objects in his relational approach to people and ruins in Chunchucmil, a Classic period Maya site in Yucatan, Mexico. In his research he argues that subjectivity is not given, but produced through practices that create relationships with people, places, and things (Hutson 2010:184). Objects play a key role in the creation of difference between people (Hutson 2010:185). While Hutson (2010:189) acknowledges the importance of objects, as a person's agency extends beyond the biological self and finds expression in practices that subject one to various relations through which they emerge as an intelligible subject, objects are still defined solely by their connections to people.

Normark (2006) takes the notion of assigning agency to objects a step further, with a theoretical concept he calls "polyagency". Normark's polyagency focuses on different agents, both material and immaterial. Each polyagent has a plurality of polyagencies depending on its dialectic relationship with other polyagents within a social network (Normark 2004:142). Materials then are polyagents which indeed can be cause and effect. Material objects are still related to the past human agent, as they were manufactured and used by him or her, however,

simply *assuming* practice based actions that inform human agency, which can then be recreated through the archaeological record is also based on the assumption that the materials we find in the archaeological record derive from linear sets of gradually developed instances.

For Normark (2004), practice can be defined as actions of a human agent in relation to materiality in a temporal and spatial setting (Normark 2004: 141). That however would suggest that time stood still. An agent creating a ceramic vessel becomes better every time he or she creates a new vessel; skill, experience, and anticipation have played a role in every archaeological deposit we encounter. Every newly created object will be different in some way, at some point. Practice therefore can not really be traced through time, it is invisible. What is visible is the artifact, which is left behind in the archaeological context. Causation (practice) and effect (artifact) are therefore non-linear and can not be assumed to automatically be related (Normark 2004:142). Instead, concentration must be shifted to what is visible first. Hence, the artifact becomes the visible cause, which, after examination, will be related to a possible effect (practice).

Lopiparo (2005) states that all practice theories have in common an agency-centered focus that is concerned with the ideational factors that affect human behavior, both conscious and unconscious, intentional and unintentional, discursive and nondiscursive, strategic and accidental (Lopiparo 2005:2). Thus, the focus in practice based theories lies with human motivated behavior. Artifacts which have been manufactured by these human beings are manifestations of a depicted order which themselves affect their surroundings, since they are polyagents as well. The objects' capability to affect its surroundings is presented in its biology of

events throughout its existence (Normark 2004:142). Once this “biology” is understood and the object’s relations to human agents have been investigated, we can begin to see other effects in the causal milieu of this relationship. Only then are we able to use the practice theories to investigate other ontologies than the visible one (Normark 2004:142).

I argue, that it is this issue of observation and visibility to the archaeologist that leads to the various interpretative theoretical frameworks in the discipline. DeLanda (2006:4) calls this the problematic link between the micro- and macro-levels of reality. Traditionally, the problematic link between micro- and macro-levels of reality has often been framed in reductionist terms. Reductionism in social sciences is often illustrated with the methodological or phenomenological individualism characteristic of microeconomics, basing the conception of the micro-level on either individual rationality, or routines and categories that structure individual experience respectively DeLanda (2006:4). Another position that has been often adopted to address the micro-macro issue is the notion that social structure is what really exists, individual persons being the products of the society they were born into, a stand that has been embraced by functionalists. As demonstrated, Anthony Giddens uses the intermediate level of practice to articulate between the micro and the macro. While there are many other examples, according to DeLanda (2006) however, this “in-between” has not been properly conceptualized and he argues that “assemblage theory” can provide the framework in which the contributions of Giddens and other authors may be properly located and the connections between them fully elucidated (DeLanda 2006:5). In “assemblage theory”, assemblages can serve as component parts in larger assemblages, thus creating intermediate levels of scale, linking the micro- and macro-levels of social reality by recognizing that social processes occur on more than the two levels of micro-

and macro-. Instead, micro and macro refer, at any given spatial scale, to the concrete parts and the resulting emergent whole (DeLanda 2006:32). I will eluminate this concept further in the next section.

2.4.3 *Assemblage Theory*

As mentioned, DeLanda (2006:8) rejects the notion of society as a whole but does not see the denying of such an entity as an equivalent to a commitment to the existence of only individual persons and their families. Rather, he rejects the conception of wholes possessing an inextricable unity in which there is a strict reciprocal determination between parts. One of the dominant theories about the relations of individuals and society, or parts and wholes, comes from functionalism. DeLanda describes the theorized relations between parts (e.g. individuals) and wholes (e.g. society) of functionalism as "relations of interiority", where the component parts are only constituted by the very relations they have to other parts in the whole (DeLanda 2006:9). In contrast to this, DeLanda argues that a whole must be analyzable into separate parts and at the same time have irreducible properties which emerge from interactions between parts (DeLanda 2006:10).

Without such complex interactions between component parts, emerging mechanisms can not be defined and observed, thus focus must shift from the relations of *interiority* to the relations of *exteriority* (DeLanda 2006:10). It is this notion of relations of exteriority that is based on what Gilles Deleuze originally called assemblages, wholes characterized by relations of exteriority (DeLanda 2006:10). Relations of exteriority mean that a component part can be detached from one assemblage and plugged into another in which the part's interactions are

different (DeLanda 2006:10). In other words, assemblages can be analyzed through their components which are also assemblages themselves. These components can be plugged in or out of assemblages in which their interactions are different but without losing their identity, because assemblages are collections of heterogeneous elements. Components in an assemblage can be material or expressive, whereas material components involve a range of causal interactions, expressive components usually involve catalysis. Both types however can either, stabilize or destabilize, consolidate or rigidify the identity of the assemblage (DeLanda 2006:22). Hence, the mechanisms that can cause the processes to effect the assemblage can be nonlinear (DeLanda 2006:19). Therefore, products must be analyzed through the historical processes that produced them, instead of analyzing them as finished entities, since the identity of any assemblage, at any level of scale is always the product of a process, and it is always precarious, since other processes can destabilize it (Figure 2-1) (DeLanda 2006:28).

As Wise (2005) notes, elements in an assemblage can be diverse things brought together in particular situations, such as everyday used materials unearthed in an archaeological dig, for example bowls, bones, cups, tiles, figurines etc. (Wise 2005:78). The collection of these materials and their relations express a particular character. The elements making up the assemblage also present the qualities encountered (e.g. large, poisonous, etc.) and the effects and efficiency of the assemblage. This leads to the question of not just what it is but what it can do. Hence, the true nature of an assemblage can only be assessed after we know what it can do and how it works (Wise 2005:78). Another example would be traditional routines observed by archaeologists through material remains or iconography, which may be interpreted and therefore reduced to being ritual and ceremonial. This however would obscure that in actuality many

traditional routines derive from problem-solving procedures which have been slowly refined over generations. The practical routines were overlaid by ritual symbolism, while they in fact lead to successful causal interactions with material entities, for example plants (DeLanda 2006:24).

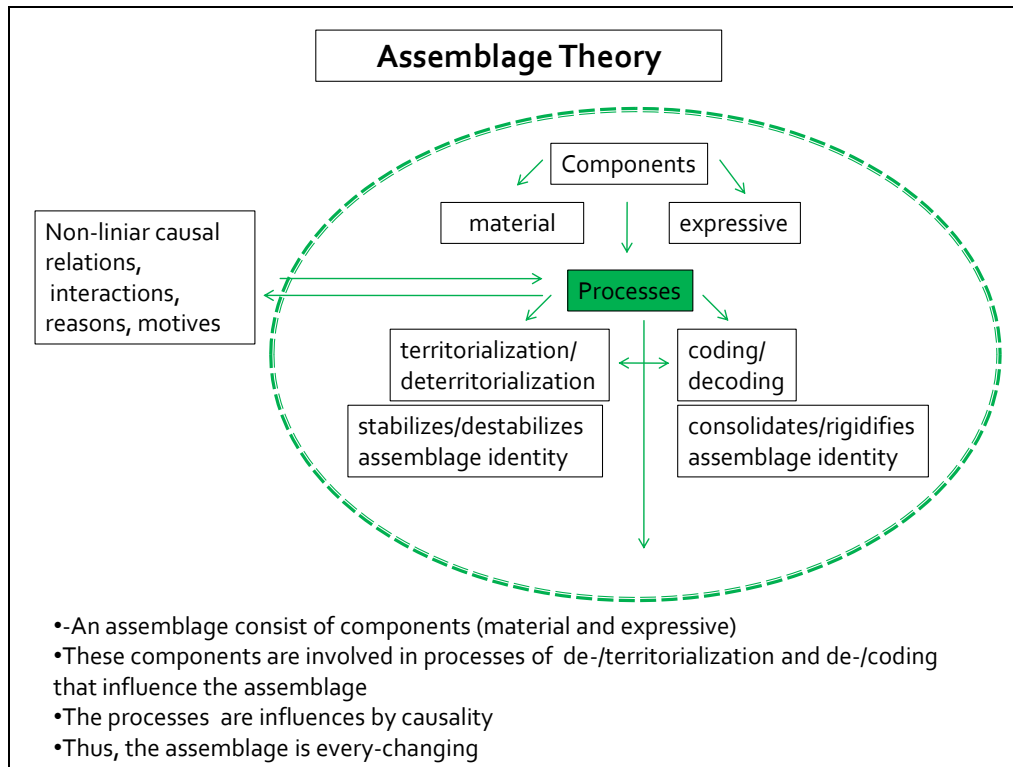


Figure 2-1: The assemblage theory concept (by Jennifer Weber, after DeLanda 2006)

2.4.3.1 A “Mad” Analogy

In "The Logic of Sense" Deleuze (2004) provides an example of how events can imply contradictory properties of a thing in a manner inconceivable within linear time, with an example from Lewis Carroll's "Alice in Wonderland" (Deleuze 2004:3, Patton 2010).

When I say “Alice becomes larger,” I mean that she becomes larger than she was. By the same token, however, she becomes smaller than she is now. Certainly, she is not bigger and smaller at the same time. She is larger now; she was smaller before. But it is at the same moment that one becomes larger than one was and smaller than one becomes. This is the simultaneity of a becoming whose characteristic is to elude the present. Insofar as it eludes the present, becoming does not tolerate the separation or the distinction of before and after, or of past and future. It pertains to the essence of becoming to move and to pull in both directions at once: Alice does not grow without shrinking, and vice versa. Good sense affirms that in all things there is a determinable sense or direction (sense); but paradox is the affirmation of both senses or directions at the same time.

With this word game of the Plato-based concept of becoming, or “Platonic-Dualism” (Deleuze 2004), Deleuze illustrates that any event points in two directions. In the given example, Alice becomes larger and also can now be labeled as having been smaller before. To assume static linearity through time would consequently mean that we only observe Alice becoming larger. The fact that she was smaller before and might be smaller again, is lost in the archaeological record. If we expand Deleuze’ example a little further and put ourselves in the shoes of an archaeologist who encountered Alice’s “Eat Me” glass box she ate out of to become smaller, after she drank the “Drink Me” potion from the bottle which caused the growth, in the following assemblage: Room-Table-Small Door-Box, we can suggest that a practiced based archaeologist would analyze the encountered “eat me” box by trying to relate it to the past human agent, in an attempt to explain what practices might have produced that box in that room.

However, we know that Alice is gone and can not give any information on her motivation on why she dropped the box where she did. If we follow Normark's example of cause and effect, we would try to avoid starting the analytical process with the invisible cause or practice but instead try to analyze the "eat-me" bottle as the visible cause in an assemblage. What can the box do? It can be filled, opened, displayed, emptied, thrown, dropped, be of sentimental value. The box was encountered on the floor in a room with a normal sized table and a small door. Since we already acknowledged that the bottle can be filled, we might arrive at the explanation that the bottle may have been filled with some kind of substance that served to shrink someone in size in order to fit through the door. After the observation and analysis of this iconic assemblage, we can try to investigate the relations of the object to the human agent, here Alice, and the practices that might explain her relationship to the room, the box, and the door. On a side note, the small door in the assemblage influenced not only how the room was perceived (small door vs. large table) but also had an effect on the presence of the box and bottle, further demonstrating how materials can act as polyagents and exist in non-static assemblages (if the box had been removed, the context would have changed, without an exit possibility, the room would become a prison).

2.4.4 Summary of Theoretical Approach

As it is known, recreating the past through deposited material objects has obvious limitations. According to cognitive-processualist Colin Renfrew (Hahn 2010), we can infer ways of thinking from material remains, actual thoughts from the past however may never be recovered (Hahn 2010:191). According to Hahn (2010), Renfrew ultimately "admits" that from a cognitive-processualist standpoint, theories about the past and human cognition are ultimately impossible to demonstrate conclusively, thus leading to absolute relativism, undermining all

meaning to research (Hahn 2010:200). I want to critique Hahn's statement here in stating that using the term "admitting" might be a poor choice of words. Given, that archaeologists try to reconstruct the past based on very few material remains and clues, I doubt it is possible to ever create a concrete, conclusive theory. What I argue is that this should not be considered a flaw. By thriving for such concrete, conclusive theories in archaeology I see the danger of leading to (1) the tendency to accept certain overlaying concepts (e.g. cosmology) instead of looking for other possible explanations, (2) the tendency to assume more knowledge about the human past agent's motivations than can be derived from the archaeological record, and/or (3) the tendency to create a false sense of fullness of the archaeological record (Normark 2006).

Following an assemblage-based analysis, I am not arguing for an objective or relativist analysis approach, nor do I reject all typological models and frameworks. Instead, while employing agency theory for the grand analysis scheme, I apply assemblage theory for the in-between analysis, bridging micro- and macro levels of reality. Here, the archaeological context is analyzed through the visible, actual encountered, materials remains first and polyagency is attributed to materiality, *before* the agent-object relationship is examined (Normark 2004:163). Although I agree with Hutson's (2010) concept of relations between people, places, and things, his approach still assumes that overall concepts employed by a past human agent are known. Following Normark (2006) I argue, however, that past agency is often explained through cosmological and ethnographical concepts, as well as assumed practices of a past agent long gone. Instead of assuming these concepts and practices focused on the past agent, I choose to focus on what materials I visibly encountered in the archaeological record. It is only after this, first, process, that comparisons of different sites and practices in relation to other practices at

certain structuration levels, and in certain arenas of power, can be made (Normark 2006:163).

Assemblage theory here is not meant to replace agency theory but aid it, as in assemblage theory agency, the relations between agents and structures, and practices are key concepts.

2.5 Conclusion

Settlement pattern research has had a thriving history in Mesoamerica in the past six decades.

With Gordon Willey as a hallmark figure, settlement surveys have influenced everything, from research on population estimates to subsistence patterns, political structures, and world views.

Mesoamerican landscapes continue to be analyzed through their ecological, ritual, political, and cosmological meanings, and with new technologies at hand, one can only guess the further advances settlement research will further undergo and based on the theoretical foundations of the past 50 years. However, it seems somewhat safe to say that it will probably lead to an increasingly better understanding of ancient settlement structures in Mesoamerica.

While agency theory provides us with an overall or “grand” framework to analyze the dynamic relationship between the past human agent and the built environment, assemblage theory, and the concept of polyagency, allows us to analyze the “immediate effects” (Normark 2004:162) between the past human agent and material remains and architecture. The writing of Lewis Carroll were not only used by Deleuze (2006) to emphasize a point through a quote by Lewis Carroll. As David Clarke (1978) cited in his book “Analytical Archaeology” from “Through the Looking Glass” (Johnson 1999:15):

Now here you see, it takes all in the running you can do, to keep in the same place.

The Queen to Alice

Clarke used this quote to demonstrate his doubt that the methods that were employed in archaeology at the time led to a better and reliable version of the past (Johnson 1999:16). While more and more information was accumulated, the materials were fit over and over again in the same endless sequence of cultures (Johnson 1999:20). Clarke argued that a modern empirical discipline ought to be able to aim at more rewarding results than the maintenance of a relative status quo and a steady flow of history books (Johnson 1999:16). While Clarke advocated the progression towards a more scientific and anthropological way of doing archaeology several decades ago, the call for movement and inquiry, (Hodder 1981:11), in archaeological theory and methods still rings true. Here, assemblage theory advocates another way of looking at archaeological data and provides a different kind of theoretical perspective for the research process I employed in this thesis.

3 NATURAL, CULTURAL AND ARCHAEOLOGICAL HISTORY

3.1 Introduction

This chapter provides a brief description of the topography and climate of Belize and the Belize Valley in particular. In addition, I review the major archaeological sites of the valley before focusing to the ancient Maya site of Pacbitun and a description of the main caves that have been encountered in the periphery and that played a central role in my survey research. Finally, I provide a background, including typologies, of ancient Maya causeways, as the Pacbitun causeway system presents a major focus point of my research. All photos, maps, and tables were made by me, unless otherwise noted.

3.2 Topography and Climate

Belize is located in the southeastern section of the Yucatan Peninsula in Central America, bordered to the south and west by Guatemala, to the north by Mexico, and to the east by the Caribbean Sea (Williams 1996). While the social geography and modern history of the country are very distinct from those of its neighbor countries, the physical geography is less of a contrast. The northern part of the country is flat and contains no known caves of significance, but the southern half of Belize has caves in great profusion throughout the limestone foothills and outliers of the Maya Mountain range (Williams 1996). The Maya lowlands reach from southeastern Mexico into Honduras, extending through Belize and Guatemala, covering an area of over 350,000 square kilometers (Figure 3-1) (Hammond and Ashmore 1981:20). Most of the Maya lowlands consist of a limestone bedrock foundation, parts of which emerged as sea levels fell during the Pleistocene (Hammond and Ashmore 1981:20). The climate is mostly humid and warm with seasonal rainfall from May to December.



Figure 3-1: Southern Maya lowlands
 Source: latinamericanstudies.org

The Belize Valley includes two topographical sub-regions, the upper Belize Valley and the central Belize Valley. The upland area is located to the west of the convergence of the Mopan and Macal Rivers and consists of slopy and hilly terrain. The central area consists primarily of alluvial flatlands and bordering hills to the west of the Belize River (Figure 3-2) (Chase and Garber 2004). According to Anabel Ford (2004:244-245) differential occupation can be found in three major resource zones along the Belize River, (1) the valley, (2) the ridgelands, and (3) the foothills. According to Ford (2004:243), well-drained uplands present primary agricultural resources, while the slow-drained lowlands and riverine environments display secondary agricultural resources. Closed depression swamps are characterized as nonagricultural resources.

3.3 Maya Chronology

The ancient Maya civilization developed in Mesoamerica, predominantly in Guatemala, Belize, Mexico, Honduras, and El Salvador (McKillop 2004). The first traces of the people who came to be known as the Maya are dated to stone tools used in the Paleoindian period (~12000 to 8000 BC), which was followed by the Archaic period (8000 to 2000 BC), which ended with the appearance of the first pottery in the Maya area (McKillop 2004). The chronology of the Maya area is generally divided into three prominent time periods, (1) the Pre-Classic/Formative period dating from 2000 BC to AD 250, (2) the Classic period dating from AD 250 to AD 900, and the (2) Post-Classic period dating from AD 900 to AD 1521 (McKillop 2004). All three time periods include sub-divisions (Table3-1).

Table 3-1: Maya time table

Time Period	From	To
Palaeoindian	~12000 BC	8000 BC
Archaic	8000 BC	2000 BC
Pre-Classic/Formative	2000 BC	AD 250
Early	2000 BC	900 BC
Middle	900 BC	400 BC
Late	400 BC	AD 250
Classic	AD 250	AD 900
Early	AD 250	AD 600
Middle	AD 400	AD 600
Late/Terminal	AD 600	AD 900
Post-Classic	AD 900	AD 1521
Early	AD 900	AD 1200
Middle	AD 1200	AD 1430
Late	AD 1430	AD 1521
Colonial	AD 1521	1810
Modern	AD 1810	To now

3.4 Sites and Settlement in the Belize Valley

According to Ashmore and Willey (1981), despite a few visits by the Spanish to some Maya ruins, settlement pattern studies in the Maya Lowlands began in the mid 19th century, notably by John L. Stephens and Frederick Catherwood (Ashmore and Willey 1981:5). As mentioned in Chapter 2, Gordon Willey (1956) concentrated the bulk of his work in the Belize Valley at the site of Barton Ramie, where he mapped over 250 mounds and excavated 65 of them (Chase and Garber 2004; Willey 1956). Barton Ramie was characterized by the dense occurrence of housemounds, lengthy sequence of occupation, and lack of large temple-pyramids, as well as stone architecture and monuments (Chase and Garber 2004:5). At the time, Willey (1956) typified Barton Ramie and the valley as a rather rural environment that was mainly abandoned after the Maya collapse (Chase and Garber 2004:5; Willey 1956:780).

The densest ancient Maya settlement in the central Belize Valley occurred along the banks of the Belize River, due to rich alluvial soils deposited through frequent floods. Thus far most ancient settlements have been located to the south of the Belize River, even though Chase and Garber (2004) mention that this can probably be attributed to the lack of archaeological reconnaissance done to the north of the Belize River thus far (Chase and Garber 2004). Thus far, Preclassic materials have been recovered at Cahal Pech, Pacbitun, and Blackman Eddy. While most the ancient Maya sites were abandoned after the Terminal Classic, ceramic analysis since Willey's and Gifford's (1978) original work at Barton Ramie has revealed an occupation period spanning from the Formative well into the Postclassic period (Table 3-1), providing evidence of almost 3000 years of continuous occupation in the Belize Valley (Table 3-1) (Chase and Garber 2004:8).

Following his research at Barton Ramie, Gordon Willey named three ceremonial centers in the valley, Xunantunich, Cahal Pech, and Baking Pot, which are all characterized by sizable, steep-sided temple mounds, lower palace platforms, two or more plazas, stelae, and at least one ballcourt (Garber et. al 2004:48). Since then, five other major centers have been identified: Buenavista del Cayo, Las Ruinas, El Pilar, Pacbitun, and Actuncan in the western end, as well as Blackman Eddy and Camelote in the central area of the valley (Figure 3-2) (Garber et. al 2004:48-49). Some of the intermediate minor centers in the area are Floral Park, Esperanza, and Bacab Na. Smaller peripheral sites of note include the *plazuela* of Bedran, the North Caracol Farm group, and the Spanish Lookout *plazuela* (Helmke and Awe 2008:83).

In reference to section 2.3 above, I want to mention here that the distinction between minor and major centers in the Belize Valley has continued to be a subject to debate to this date. Gyles Iannone (2004:278) has argued for a greater range of settlement variability, than solely identifying them as major and minor centers. Therefore, he has suggested a loose typology consisting of lower-, middle-, and upper-level settlement types, with according subtypes. These types range from single housemounds to major centers (Iannone 2004:279-282). Based on the results of reconnaissance surveys conducted by the Belize Valley Archaeological Project, it has been suggested that the major centers along the Belize River are 9.9 km apart (Driver and Garber 2004:289). These major centers include Baking Pot, Blackman Eddy, Cahal Pech, Camelote, and Xunantunich. Therefore, Driver and Garber (2004:289-292) proposed a three-level site ranking scheme that groups sites located within 2 km of a major center into Type 1, sites beyond the 2 km range into Type 2, and sites located equidistant between major centers into Type 3. As examples of Type 3 sites they name Floral Park, Esperanza, Nohoch Ek, Ontario, and Warrie Head (Driver and Garber 2004:292-293).

Ford (2004:254) named three important variables that contribute to the hierarchical structure and underwrite power in complex societies: (1) the quality of subsistence base, (2) the distribution of subsistence resources, and (3) the level of critical resource control. As the primary subsistence resource she names the well-drained ridgelands, which demonstrate a long settlement prehistory, high settlement densities, concentration of large elite residences, and the presence of a ceremonial center (Ford 2004:242).

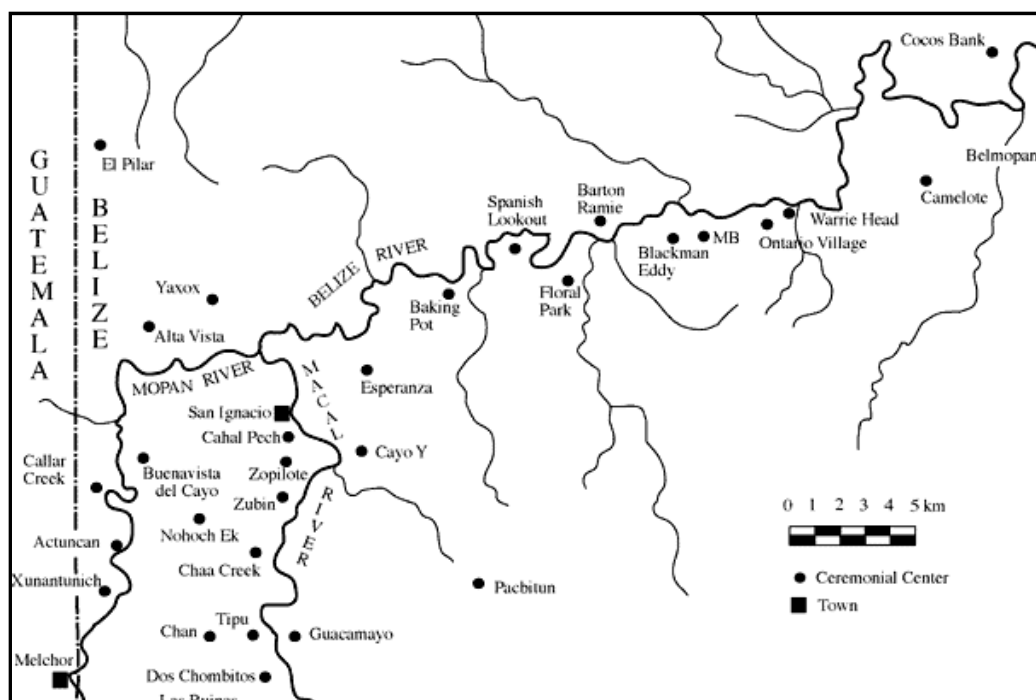


Figure 3-2: Ceremonial centers in the Belize Valley
Source: Famsi.org

While much archaeological research was undertaken in the Belize Valley, following Willey's work at Barton Ramie, the bulk of this research has concentrated in the Classic period occupation. This has changed in the past years. For example, at the site of Blackman Eddy, Garber and colleagues (2004) focused on the Formative period, which revealed a developmental sequence of architectural construction initiated by approximately 1100 BC, as well as evidence for the trade of exotic goods from the Guatemalan highlands, the Motagua Valley, and the Caribbean coast (Garber et. al 2004:46). Blackman Eddy is located approximately 2 km from Barton Ramie and probably served as an administrative center for the Barton Ramie settlement zone (Garber et. al 2004:67). Like Blackman Eddy, the site of Baking Pot also served as a major center in the valley. As the sixth largest known site in Belize, Baking Pot lies approximately 10.2 km northeast of Cahal Pech, 11 km west of Blackman Eddy, and about 12 km north of Pacbitun.

Covering approximately 5.6 hectares, the monumental architecture at the site includes monumental structures, plazas, and courtyards, as well as intrasite causeways (Helmke and Awe 2008:81).

Buenavista del Cayo is a medium sized center located on the Mopan River, within 5 km from Cahal Pech, 6 km of Xunantunich, and 13 km from El Pilar. The site was first occupied during the Middle Preclassic period. Cahal Pech or “Place of Ticks” (Yucatec Maya) is a major center overlooking the town of San Igancio and was occupied from about BC 1000 BC to 800 AD. By the Late Preclassic, Cahal Pech had developed into a major center in the upper Belize Valley (Awe et. al 2009:179). The site includes 34 structures, which include pyramids and several long-range, residential-type buildings in the site center, as well as 7 courtyards. The tallest structure, Structure A- I, stands 12 meters high. The site also contains two ball courts, five plain stelae, one altar and possibly a sweat-house.

Like Cahal Pech, the site of El Pilar was also first occupied during the Middle Preclassic. The site, bordering the Belize Valley to the northwest, displays earliest construction phases dating to approximately 700 BC and extending into the Terminal Classic, around AD 900 - 1000 (Ford 2004:242). Including about 200 structures per square kilometer at its peak occupation, all together, El Pilar consists of 50 hectares of monuments in the core area, which is connected by a causeway system that extends into the modern political boundary of Belize and Guatemala (Ford 2004:242).

It has been argued, that Cahal Pech served as a principal royal home from the 7th century until the collapse (Taschek and Ball 2004:199). Taschek and Ball (2004:198) have proposed that

the palace compounds at Buenavista and Cahal Pech were used concurrently from the Late to Terminal Classic periods. Here, Cahal Pech served as the “summer palace” during the dry season and Buenavista served as the “winter palace” during the rainy season. Thus, both sites displayed permanent, year-round, long-term residency and, as a consequence, not only grew but also underwent heavy remodeling and renovations (Taschek and Ball 2004:203).

Xunantunich is the largest center in the Belize Valley, located at the western end of the Belize River Valley (Fields 2004:181). It was predominantly occupied between AD 650 and AD 1000. The site displays more than 25 monumental structures and six major plazas. The tallest building is the pyramid “El Castillo”, which rises 40 meters above the main plaza (Plaza A-1). El Castillo displays a stucco frieze on its east side (Fields 2004:181-182). Other than Taschek and Ball (2004:203), who have argued that the palace at Xunantunich served only as an occasional and temporary residence for royal visitors and ceremonial purposes, Leventhal and Ashmore (2004:178) have stated that the site emerged as a major force during the Late Classic period, a time when Buenavista del Cayo declined in power.

Another major political player in the Late and Terminal Classic periods was the site of Caracol (Chase 2004: 329). Though not located in the Belize Valley, Caracol’s realm of power might have extended as far as Pacbitun at the time (Chase 2004:330; Healy et. al 2004:225). The archaeological ruins of the site can be described as the largest known site in the Southern Maya lowlands. With its various parts linked by a dendritic causeway system, Caracol covers 200 km², displaying a massive, modified landscape that ties settlement, roadways, and agricultural terraces together in a complete settlement system (Chase et al. 2011:388).

3.5 Pacbitun

As previously mentioned, Pacbitun is a major ceremonial center in the Belize Valley (Garber et. al 2004:48). Archaeological investigations started in 1980, under the direction of Paul Healy of Trent University, with preliminary survey and mapping, followed by extensive excavations in the site core and surrounding areas (Healy et. al 2004:207).

3.5.1 *The Pacbitun Environment*

The site is located in the foothills of the Mountain Pine Ridge in the Cayo District, about 3 miles from San Antonio Village. Situated at the juncture of two eco-zones, the lowland tropical rainforest and the Mountain Pine Ridge, the surrounding terrain is hilly with naturally fertile soils trapped in low-lying catchment basins and valley-like depressions. Pacbitun was first inhabited about 800 BC (Healy et al. 2007), and reached its peak of cultural development during the Late Classic period (AD 600-900). At this time the site likely controlled an area of 9 km² (Figure 3-3). Ceramic analysis indicates that the site was possibly abandoned by the beginning of the 10th century AD (Healy et al. 2007).



Figure 3-3: View to the north in the Pacbitun periphery

Settlement studies at Pacbitun have shown a population rise from the Preclassic through Classic periods. This goes along with an apparent increase in maize production in the latter, shown in intensive constructions of agricultural terraces in the hilly zones surrounding the site, suggesting the level zones were already in use (Healy et. al 2004). As Healy and colleagues (2004) note, the residents of Pacbitun used animals for both, subsistence and ceremonial purposes. Animals were derived from undisturbed and cut forests. Although Pacbitun is farther from a riverine ecozone, river turtles and freshwater gastropods have been found, which suggests that frequent trips to nearby creeks were made.

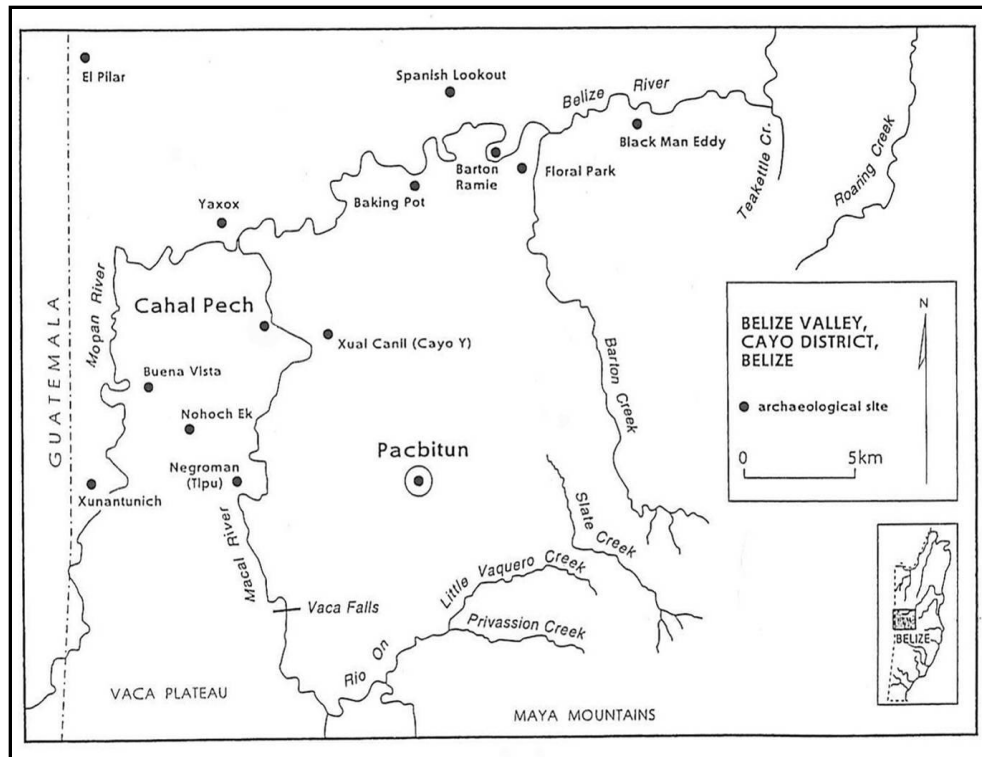


Figure 3-4: Location of Pacbitun in the Upper Belize valley
Source: Famsi.org

3.5.2 *The Pacbitun Site Core*

The core zone of Pacbitun consists of five primary plazas (A-E), surrounded by a variety of masonry structures (Figure 3-4). Plaza A is situated about six meters above the other plazas, marking the highest level ground. According to Healy and colleagues (2004:208), Plaza A appears to be the ritual and ceremonial center of the site. Two stepped pyramids (Structures 1 and 2) face each other across the plaza on the east and west sides. Structure 1 is the largest structure on site and has two attached smaller flanking temple pyramids (Structures 4 and 5) attached on either side of it, forming an E-Group Complex together with Structure 2 (Figure 3-5) (Healy et. al 2004:209). On its north and south sides, Plaza A is framed by two large range structures (Structures 3 and 6). Also located at Plaza A, were 20 monuments, including a stela

and an altar complex in the center (Healy et. al 2004:208). Of the three monuments that contained traces of carving (Stela 6, Altars 3 and 4), only Stela 6 presented information that could be partially reconstructed. The carving depicts a seated, elaborately dressed individual, as well as glyphs and traces of the Long Count calendar, referring to an event about AD 475, making Stela 6 one of the earliest in the Maya lowlands, together with stelae from Blackman Eddy and Zopilote (Healy et. al 2004:214).

To the west of Plaza A lies Plaza B. Plaza B presents three enclosed courtyard groups on its south side, each of which is surrounded on four sides by multi-chambered range structures, and a large range building (Structure 8) on its north side (Healy et. al 2004:208). The multi-chambered structures to the north form the palace complex which included a slate workshop and storage facility (Healy et. al 2004:210-211). Plaza C is the smallest plaza on site and lies to the west of Plaza B and south of the largest open area, Plaza D. Excavations have unveiled evidence for a Middle Preclassic village below Plazas B-D. Plaza E is marked by a ballcourt, situated to the north of it. Constructed during the Late Preclassic, this ballcourt is one of the earliest in the Maya lowlands identified to date (Healy et. al 2004:211). Excavations have revealed several caches and burials in the core zone (Healy et. al 2004:214-216). Further archaeological research, including settlement surveys and population estimates for Pacbitun, is discussed in Chapters 4 and 5.

As mentioned, it has been argued that Pacbitun might have been politically linked to Xunantunich, as well as Caracol, which lies about 30-40 km away (Chase 2004:330; Healy et. al

2004:225). Thus far, material evidence has linked Pacbitun closer to the Valley, while burial practices have shown traces of both, Valley- and Caracol customs (Healy et. al 2004:225).

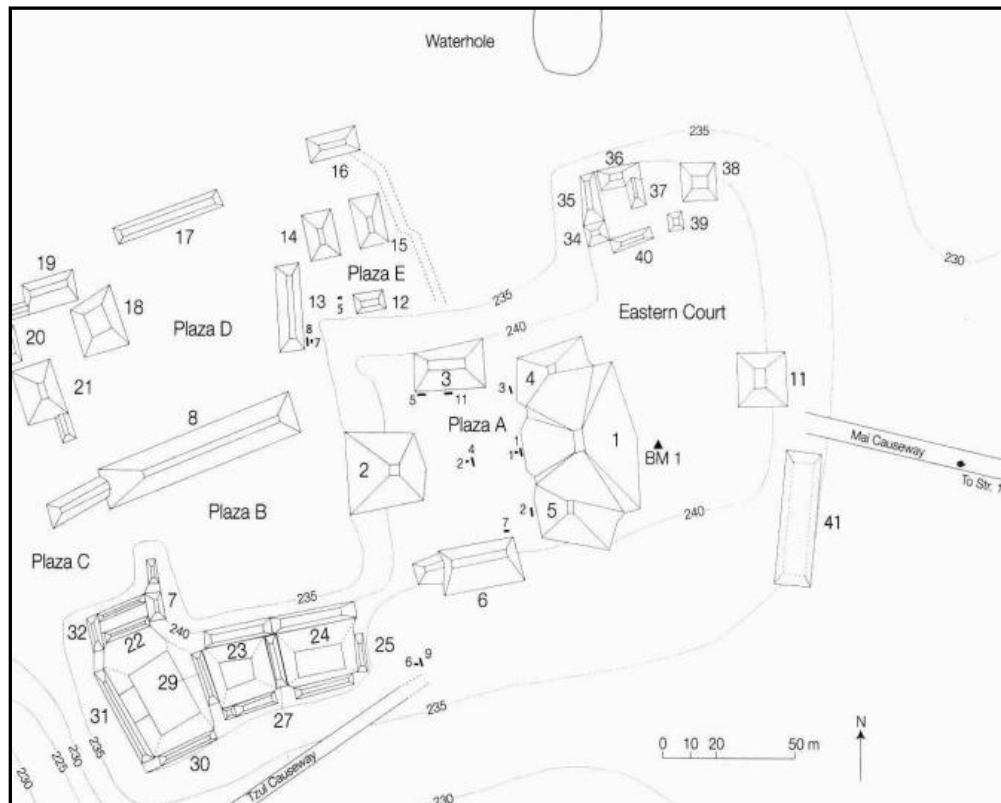


Figure 3-5: Pacbitun site core, depicting Plaza A, Plaza B, and the Eastern Court, (after Healy 2007: Figure 2)



Figure 3-6: Structure 1 in Plaza A in the site core

3.5.3 Caves in the Pacbitun Periphery

Here I provide a brief description of the caves Actun Merech, Actun Pech, Tzul's Cave, and Crystal Palace, as these four caves were focus points in my survey routes. For preliminary descriptions of the ceramic depositions encountered in the caves see Chapter 5. Approximately 300 caves have been identified in Belize over the past 100 years, of which 198 are registered archaeological sites (McNatt 1996). Archaeological evidence such as ceramic dumps, burials, art, and artificial construction support the notion of primarily ceremonial activities within these caves. It has become standard practice in Belize to give the caves names taken from the Mayan languages. Actun is the Mayan word for "cave" (ac- hollow, tun- stone). In common with cave culture everywhere in the world, names relating to life after death, sorcery, bats, and religious matters tend to predominate (McNatt 1996).

3.5.3.1 *Actun Merech*

Actun Merech (or Lizard Cave) is located about three kilometers to the southwest of Pacbitun. It is a dry cave with nine identifiable rooms or chambers (Rooms A-I). The cave measures approximately 50 meters in length and is L-shaped (Figure 3-7). The entrance to the cave is situated near the summit of a steep hill, with the cave facing west toward Tutu Creek (Figure 3-7). It is located 370 masl. At the base of the hill is a natural spring, which has been modified by the ancient Maya. There is clear evidence of a stone wall made of roughly-hewn slate blocks encircling the edge of the spring (Powis 2010; Weber and Powis 2010).



Figure 3-7: Entrance Actun Merech

The mouth of the cave is relatively large for our area, measuring approximately three meters in diameter. Upon walking into the entrance (Room A), which is similar looking to a

large modern-day foyer, the next three rooms (Rooms B, C, and D) become very restrictive, only large enough to accommodate one person to enter at a time. From Room D to Room E, one must descend steeply about 2 meters. In contrast to the Rooms B, C, and D, Room E is relatively large and spacious, with a domed ceiling about 6 meters high. There appeared to be evidence of burning on the ceiling, but further inspection is needed to verify this observation. The room itself can accommodate a number of people at any one time. There are numerous horizontal formations along the walls of this room. These small ledges protrude out approximately 30 cm from the walls and extend down from the ceiling to the floor (Powis 2010; Weber and Powis 2010).

Room E has two small hole-like openings on either side of its chamber, one to the north and one to the south. Each one becomes larger and more circular as one descends deeper into them. On the north side, the hole has a vertical depth of 15 meters. It contains a few pottery sherds and animal bones at the bottom of it. On the south side, the hole descends 25 meters or more, and has not been investigated to date. Rooms F, G, and H, situated southwest of Room E, are small and very restricted. Room I, at the back of the cave, represents another large and open chamber. Like Room G, there are a series of horizontal formations in this room (Figure 3-8) (Powis 2010; Weber and Powis 2010).

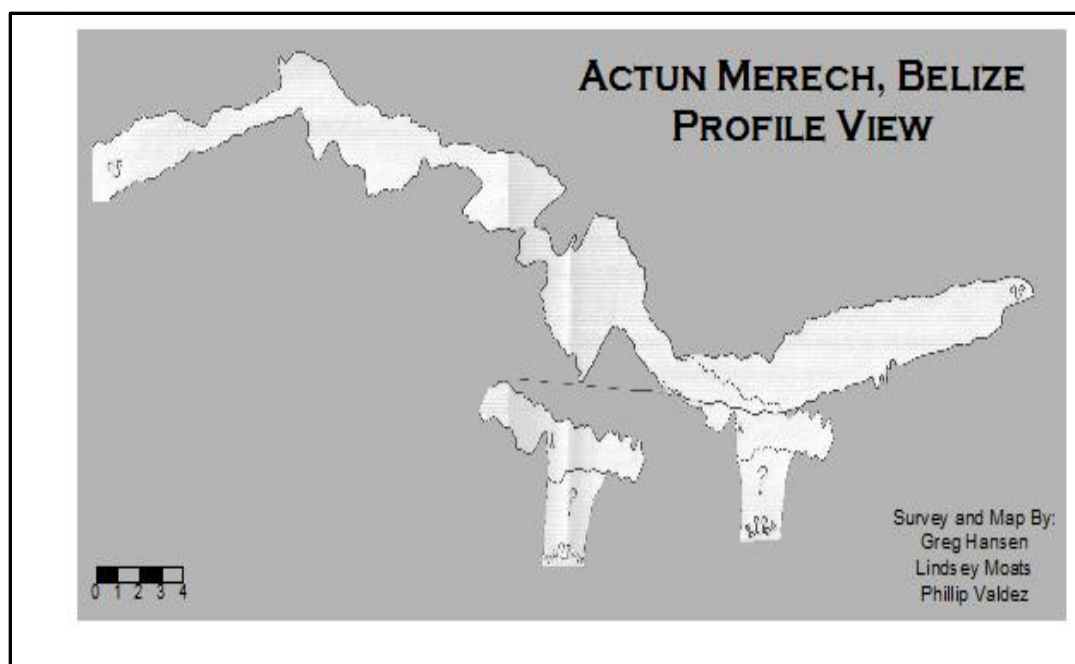


Figure 3-8: Actun Merech mapped profile (after Powis 2010: Figure 21)

3.5.3.2 *Actun Pech*

In 1995, Actun Pech (or Tick Cave), formerly known as Actun Petz, was preliminarily surveyed by Healy and colleagues (1996). It is the only cave that Healy and his colleagues investigated in the periphery of Pacbitun. Actun Pech is a small, dry cave (Figure 3-9) situated on top of a steep hill directly next to (or east of) the hill on which Actun Merech is located. This cave is at an elevation of 345 masl. It is about 25 meters long, oriented east-west, and is divided into four chambers (Figure 3-10) (Rooms A-D).

Twenty-three whole and partial pottery vessels (including 16 ollas) were found throughout the cave. Human remains (four adults, one sub-adult, and one child) were found on the floor of Room D, the deepest and easternmost chamber of the cave. The bones were well-preserved and found largely in correct anatomical position. The human remains were located

adjacent to a number of whole and broken pottery vessels. The cave shows evidence of ritual use in form of broken off stalactites and stalagmites (Healy et al. 1996). In 2010, a 50 cm by 50 cm excavation unit was placed in Room D, adjacent to the human remains. No artifacts or additional bone material were recovered (Powis 2010; Weber and Powis 2010).



Figure 3-9: Entrance Actun Pech

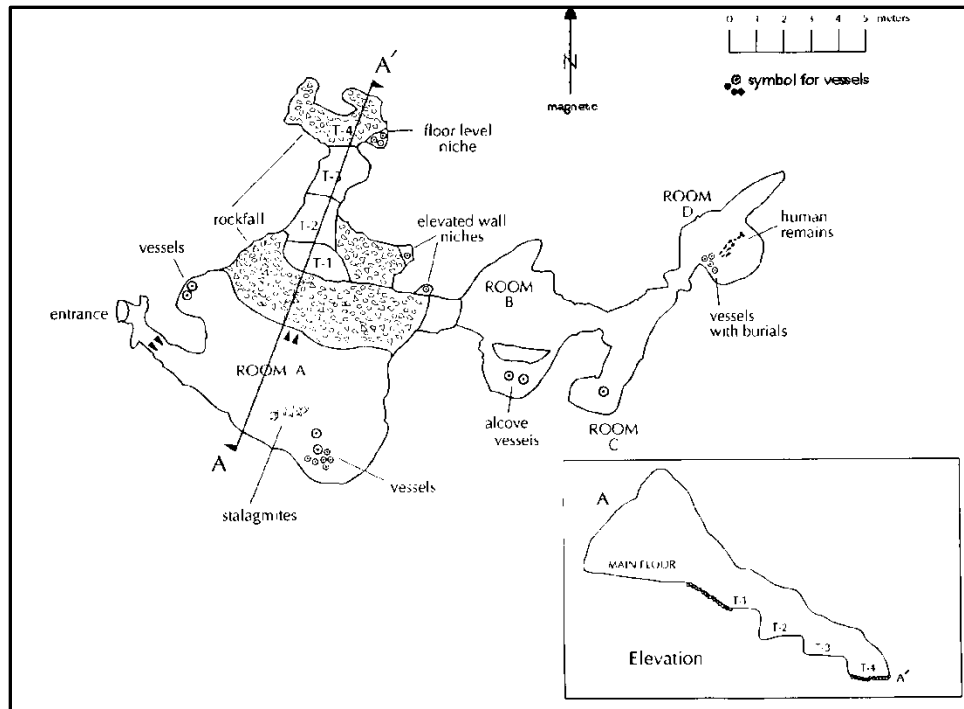


Figure 3-10: Actun Pech mapped profile (after Powis 2010:Figure 22)

3.5.3.3 Tzul's Cave

Tzul's Cave is a long, narrow cave situated on top of a steep hill directly west of the hill on which Actun Pech is located. It sits at an elevation of 259 masl. The cave is located about 70 meters from Tutu Creek and it measures approximately 35 meters in length and is shaped roughly like the letter "V" (Figure 3-11). There are six rooms (Rooms A-F) in this cavern. The entrance to the cave is large enough to walk through, but abruptly descends vertically onto a small terrace (Figure 3-12) (Powis, 2010, Weber and Powis 2010).

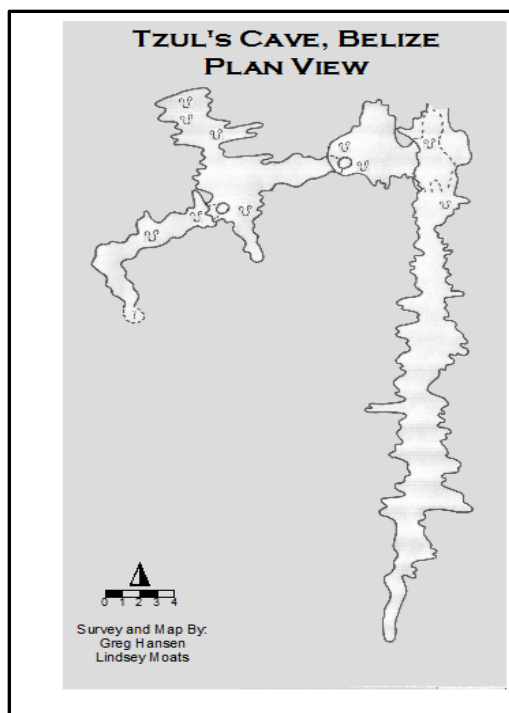


Figure 3-11: Tzul's Cave mapped profile (after Powis 2010:Figure 26)



Figure 3-12: Entrance Tzul's Cave

Room A, oriented north-south, is the longest and narrowest in the cave. No artifacts were found in this room. The smallest room in the cave, Room B, connects the entrance to Room A. It contained some sizable Late Classic rim sherds. Room C is relatively spacious compared to Rooms A and B. There are a number of sizable niches in this room, which contain rim sherds. Room C was sealed at the west end by a circular piece of slate about 50 cm in diameter. This slate slab was placed to block entry from Room C into Room D. The actual diameter of the opening from Room C to Room D was much larger than the slate slab. As a consequence, a small wall, one meter high, was built beneath the orifice inside Room D. The construction of the wall narrowed the opening between the two rooms allowing the slate slab to be mortared in place. Similarly, a slate slab was also used to block entry from Room D into Room F. In Room D there is a small alcove that contained a few complete serving dishes, as well as broken olla sherds and a cache (Powis 2010, Weber and Powis 2010).

3.5.3.4 Crystal Palace

As mentioned, Crystal Palace is located south of Pacbitun to the east of Actun Pech, Actun Merech, and Tzul's Cave. This cave has not yet been mapped and all measurements are preliminary. Outside of the cave is a single housemound located 15 m to the northwest of the entrance. Surface collection on top of the mound yielded three Late Classic pottery sherds. The entrance itself is relatively large, measuring about 4 m by 2 m (Figure 3-13). Once inside, one descends two meters into a large, open main chamber. The entrance gradually slopes downward, allowing access to more than one person at a time (Figure 3-14).



Figure 3-13: Entrance Crystal Palace



Figure 3-14: View of main chamber in Crystal Palace

From the main chamber, one can see that the cave is v-shaped. It measures approximately 55 meters in length, with a height of about 4.5 m, and a width of 17 m. Inside, two architectural stairs were found, as well as numerous caches of vessels (broken plates, bowls, and ollas), and broken stalactites and stalagmites, suggesting a possible relation to ritual usage, as well as water collection and/or food offerings to Maya deities (Healy et al. 1996). Two caches, containing numerous vessels, were placed beneath roof collapse in two separate locations within the cave (Figure 3-15).



Figure 3-15: View of cache inside Crystal Palace (photo courtesy of PRAP)

Overall, this cave is covered with an abundance of stalactites and stalagmite formations, as well as sherd deposits in various different locations, including niches which are very difficult to access. Room names still have to be assigned to Crystal Palace; however, it can be said that the chamber system seems to be rather uncomplicated, with relative large and open rooms. A

number of small ledges and niches are still to be explored. Thus far, no animal or human remains have been found (Powis 2010; Weber and Powis 2010).

3.6 Ancient Maya Causeways

An ancient Maya causeway is a raised road or *sacbe* (plural: *sacbeob*), which is the Yucatec Mayan term (Shaw 2008:4). The term *sacbe* can be divided into the morphemes *sac* and *be*, translated into “white” and “road” respectively (Shaw 2008:4). These roads consisted of dry-laid boulders at the base, topped with cobbles and filled with gravel. This then was plastered with powdered limestone, hence the term white road.

Causeways occur in all kinds of lengths, heights and widths (Shaw 2008:5). In general, causeways are classified into (1) intrasite *sacbeob* for short distances within a single site, and (2) intersite *sacbeob* for distances between different sites (Shaw 2008:81). Typologies between causeways concentrate on form and length. According to Shaw (2008:83), the problems with identifying causeways based on form are that construction materials and methods might differ according to the terrain and materials available in the environment. For longer causeways that would mean that throughout its course, it could change form and display different building materials, making a typology seem dubious. In addition, most archaeologists have recorded length but not construction types, so there is often much information available.

Based on the collected information on 190 causeways in the Maya Lowlands, Shaw (2008:84) constructed a classification system on the length of causeways. As a result, she designated three *sacbe* types: (1) the local intrasite *sacbe*, less than one kilometer in length, (2)

the core-outlier intrasite sacbe, one to five kilometers in length, and (3) the intersite sacbe, five or more kilometers in length (Shaw 2008:84). As a result, the most frequent example appeared to be the local intrasite sacbe, followed by the core-outlier intrasite sacbe, and with the intersite sacbe occurring least frequently. In addition, sacbe systems have been identified as (1) linear sacbe systems, (2) cruciform sacbe systems, (3) radial/solar sacbe systems, and (4) dendritic sacbe systems (Shaw 2008:96-103). A linear sacbe system is characterized by tying together groups that are approximately the same size, not indicating a clear hierarchy in their stipulation of a center. A cruciform sacbe system displays roads radiating from one central direction into four directions at relatively regular angles. The radial/solar sacbe system also radiates from a single core but in a variety of angles. In the dendritic sacbe system the roads are linking architectural groups located in concentric rings around the site core. Examples of dendritic causeways can be found at Cahal Pech and Caracol (Chase 2004:332).

Thus far, some of the oldest causeways have been dated to the Middle to Late Formative period in places like Nakbe El Mirador, Barton Ramie, and Tikal, to name a few (Shaw 2008:5). Aside from their function as transport and communication routes, causeways also reflect different levels of social activity and meaning in the past, as roads do today, from single human agents to hierarchical relations between centers.

3.7 Conclusion

This chapter provided a brief background on the topography and the environment of Belize and the Belize Valley in particular. In addition, this section served as a concise review on settlement research and the major archaeological sites in the valley. This was followed by background information on Pacbitun, as well as the caves that informed my survey routes, Actun Merech, Actun Pech, Tzul's Cave, and Crystal Palace. Finally, I provided information on causeway functions and typologies.

4 METHODOLOGY

4.1 Introduction

This chapter is a review of the overall project goals and how they were operationalized. I begin with a brief review of settlement survey methods in Mesoamerica before turning to previous and current research goals at Pacbitun. I then address the methods I employed during my survey, ceramic analysis, and data analysis. Since the main tool aiding me in organizing and analyzing my data was Geographic Information Systems (GIS) I have also included a review of the historical development and application possibilities of GIS in archaeology, where I examine and critique predictive modeling techniques, like least cost path analysis. This is followed by the description of the GIS technologies I employed while analyzing the data I collected during the Pacbitun survey.

4.2 Past and Present Research Objectives at Pacbitun

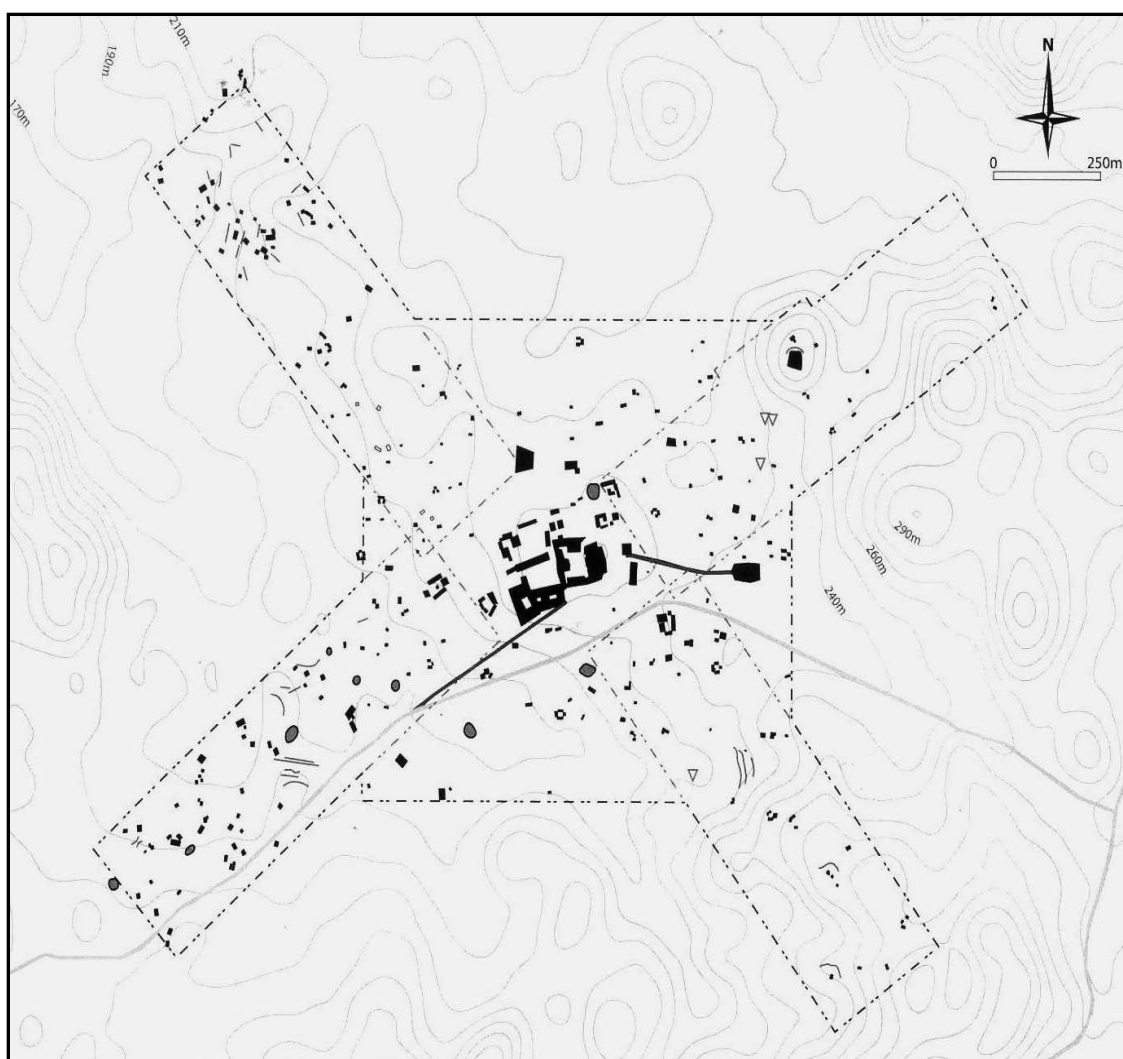
Since 2008, all archaeological investigations at Pacbitun, including the survey work of the past two years, have been carried out under the permit issued to Dr. Terry G. Powis of Kennesaw State University, by the Belize Institute of Archaeology (IOA). Research goals in 2008 mainly concentrated on exposing a Middle Preclassic Platform in Plaza B in the site core (Figure 3-5) (Powis 2009; Powis 2010). In 2009, work on the Preclassic architecture in the core continued, however the main research focus shifted towards the investigation of cave sites in the southern periphery. During the 2009 season, twelve caves, located within three kilometers of the core, were identified. Three of these caves were mapped (Actun Merech, Actun Pech, and Tzul's Cave). During the 2010 field season, the goal was to survey the area between the site core of Pacbitun and these three previously investigated caves. In addition, investigations in the site core

were also expanded to Plaza A and the Eastern Court (Powis 2010). Detailed description of the 2010 field survey methods are provided below.

Banning (2002) notes, that the most common activity in regards to survey is site-oriented survey. Here, measuring or estimating the size of the site and documenting land-use patterns over time is conducted with the goal of understanding the form of the settlement systems on a regional scale. It is such a site-oriented survey that helps define the survey objectives in the periphery of Pacbitun. From the late 1980's to early 1990's, the archaeologists from Trent University focused much of their attention on settlement within two kilometers of Pacbitun (Figure 4-1). Thus, our knowledge of the relationship between the site and the caves beyond this distance remains unclear. Therefore, it is one of the ongoing goals of the Pacbitun Regional Archaeological Project (PRAP) to explore ritual landscape use, ancient settlement, signs for social stratification, and environmental modification, both on local and regional levels.

It is through the collection of information that might be relevant to the probable ancient site environment that archaeologists gain clues about what factors that might have encouraged settlement at a particular place, or were relevant to the economy, site function, or the site's relationship to other sites (Banning 2002). In order to find these clues that could help answer these various socio-economic questions, PRAP has set out to investigate and analyze the 9 km² periphery surrounding the ancient Maya site of Pacbitun. For the past two fieldseasons, 2009 and 2010, this has included the searching for and recording of caves along with all other natural and cultural features encountered (Weber and Powis 2010).

My field survey was carried out in conjunction with Georgia State University's Anthropology Department, under the advisement of Dr. Jeffrey Glover. Functioning as a small component of the PRAP, the survey project was carried out solely by me, and one support staff for guidance, the landowner Joe Tzul. Two undergraduates assisted me in two occasions for training purposes.



**Figure 4-1: Depiction of survey areas approx. 1-2 km out of the site core,
(after Healy 2007:Figure 3)**

As mentioned in Chapter 3, during the 2009 season, twelve caves, located within three kilometers of the core, were identified. Three of these caves were mapped (Actun Merech, Actun Pech, and Tzul's Cave) (Figures 4-2, 4-3). One of the goals during the 2010 field season was to survey the area between the site core of Pacbitun and these three previously investigated caves. Due to the unexplored nature of the periphery, survey plans focused on recording all features encountered (e.g., housemound, terraces, reservoirs, springs, sinkholes, rockshelters) between the core and the limestone hills in the periphery. The recording all of the natural and cultural features situated in this area will help us to better reconstruct various aspects of the ancient Maya society at Pacbitun. For example, recorded features, like terraces and housemounds, provide clues about agricultural techniques, settlement patterns, and social stratification. Through analyzing the interrelation of these societal aspects, the project hopes to gain new information about ancient Maya economics, politics, and belief systems (Weber and Powis 2010).



Figure 4-2: Location of Pacbitun in relation to Tzul's Cave, Actun Pech, Actun Merech, and Crystal Palace in the periphery, as well as the town of San Antonio to the east (base map from Google Earth)

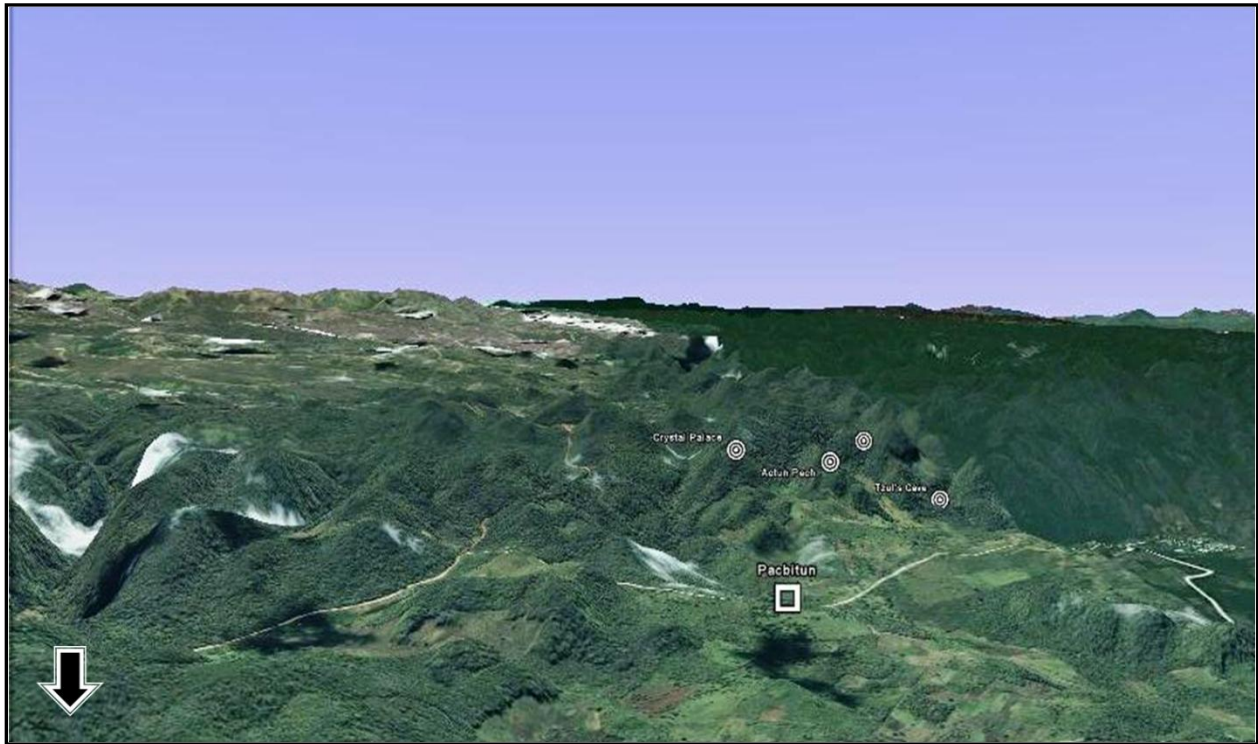


Figure 4-3: Distribution of Tzul's Cave, Actun Pech, Actun Merech, and Crystal Palace in the periphery, seen through perspective view looking to the south of Pacbitun (base map from Google Earth)

4.3 Survey

4.3.1 Tools

I recorded both, natural and constructed features, using a Garmin GPSmap 60Cx handheld unit. Afterwards, I entered the GPS coordinates and pertinent attributes into a geospatial database. To organize, visualize, and analyze these data, I used the Geographic Information System (GIS) ArcGIS 9.3 (see below). I also acquired remotely sensed data from Geoeye Imagery, and Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM) data from the JPL-NASA website. Other survey tools included a compass, a measuring tape, and a camera. All coordinates were recorded in UTM Zone 16 N WGS84.

4.3.2 *Pacbitun Field Survey*

The fieldwork for this study occurred in June and early July of 2010. The survey in the periphery was a general reconnaissance of the region, which uncovered numerous cultural features in the area. These features will be discussed in chapters six and seven. The survey I conducted can be described as a purposive survey. Banning (2002) describes purposive surveys as “surveys designed to optimize the probability of discovering particular kinds of archaeological materials with a given amount of prospecting” (Banning 2002:133). Here, “prospectors use experience, theoretical models, or hypothesis based on empirical data to predict where (survey) targets might be located or to restrict the amount or territory a survey must cover to provide satisfactory results” (Banning 2002:133).

As mentioned, almost none of the 9 km² periphery at Pacbitun had been previously surveyed, and due to the time constraints of the field season, I had to decide on which portion of the periphery my survey would focus. Based on the previously collected information that Actun Pech, Actun Merech, and Tzul’s Cave had all been used ritually by the ancient Maya, I decided to make the possible paths to these three caves my primary survey targets. Cultural deposits in form of pottery in the caves suggested that people did travel to the caves. Therefore, I hypothesized that I might find traces of pilgrimages or traveling routes, or any other form of human presence in these regions to the cave, thus suggesting the highest probabilities to encounter more cultural features. According to Banning (2002), “surveys of this type involve beginning the search in an area where prior information suggests the probability of finding targets is highest, and then widening or intensifying the search in the light of information gained as survey progresses” (Banning 2002:135). Due to its location close to the other three caves, I

incorporated a newly found cave, Crystal Palace, to the area of investigation, widening my prior research area towards the east (Figures 4-4, 4-5).

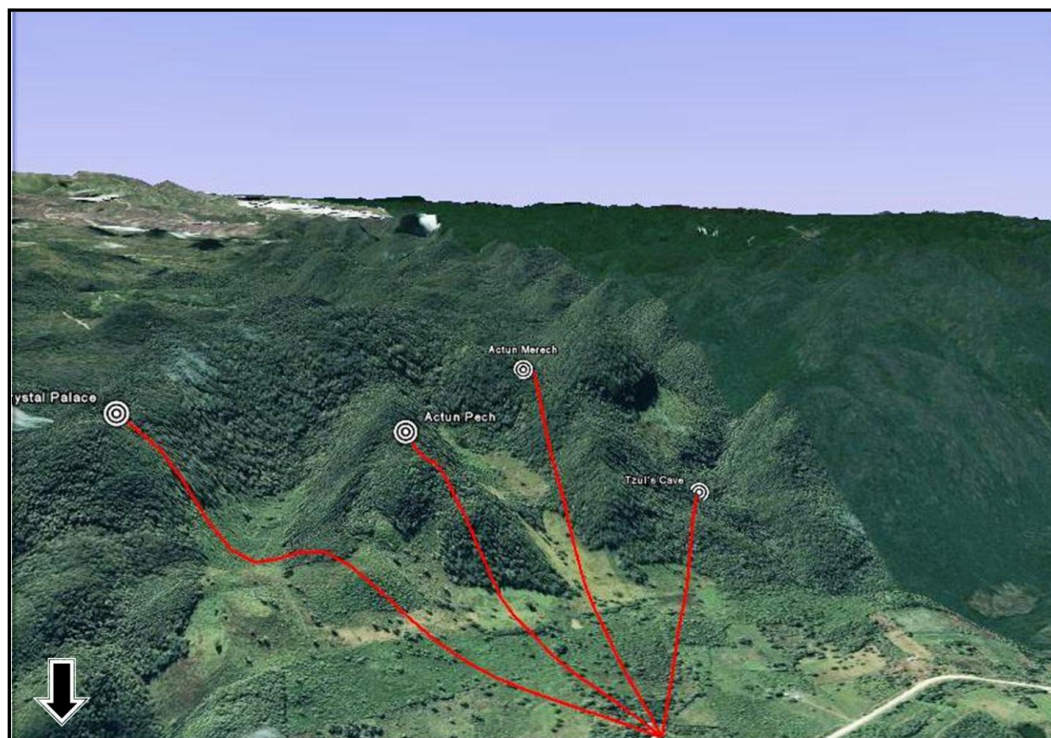


Figure 4-4: Initial survey route to caves (base map from Google Earth)

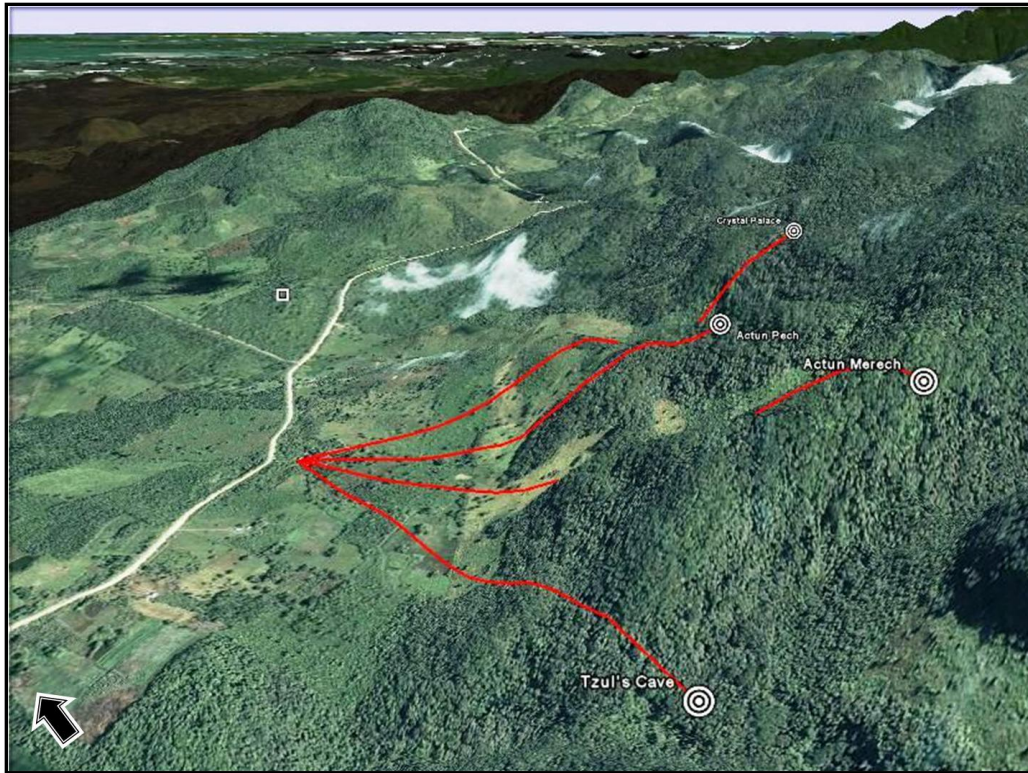


Figure 4-5: Initial survey route to caves (base map from Google Earth)

The landscape in the Pacbitun periphery is made up by the hilly jungle terrain. Due to this extreme topography and dense vegetation of the tropical rainforest, an unsystematic survey approach was chosen over a grid-based systematic sampling technique. The difference between both methods is depicted below (Figure 4-6a, b).

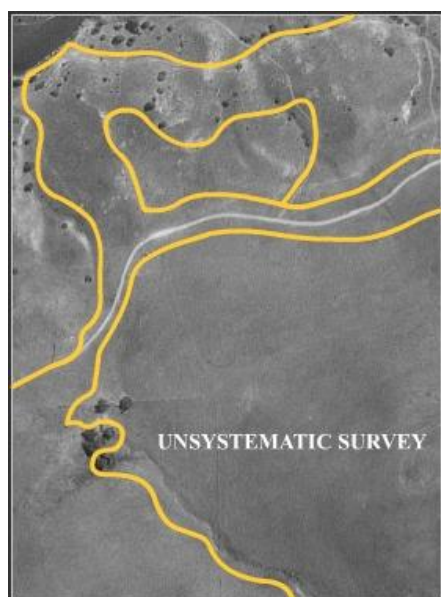


Figure 4-6a: Unsystematic Survey
(Source: UTexas.edu)

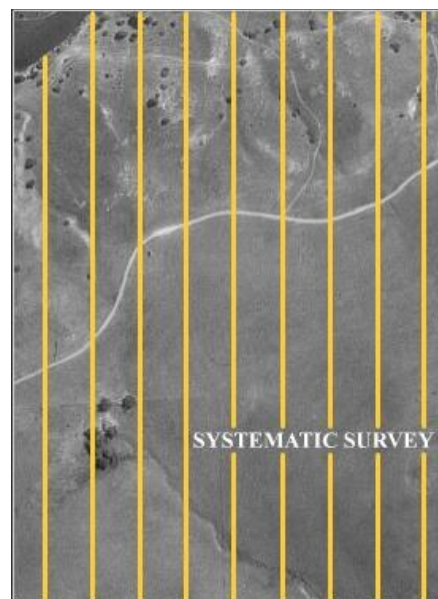


Figure 4-6b: Systematic Survey
(Source: UTexas.edu)

Of course, no survey is completely unsystematic. In the Pacbitun periphery, I followed the Bayesian survey approach. The Bayesian approach is a prospection survey approach based on prior probabilities where “survey starts in the region with the highest probability as estimated from previous experience, historical evidence, or even experts’ guesses” (Banning 2002:146). These probabilities change as new information is incorporated, affecting the survey time spent in a *prior probability* area which might end up being a lower or higher *posterior probability* area, based on survey results (Banning 2002:146).

While I had to adapt my transect paths to the terrain, I also surveyed the area between my four cave paths, looking for various other features. These paths were adapted and changed during the survey, as I adjusted my prior probability values for certain areas. For example, as I encountered a chultun and a plazuela group in close proximity to one of the caves, I went back to the others to see if I could find similar arrangements in those locations as well. Also, some

survey days were based on my informants' prior knowledge of the area, while recording other encountered features along the way.

As the paths to the caves in the periphery suggested the highest *prior probabilities* to encounter more cultural features, the *posterior probability* results confirmed this notion, as I was able to record various agricultural terraces, housemounds, reservoirs, rock shelters, plazuela groups, chultuns, springs, and sinkholes. In total, I surveyed an estimated area of about three km². The surveyed area was shaped like a pie wedge, extending from the site core towards the southwest. Within this area, I hope to have recorded all visible features (Figure 4-7). Of course, I must always assume that I might have missed something.

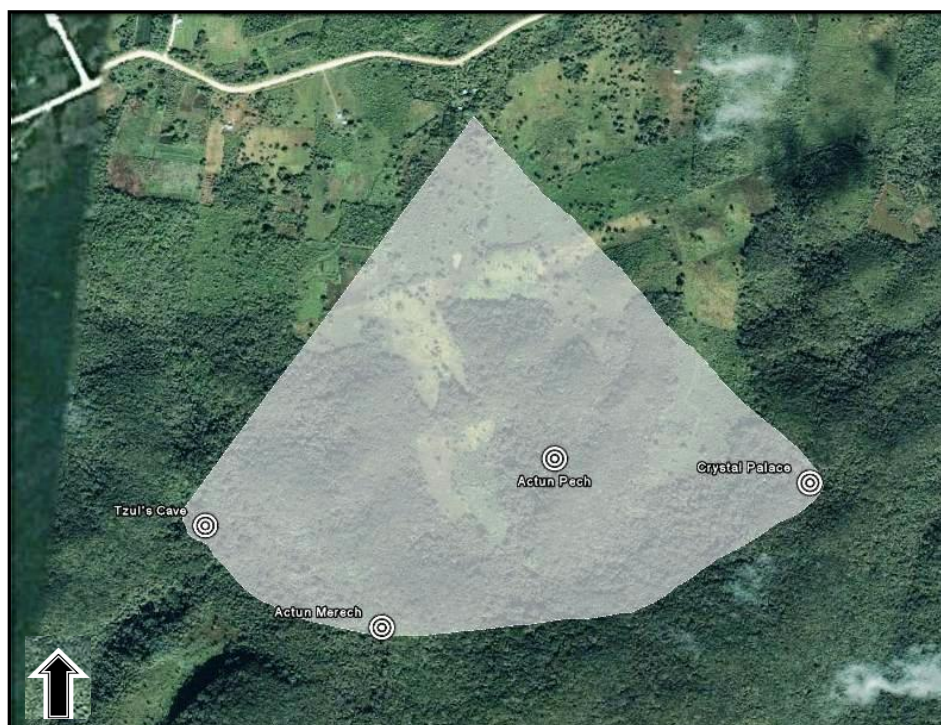


Figure 4-7: Area surveyed (base map from Google Earth)

4.3.3 *Pacbitun Causeway Survey*

Another goal was to resurvey the two causeways previously reported at the site core, named Tzul and Mai causeways by investigators from Trent University (Healy et al. 2007). These causeways had only been recorded in the site core, but causeway remnants in forms of topographic elevations and limestone gravel were also visible in the landscape while driving to the site. Therefore, we decided that the causeways should be recorded with a track feature of the GPS unit, and I investigated their directions and length.

4.4 **Surface Collections and Shovel Tests**

After discussions with Dr. Glover, I decided that even small excavation units in any features would not be advisable due to time constraints. Therefore, artifact collections were limited to surface findings. I conducted surface collections in seven different locations along the causeways, as well as at different architecture locations (Figure 4-8). These controlled collections were conducted in order to examine (1) the type of artifacts used for fill in the causeways and (2) get a general idea for the occupation period in the periphery settlement. In order to estimate a possible construction date of the causeways and two housemounds associated with a causeway and a cave, respectively, shovel tests were conducted in seven different locations, as described below in Chapter 5. Artifacts were analyzed in the field research laboratory in December of 2010.

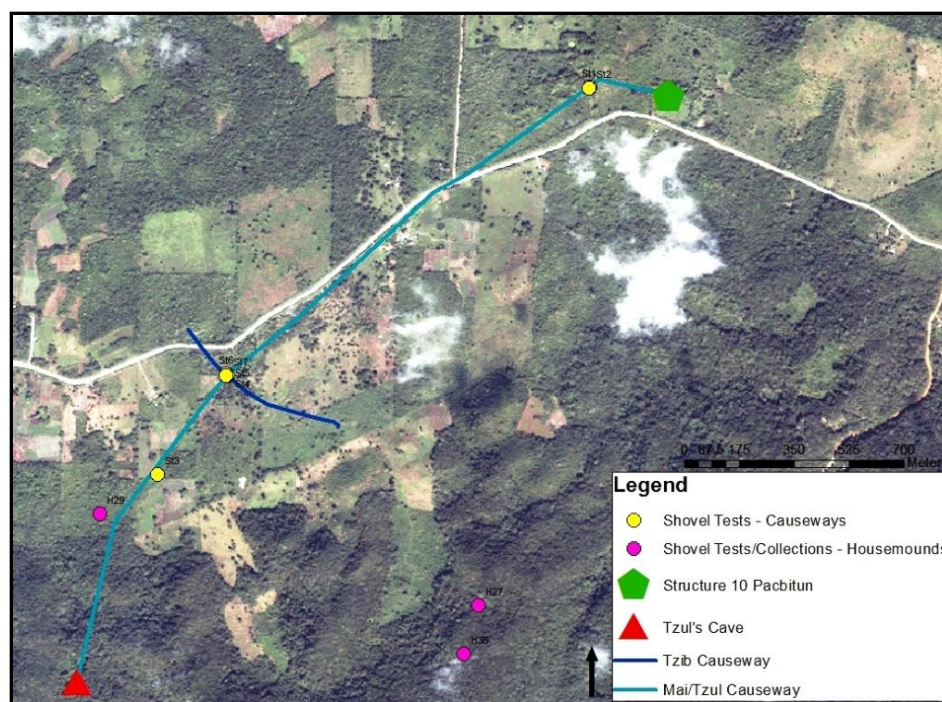


Figure 4-8: Locations of shovel tests and surface collections

4.5 GIS Analysis

Until GIS started to slowly enter the archaeological sector in the late 1980s, most spatial archaeology data had been tabulated and plotted by hand on simple, flat maps (Wheatley and Gillings 2002). Since that time the recording of spatial data has changed enormously. Used for the interpretation of regional survey data, site catchment analysis, visibility analysis, and spatial modeling, it would be hard to find an archaeological project today that does not use GIS in some way (Wheatley and Gillings 2002).

4.5.1 History of Predictive Modeling

Predictive modeling is a technique that seeks to predict the probability of encountering a phenomenon in unsampled areas based on knowledge gained from sampled areas, which then may provide insight into a suspected pattern (Conolly and Lake 2006:145). This approach has its

origins on the archaeological settlement studies of the late 1950s and 1960s, initiated by Gordon Willey (Verhagen 2007:13). The “new archaeology” movement emerging at the time promoted an ecological approach, leading many archaeologists to understand that settlement location is mainly determined by environmental factors (Verhagen 2007:13). This ecological determinism was backed by the introduction of Chisolm’s geographic location theory to archaeology in 1962, which was then followed by Higg’s and Vita-Finzi’s introduction of site catchment theory in 1972 (Verhagen 2007:13). Site catchment theory tried to capture the rules that determine human spatial behavior, approached from the angle of subsistence economy (Verhagen 2007:13). During the late 1960s and early 70’s, as a part of the general processual trend, interest in the application of quantitative approaches for the analysis of sites and settlement patterns grew, leading to a growing volume of academic papers on sampling and spatial analysis in archaeology (Verhagen 2007:13).

Most of the work on the development of archaeological predictive models was undertaken in the United States in the 1970s and 1980s. It was then when various government agencies became interested in the ability to predict locations of archaeological sites within fairly large regions from information based on surveys of far smaller areas (Wheatley & Gillings 2002). This new interest was mainly due to the introduction of the National Historic Preservation Act of 1966, which meant for government agencies that they needed to increasingly identify and record historic properties, and thus driving Cultural Resource Management growth in American archaeology (Verhagen 2007:14-15). With this new workload, a demand for cost- and time saving approaches was generated. In the late 1970s the Southwestern Archaeology Research Group laid the first foundations of data driven predictive modeling with the “Granite Reef

Archaeological Project” (Verhagen 2007:14-15). As Kvamme (1995:2) notes, the Granite Reef Archaeological Project of 1979-82 was the first to incorporate full-blown GIS applications in archeology. While incorporating the services of a professional computer scientist, who had written a raster-based program called MAPS, the project was able to establish distinct data layers for elevation, soils, geology, rainfall, temperature, and other surfaces over an area of 32.000 km². With this, the archaeologists were able to develop models, which were weighted layer combinations, of environmental suitability for early hunters, for travel in the desert, and for prehistoric agriculture (Kvamme 1995:3). As computer technology started to become sufficiently advanced, cartographic modeling started to become more sophisticated (Verhagen 2007:14). In the United States, as the governments continuously called for new means to project and predict the locations of archaeological sites, K.L. Kvamme was one of the first people to develop a methodology for predictive modeling, based on statistical associations between the environmental data of known sites (Kvamme 1995:3). He started out systematically mapping what he calls archaeological location decision surfaces, in order to collect data for the statistical models. By 1982 however, he had written computer programs to digitize the required map inputs, interpolate DEM, and derive analytical surfaces, perform distance operations, and thus produce predictive model surfaces (Kvamme 1995:3).

Kvamme’s groundbreaking work was followed by the further development of statistical and spatial analysis techniques for data driven predictive modeling (Verhagen 2007:15). Kohler’s and Parker’s work in 1986 and Judge’s and Sebastian’s work in 1988 are regarded as some of the most influential predictive models developed during the 1980s. In 1990, Warren wrote about the application of logistic regression to obtain the statistical correlations and

predictions sought for, which have now become a common methodology (Verhagen 2007:14-15).

4.5.2 Approaches to Predictive Modeling

Generally, modeling techniques are distinguished between inductive modeling and deductive modeling. Inductive modeling is viewed as a data driven approach, where statistical tests are applied to the data in order to see if a relationship can be found between a sample of known sites and a selection of landscape characteristics. The deductive modeling approach is a theory driven approach and starts by formulating a hypothesis on the location preference of prehistoric people by selecting and weighing the appropriate landscape parameters (Verhagen 2007:14). Before any predictive modeling technique can be applied, several other tasks must be fulfilled.

Luke Dalla Bona (1994), from the Ontario Ministry of Natural Resources Model, names three stages that should be incorporated into any predictive modeling process: (1) Hypothesis building, field reconnaissance, data collection and organization, (2) association between environmental variables and sites, literature review, initial modeling development and test, and (3) subjecting the model to a number of applications and refinements (Table 4-1). Dalla Bona (1994) states, that during the second stage, additional field surveys are necessary to collect more baseline data and/or groundtruth and test the model.

Table 4-1: Summary of Three Stage Modeling Process (after Dalla Bona 1994: Table 2)

Primary Stage	Hypothesis Building
	Initial Data Collection
	Field Reconnaissance, Collection of Baseline Data
Secondary Stage	Deductive Phase of Modeling
	Association between Environmental Variables and Sites
	Literature Review and Integration of Model(s)
	Development of Application of Initial Model(s)
	Testing of Model(s) on Previously Surveyed Areas
Tertiary Stage	Continued Application of Model(s)
	New Data Continuously Incorporated into Process
	New Sites Discovered are Interpreted and Incorporated into Existing Model(s)

4.5.3 *Least Cost Pathways*

One of the predictive modeling techniques I employ in my research is least-cost pathway analysis, or LCP analysis. A LCP is a route that minimizes the total cost of moving between two locations across an accumulated cost-surface (Figure 4-9). Least-cost paths in GIS are also called “Optimum Paths” and are frequently used to calculate the optimum path for power lines, highways, and other linear features crossing the landscape (Batton 2006). In archaeology, the calculations of least-cost paths cannot only help to predict known or unknown past travelling or transport routes, but they can also be used to explain the location of monumental art, to predict prehistoric economic boundaries around central places, and to predict the economic interrelation of sites (Batton 2006).

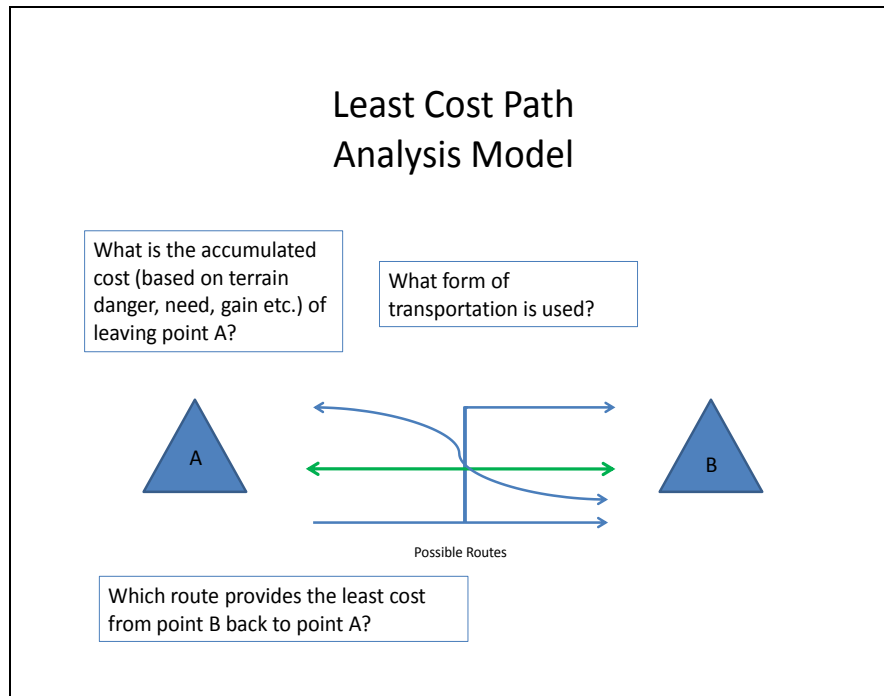


Figure 4-9: Least cost path analysis model (by Jennifer Weber)

GIS software usually implements a two stage process to calculate a LCP. First, it creates a cost-surface that models the accumulated cost of traveling outward from the origin, using a relevant transport technology. Here, one (preferable for unknown routes) or several (preferable for known routes) variables can be used. Second, the calculation traces the route of steepest reduction in accumulated cost from the destination back to the origin (Conolly and Lake 2006:252).

In ESRI's ArcGIS Spatial Analysis program, this model requires digital elevation data in a raster data format. One then creates a friction surface grid, based on the accumulated information on the environment (topography, etc.). This means creating a slope file from the raster data in ArcGIS. The program then assigns every cell between point A (source) and point B (destination) a value, so it can calculate the accumulative cost to move over the surface (Figure

4-10). This concept might be better explained in its actual computational context: In computer science each cell on a raster surface is called a node. Nodes are connected by links. The LCP algorithm is calculated based on the node value at each end of the link (Figure 4-11). It searches the lowest node value at the end of each link, on the most direct way to the destination cell.

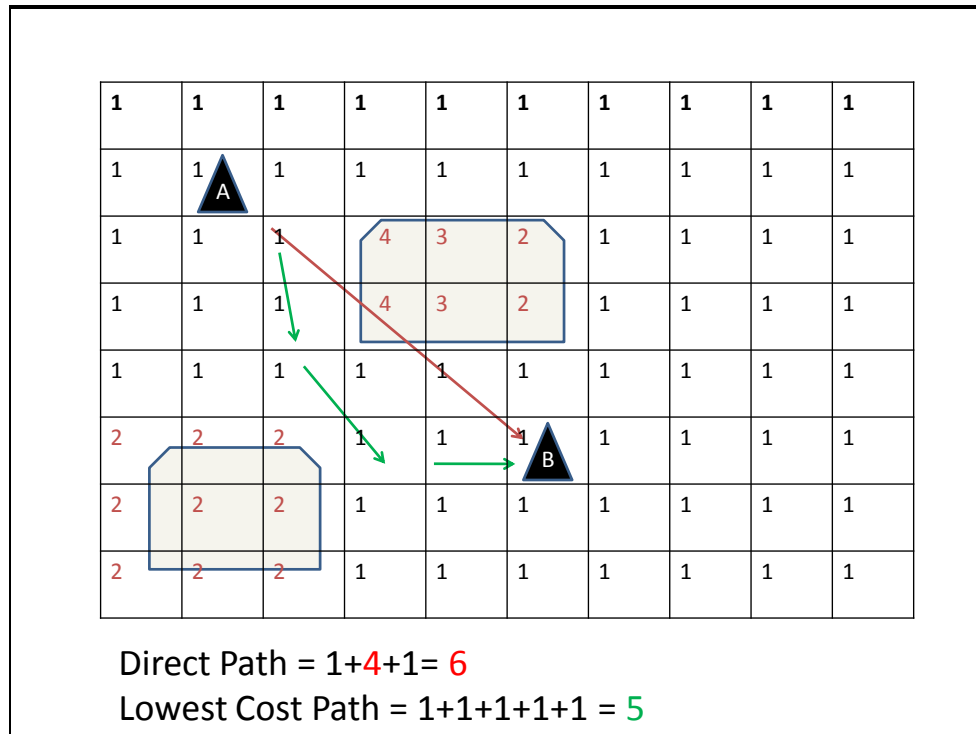


Figure 4-10: LCP function model (by Jennifer Weber)

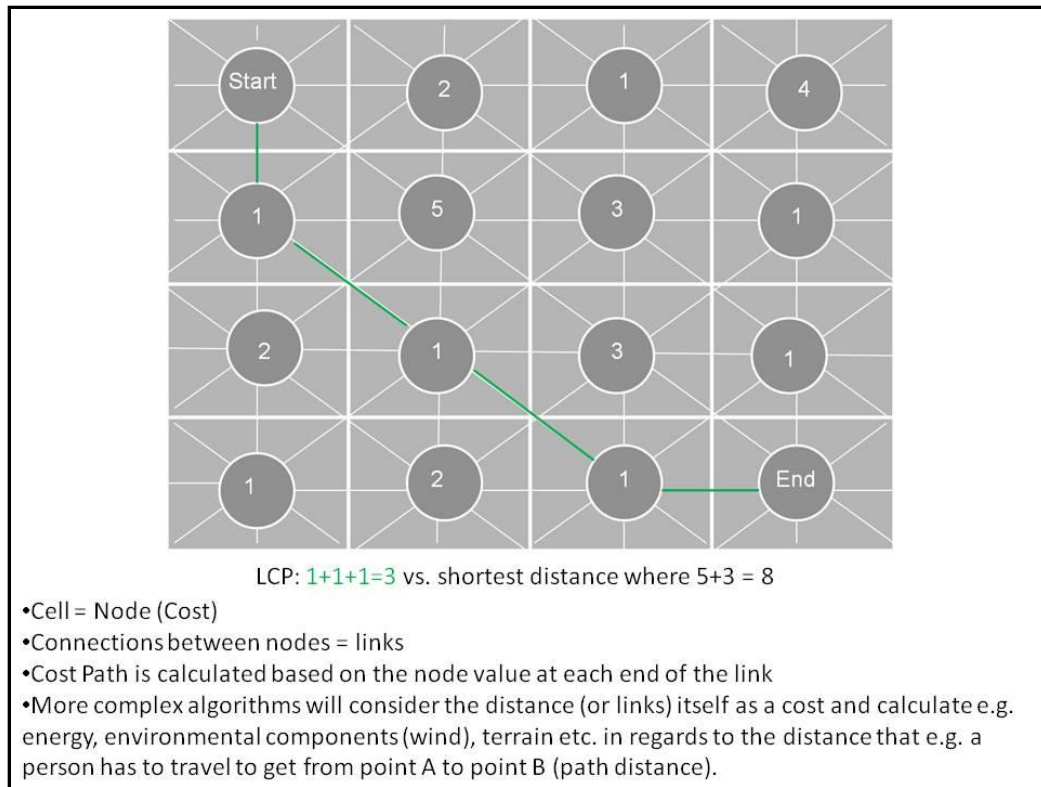


Figure 4-11: LCP algorithm (by Jennifer Weber)

This is an example of a very simple function that runs solely on one value, for example data derived from elevation levels. This of course can be tricky, for example when the data includes waterbodies with low elevation levels, which the algorithm will not recognize. Rather, it would mistake the sea or lake as a valley or other type of terrain that is easily accessible, when in truth, it is not. Therefore, other variables can be added to various spatial analysis tools to provide more complex analysis methods. An example of applying other variables to this analysis process is demonstrated by Batton (2006), who used LCP's to explore the role trade and communication links played in the location of three prehistoric settlements in east Central New Mexico. He was investigating whether exchange was a factor in decisions about community location. Following extensive environmental and historical research, Batton (2006) started out with the cost surface, which is, as mentioned above, a raster map where the z-dimension is the least accumulated travel

cost of each cell from a specific source point. Arguing that he did not know enough about the prehistoric values in his research area to implement multiple variables (e.g. water sources, shelter, fuel sources, defensible locations), he used the walking speed on a terrain or varying steepness, also called the “Hiking Function” developed by Tobler in the 1970s (Batton 2006; Tobler 1993) (Figure 4-12).

Tobler’s Hiking Function

$$V = 6(-3.5 \times |S + 0.05|)$$

V = Walking Velocity (kms per hour)
S = Percent Slope (rise over distance dh/dx)

Elevation values (from DEM) must be converted into slope values (via ArcGIS or GRASS), then converted to the cost of crossing each cell. Thus, allowing slope values to be converted into time required to traverse a cell of the raster.

Figure 4-12: Tobler’s Hiking Function (by Jennifer Weber, after Tobler 1993)

Based on the predicted pathways Batton (2006) derived from the LCP analysis, he was able to gain important insights and create testable predictions. He created hypotheses he could now investigate by implementing ground-truthing of likely pathways, spatial analysis of site distributions around LCP’s, assessing the relationship of LCP’s with rock art, and refining the algorithm with additional environmental and social variables (Batton 2006). An example of a similar research approach conducted in Mesoamerica was led by Carballo and Pluckhahn (2007)

who also implemented least-cost path analysis in order to quantify the utility of the Tlaxcala Corridor for interregional transportation relative to other corridors, as well as spatial distributions between sites. They also utilized the Hiker Function by Tobler (Carballo & Pluckhahn 2007).

Aside from employing functions like Tobler's Hiking Function, ArcGIS' spatial analysis tool also offers options to add so called "offsets" to environmental data. Here, the cells of a raster dataset can be given certain offset values by the researcher, depending on knowledge of environmental factors. For example, a waterbody in the landscape between point A and point B could be manually given a very high value, indicating that it would have presented an obstacle that most likely would have not been crossed by foot. Or, the cells next to the waterbody could be given a low value, indicating that a path running by here would have been likely as a source to collect water, as indicated by previous research. In addition, researchers are actively trying to create new ways to incorporate the uncertainty in our inherent knowledge about past human behavior and natural processes.

An example of this is Dempster-Shafer-Theory, a mathematical theory that incorporates this uncertainty by assigning various weights of evidence to defined variables, in that way estimating the probability for supporting a specific hypothesis. Here, each domain of knowledge entails uncertainty and the complement of a hypothesis must not automatically be assigned to its negation, but has to be assigned an uncertainty factor (Boos et. al 2010). An aggregation rule is used to include numerous pieces of information (evidence) with varying weight into a decision making process thus supporting or excluding defined hypotheses (Boos et. al 2010). Boos and colleagues (2010) of Mainz University have successfully applied this theory in order to predict

prehistoric settlement structure and land use surrounding the Celtic oppidum “Hunnenring” in Saarland, Germany. Examples like this show that GIS applications are steadily developing and will become more and more sophisticated to help archaeologists interpret the past.

4.5.4 *Benefits and Limitations of Predictive Modeling and Least Cost Paths*

Predictive modeling works with software and is therefore dependent on input data by the user. The main critiques surrounding the method have been (1) the use of incomplete archaeological data sets, (2) the biased selection of environmental parameters, (3) a neglect for the influence of cultural factors, and (4) a neglect for the changing nature of landscapes. Based on the inability of archaeologists to obtain the appropriate datasets needed for predictions that cover all aspects of site locations, many question the explanatory power of these models (Verhagen 2007:17). A theoretical critique of the predictive modeling has been that it is based on environmental determinism and that the description of patterns, and their modeling for whatever purpose cannot be separated from the process of explanation in this way (Wheatley & Gillings 2002:179).

While I acknowledge these critiques, I argue that predictive modeling techniques are none the less helpful tools in archaeological data analysis. Software-based models rely on the data input and will generate results based on the data they have been fed. If the data are incomplete, which it inevitably must be, based on the premise that there is no such thing as law-like statements about human behavior, then the prediction model will always be – at least to some point – faulty. But this does not make predictive modeling techniques useless. Predictive modeling can still contribute important information to archaeological analysis as a research tool,

but also as a supportive analysis device. Hence, through the application of predictive modeling techniques, like ArcGIS's least cost path analysis tool, I systematically test and discuss to what extent testable predictions can be made about the possible pilgrimage routes linking the site of Pacbitun to its hinterland caves.

4.5.5 Database

There are lots of different types of database models, ranging from single-table, flat-file databases to highly complex relational models which allow for a variety of different analysis approaches (Conolly and Lake 2006:52). In the relational model the database is broken into separate tables, each containing a coherent package of information. Given, that I collected data from an archaeological survey, I needed to create a system that allowed me to store information about the types of archaeological data I encountered and relations between those types and the site of Pacbitun. Therefore, I decided to create a relational database in MS Access. Here I created a table for each feature class I encountered: aguadas, caves, chultuns, housemounds, plazuelas, rockshelters, sinkholes, springs, stelae, other structures, temples, terraces, walls, and wells. In addition I created tables for all GPS points that were related to the causeways and the Pacbitun site center.

4.6 Conclusion

Described as the most powerful technological tool to be applied to archaeology since the invention of radiocarbon dating, GIS has also been framed as a technology without intellectual vigour, overly dependent on simple presuppositions about the importance of spatial patterns in a dehumanized artificial space (Conolly and Lake 2006:10). I think that it should be clear that GIS

applications, like predictive modeling techniques, can not do the archaeologist's work, as every application is dependent on the right code and data input. Rather, GIS should be applied as a contributing tool that can aid in either refining or rejecting hypotheses. The diverse functions of GIS have served many different disciplines from computer science to architecture. In archaeology it can be applied as a research tool, but also as a supportive analysis device, which is how I use it in this study.

5 ANALYSIS

5.1 Introduction

This chapter presents the survey and ceramic data collected during the course of the 2010 field season in the Pacbitun periphery. I will start out with a brief description of all the features I recorded, followed by a discussion of how the newly recorded data alters the prior information on settlement patterns and population estimates for Pacbitun. Then, I provide a general overview of causeway typologies, followed by the description of the causeway system encountered in and around Pacbitun. In addition, I address the results of the shovel tests and surface collections I conducted, as well as the ceramic identification thereof. The analysis of the causeway survey and collected ceramics is followed by the description and results of the least cost path analyses that I conducted on my survey data. All maps, tables, and pictures were made by me, unless otherwise noted.

5.2 Survey Results

In addition to the targeted four caves, Actun Pech, Actun Merech, Tzul's Cave, and Crystal Palace (Figure 5-1), I recorded three more caves, 90 agricultural terraces, 80 housemounds, six reservoirs, three rock shelters, four plazuela groups, two chultuns, two springs, one sinkhole, two wells, two isolated stelae found in the fields, as well as several other structures (Figures 5-2 to 5-7).

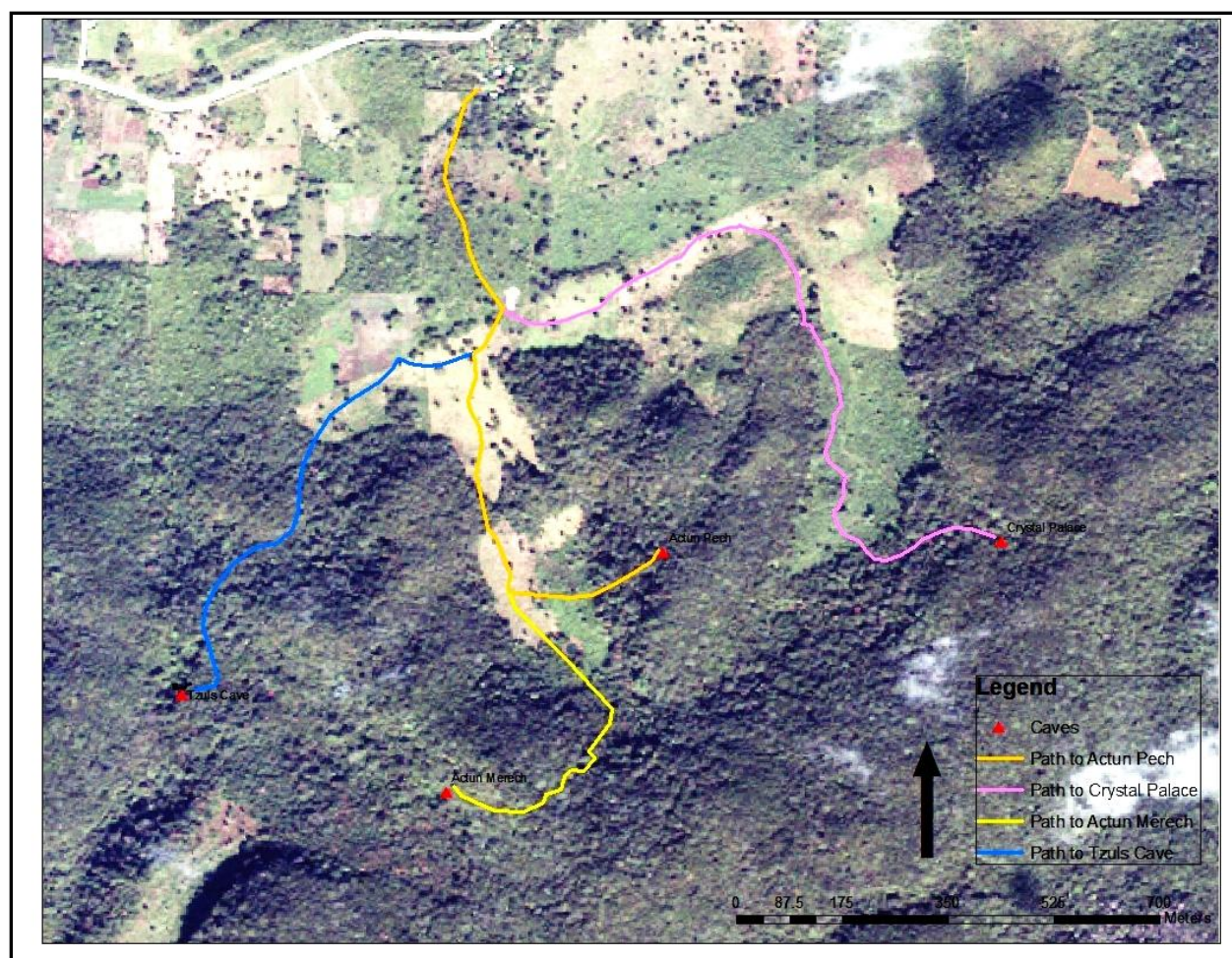


Figure 5-1: Initial survey routes to caves in the terrain

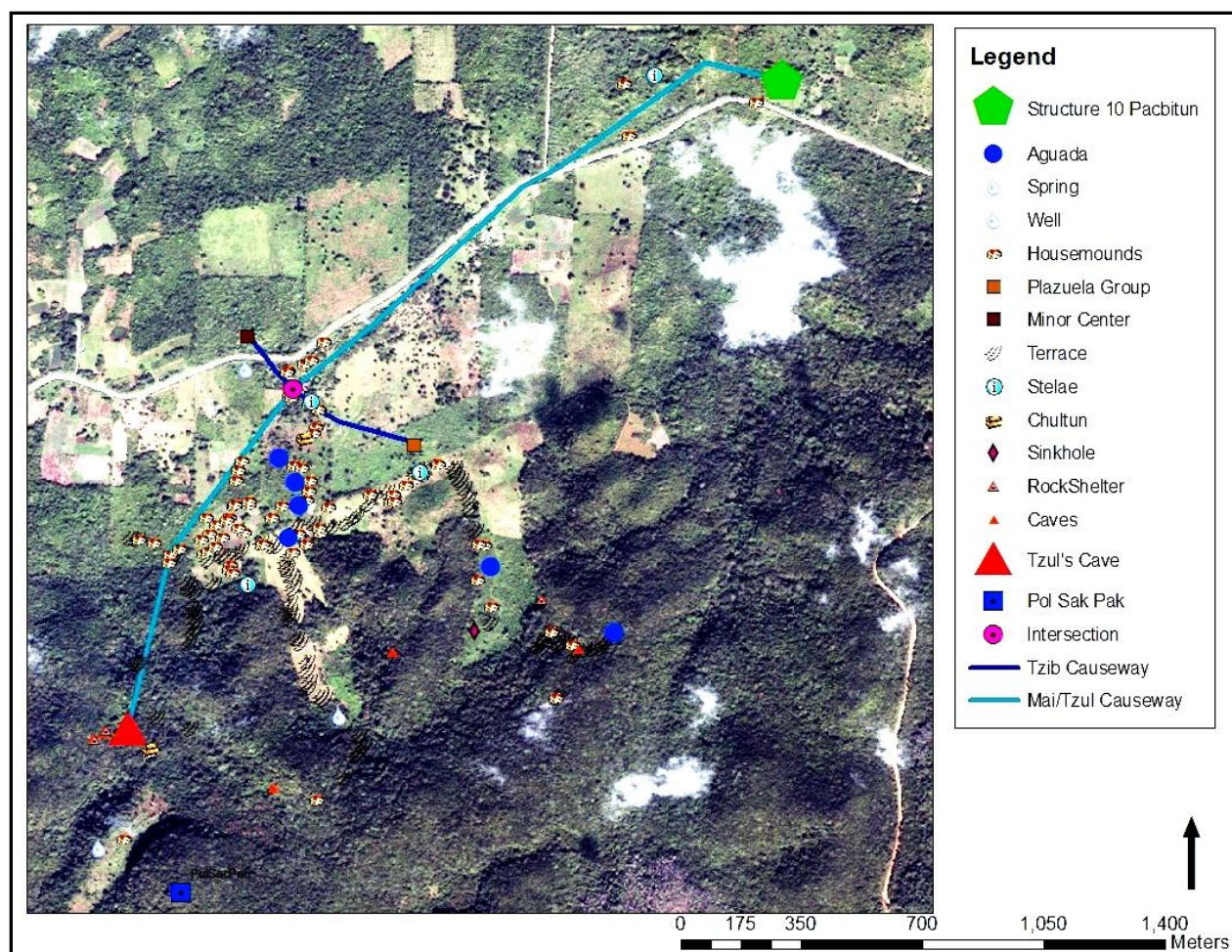


Figure 5-2: Survey features encountered



Figure 5-3: Terracing in the Pachitun periphery



Figure 5-4: Spring and dug well in the Pachitun periphery



Figure 5-5: One of several ancient water basins in the Pacbitun periphery



Figure 5-6: Slate covered chultun, encountered near Tzul's Cave



Figure 5-7: Structure remnants encountered in the periphery

5.2.1 Settlement Patterns and Population Estimates

The newly found settlement data contributes to our knowledge about the occupation at Pacbitun. This research is in line with other regional settlement pattern studies that date back to Willey's (1956) groundbreaking regional survey work at Barton Ramie, which contributed greatly to the analysis of population estimates for the ancient Maya. While formerly mostly unobserved, surveys and recordings of housemounds over the past 30 years have served as a way to estimate population densities (e.g. Healy et. al 2007; Magnoni 2006; Marcus 1976:79; McKillop 2004). Past population estimates in Mesoamerica are generally based on (1) human skeletal remains, (2) artifact assemblages like ceramics, from surface or excavated contexts, (3) architectural features such as residential units, (4) calculation of mean family size based on roofed-over or living floor area, or (5) carrying capacity of the land (Magnoni 2006).

In regards to housemounds, population estimates in the Maya Lowlands have been based on the counting of mounds which are then multiplied by the number of people estimated per house. Generally, the number of people per house has been calculated as 5.6. This is based on ethnographic data derived from a study in the Yucatec Maya village of Chan Kom by Redfield and Villa Rojas in 1962 (Campbell-Trithart 1990:79). It should be mentioned that while the number of 5.6 people per house has been slightly altered, with an estimated 5.5 people per household by Kolb and colleagues (1985), influential factors like disease, war, and contact with the Spanish must be considered as factors that can dramatically alter such an estimation (Campbell-Trithart 1990). Other problems with this kind of population estimation lie with hidden and/or destroyed structures, and the misinterpretation of mounds other than housemounds, as well as abandoned homes (Campbell-Trithart 1990:79; Healy et. al 2007).

Healy and colleagues (2007) calculated the population at Pacbitun. They estimated 1218 persons living in the epicenter, and the surrounding core zone. The epicenter is composed of monumental architecture and was the religious and political center of Pacbitun. The core zone surrounding the epicenter was estimated to be 1 km² in area and marked central Pacbitun (Healy et. al 2007:18). In the 8 km² periphery, 704 persons per km² was the calculated population density, which resulted in a total of up to 5632 persons in the periphery. The estimated total population count for all of Pacbitun then was 6850 persons at its height of settlement during the Late Classic (Healy et. al 2007:32). These numbers were based on a calculation of 5.5 persons and a 100% occupancy rate assumption. To achieve a more realistic occupation rate, Healy and colleagues (2007) added on 10% to account for hidden structures and subtracted 31.5% to

account for the possibility of non-contemporaneous mounds, the non-residential function for some mounds, and the lack of occupation (Healy et. al 2007:28-32) (Figure 5-7).

<i>Period (Phase)</i>	<i>Periphery (%)</i>	<i>Core (%)</i>	<i>Epicenter*</i>	<i>Total (A)†</i>	<i>Total (B)††</i>
Late Classic (Tzib) (A.D. 700–900)	5632 (100)	1018 (100)	200	6850	5377
Late Classic (Coc) (A.D. 550–700)	1718 (30.5)	51 (5)	53	1822	1430
Early Classic (Tzul) (A.D. 300–550)	760 (13.5)	102 (10)	26	888	697
Late Preclassic (Puc/Ku) (300 B.C.–A.D. 300)	620 (11)	51 (5)	20	691	542
Middle Preclassic (Mai) (900–300 B.C.)	0 (n.d.)	0 (n.d.)	16–49	25	20

* The Tzib phase Late Classic Epicenter population estimate, based on elite residential (palace) structures, represents 3% of the combined Periphery and Core Zone population (unadjusted). This same percent is used for all earlier periods except the Middle Preclassic Mai phase, for which independent architectural evidence exists.

† Total (A) calculation assumes 100% occupancy, and all mounds being residential.

†† Total (B) is calculated with a residential rate of 78.5% (reducing the population estimate by 21.5%). In this adjustment of the raw population count (Total A), 10% is added to account for various hidden structures, but 31.5% is deducted to account for the possibility of non-contemporaneous mounds, a non-residential function for some mounds, and for disoccupation (after Culbert et al. 1990: 115).

Figure 5-8: Pacbitun population estimates (after Healy et. al 2007)

This resulted in an occupation rate of 5377 persons for Pacbitun in the Late Classic, with an estimated population density of 956 persons per square kilometer in the one km² core zone and 553 persons/km² in the eight km² periphery (Healy et. al 2007:32). Following the same approach, I estimated the total population for the number of housemounds I recorded. In total, I recorded 80 housemounds. After reviewing the surveys conducted through Trent University and comparing the survey area with mine, I noticed a possible overlap in ten mounds, three of which are situated in the site core and seven in Trent University's southwestern survey transect. Therefore, I subtracted these ten mounds from my collected data, resulting in 70 newly recorded

housemounds. This implies an estimated occupation rate of 302.2 people/km² who lived within my survey area, which was the size of approximately 1.5 square kilometers (Table 5-1).

Table 5-1: Population estimates for surveyed housemounds

Housemounds	Occupation Rate	100% Occupancy	Adjustment	Total
70	5.5 persons/mound	302.2	-21.5%	237.2

The adjusted calculations from 237.2 persons per 1.5 km² result in 158.1 persons per square kilometer, an estimation that is less than half of the number of persons Healy and colleagues (2007) had calculated for the periphery. However, as he mentioned, mound density at Pacbitun diminishes as one proceeds away from the epicenter and core zone into what appeared to be farmland, with the most significant drop-off in settlement starting approximately 250 meters from the epicenter (Healy et. al 2007:24). Based on the data I collected, this drop-off appears to be more gradual than originally suggested. Given that Healy and colleagues (2007) surveyed four 1000 meter x 300 meter transects out of the one km² core zone at the center, it can be estimated that the farthest out into the periphery those transects extended was about 1.3 km to 1.45 km. Aside from four to five housemounds that might overlap between both surveys, my own settlement survey area starts about 1.5 kilometers out of the site center (Figure 5-9).

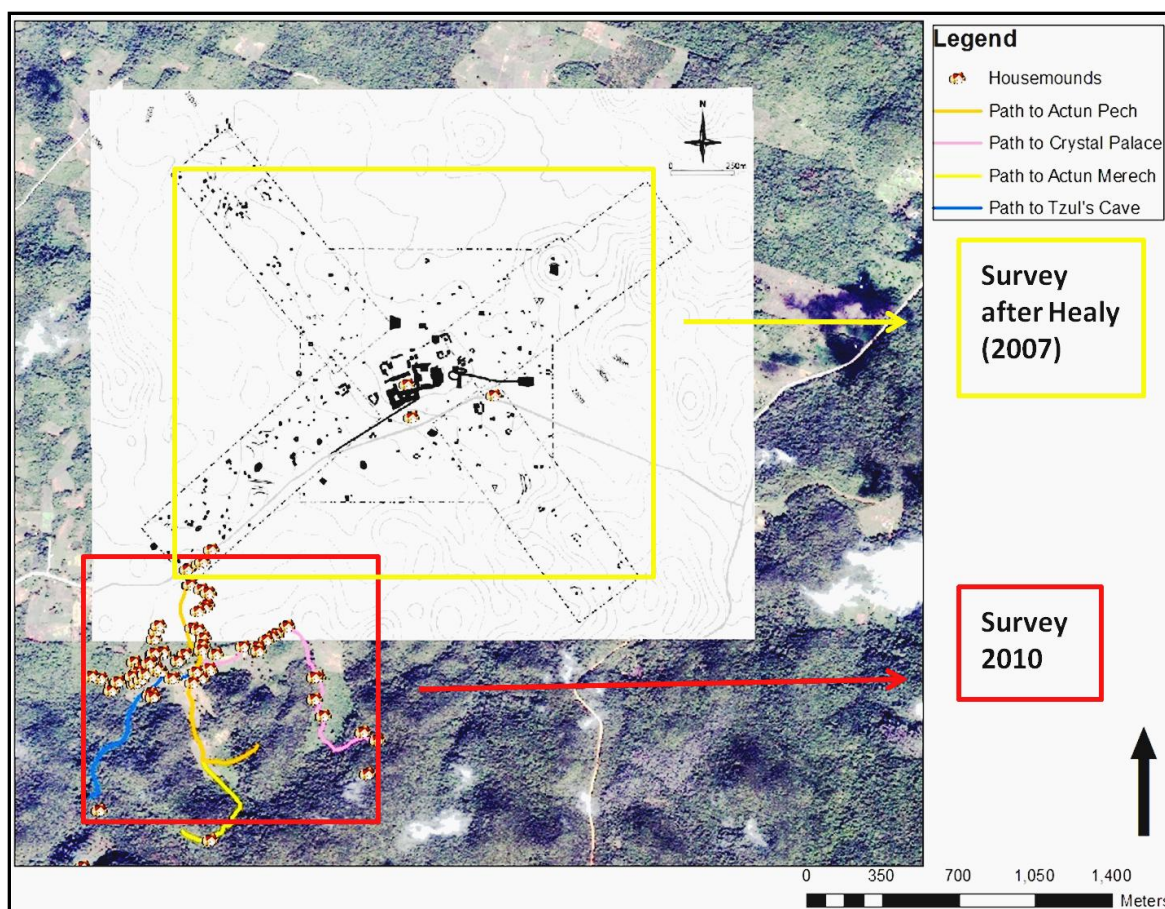


Figure 5-9: Comparison of surveys at Pacbitun

My survey area extended approximately three km outwards, from the site core into the southwestern periphery. If I extend the size of the Pacbitun periphery to the furthest recorded housemound I recorded and calculated a settlement area in accordance to Healy and colleagues (2007), then the peripheral area of Pacbitun would increase from 8 km² to 24 km² (Figure 5-10). This is based on the calculation of a 5 km x 5 km peripheral area, subtracting 1 km² for the core center.

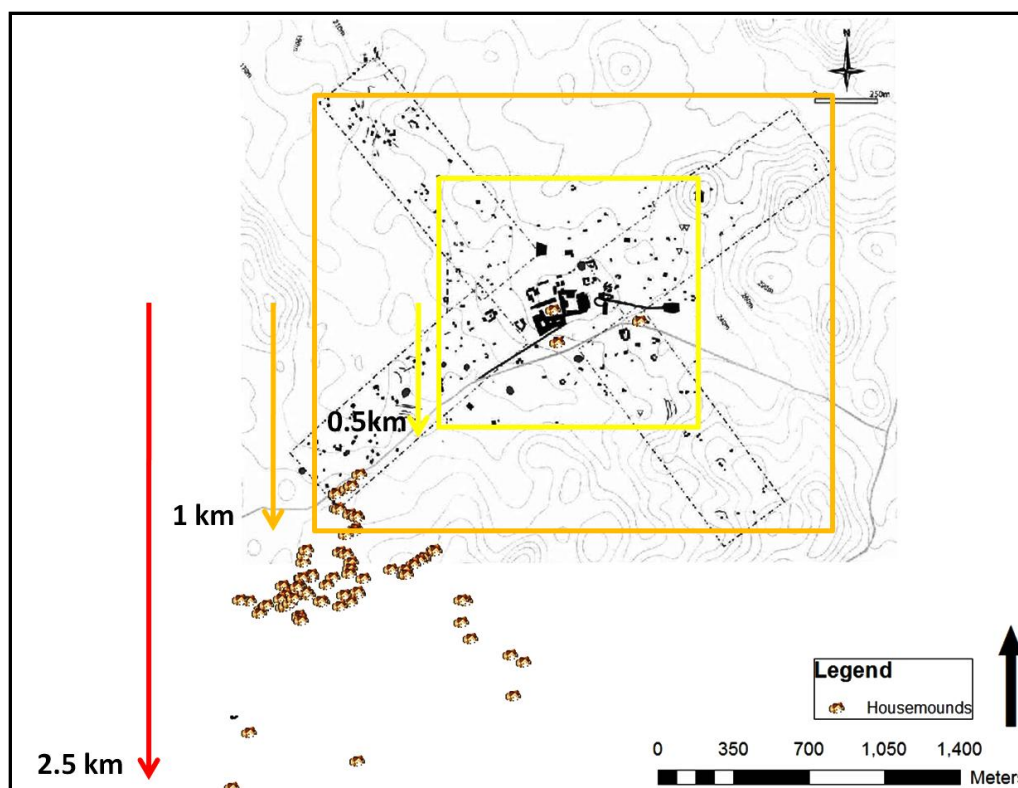


Figure 5-10: Pacbitun area calculation

However, it needs to be considered that my survey area of approximately 3 km² is most likely not representative of the whole periphery, as the housemounds I recorded cluster near water sources and agricultural terraces to the southwest. Healy and colleagues (2007) found similar results in the transect surveys, noting that settlement in the western transects was found to be more dense. A fact, he thought might be attributed to a more gently rolling terrain, pockets of deeper soils, and a greater abundance of water sources in the form of streams and springs to the western side of Pacbitun (Healy et. al 2007:22). Therefore, I will not base my calculations on an adjusted site size of 25 km² but rather estimate the population according to the 9 km² site size given by Healy and colleagues (2007). Of course, in order to get more conclusive information on the population estimates and occupation periods, excavations, along with more surveys, would need to be conducted. However, in regards to the number of housemounds I encountered, I

suggest the following preliminary population adjustments, based on the assumption that the mounds I surveyed were occupied during the Late Classic, the period of highest population density at Pacbitun (Healy et. al 2007) (Table 5-2):

Table 5-2: Adjusted population estimates for Pacbitun

Period	Calculations	Core and Epicenter	Outer Core	Periphery	Total
Late Classic	5.5 persons per mound/ - 21.1 % adjustment	956 persons in the 1 km ² core zone (after Healy 2007)	553 persons in 4 km ² area outside of the core zone (formerly 553 persons/8 km ² periphery) = 2212 persons	158.1 persons per 1 km ² area outside of the outer core (now 4 km ² , formerly 8 km ² of peripheral area), (no. is rounded to the closest person) = 632 persons	3800

Here, I created an additional “occupation square”, the “outer core”. The calculations for the Core and Epicenter remain the same, the periphery however is not based on 553 persons/km², multiplied by eight km². Rather, I used the estimated population estimates by Healy and colleagues (2007) for the periphery and reduced it to the area between his core zone and my peripheral survey area, now the outer core, which results in 2212 persons living in an area of 4 km². The calculations for the periphery are then based on an adjusted peripheral area of the remaining 4 km², resulting in 632.4 people living there (Figure 5-11).

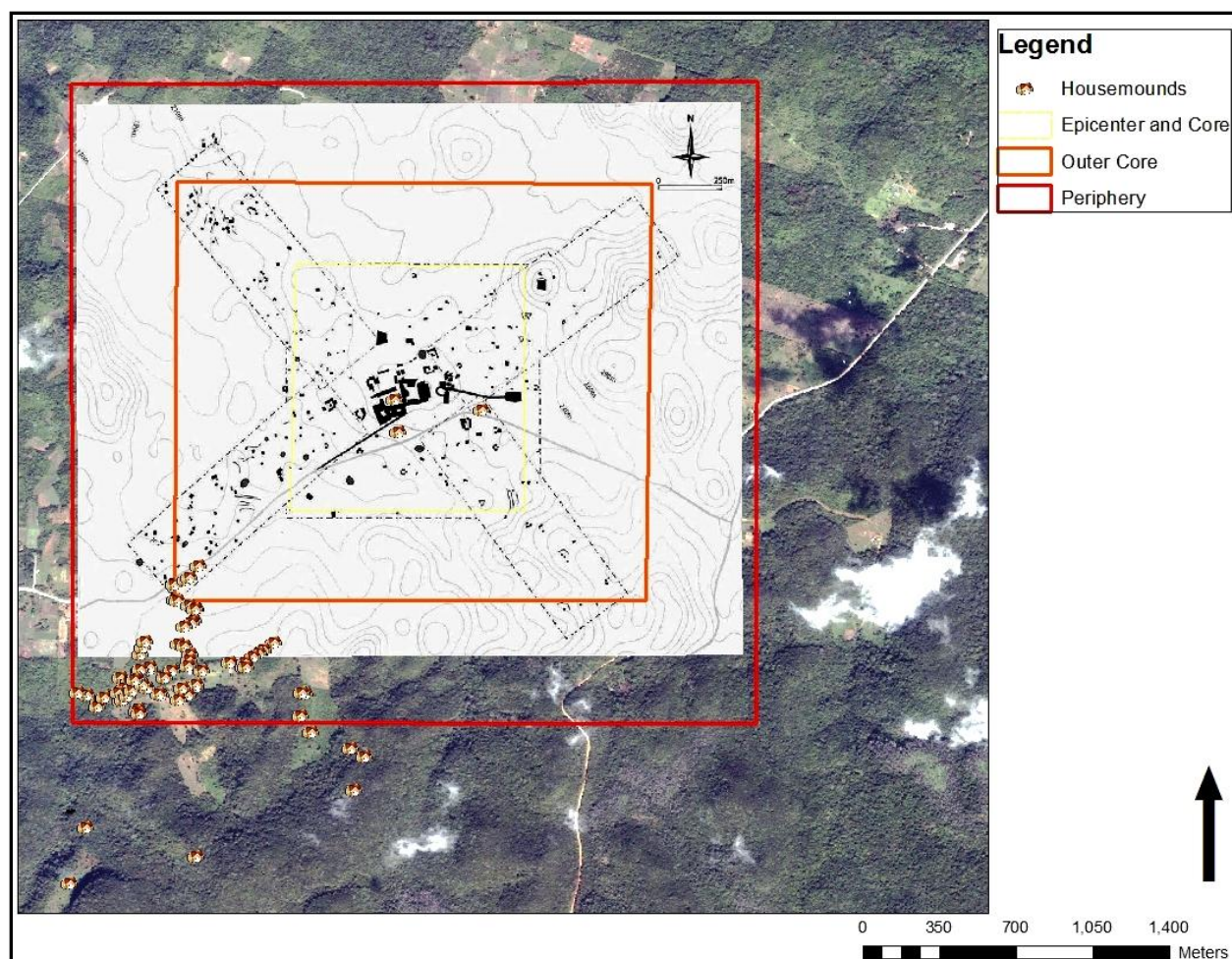


Figure 5-11: Pacbitun adjusted occupation areas

Based on these preliminary calculations I propose to adjust the total population estimate for Pacbitun (based on a nine square kilometer area) from former 5377 persons to 3800 persons in the Late Classic. These results are, as mentioned, only preliminary in nature and need to be further adjusted, following a complete coverage survey and housemound excavations.

5.2.2 *The Causeway System at Pacbitun*

During my survey I discovered that the causeway system at Pacbitun was more extensive than anyone had originally assumed. I was not only able to re-survey the causeways in the site center (Healy 2007) but also found extensions of them, as well as one previously unknown ancient Maya road. As mentioned in Chapter 3, studying these ancient roads can provide insights into political activities, social organizations, economics structures, and cosmological ideals on intra- and intersite levels (Normark 2006). Thus, the causeways in and surrounding Pacbitun swiftly became a primary research focus. There are three causeways present at Pacbitun and in its periphery: Mai causeway, Tzul causeway, and Tzib causeway (Figure 5-12). Below I present the basic descriptions of each, my interpretations of these causeways are discussed in Chapter 7.

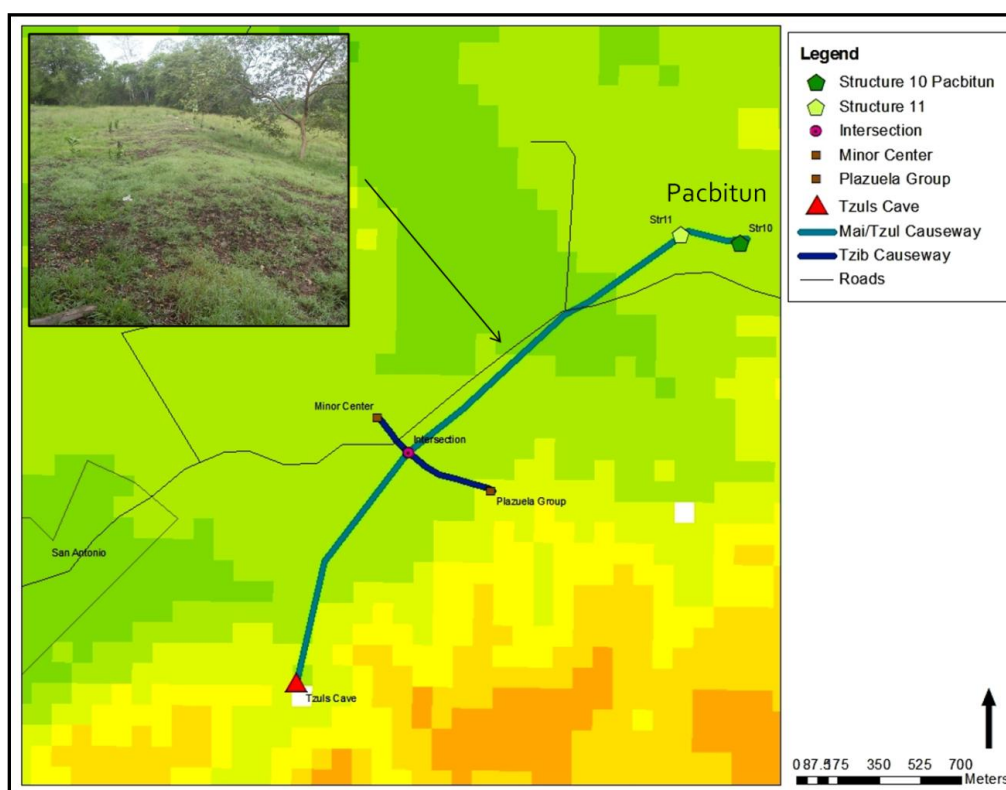


Figure 5-12: Causeway system at Pacbitun

5.2.2.1 *Mai Causeway*

Mai causeway is a local intrasite sacbe, about 273 meters in length. In the Pacbitun site core, the Mai causeway starts adjacent to Structure 11 where it meets with Tzul causeway (Figure 5-13). From there, it runs east at a ca. 120 degree angle before terminating in front of Structure 10. It is ca. 13 meters wide. The area was very overgrown and I was unable to follow the path on the actual causeway. Because of this, I was not able to take a GPS point after 190 meters, where the causeway changes its direction from ca. 120 degrees to an almost 90 degree angle and runs for the remaining 83 meters.

5.2.2.2 *Tzul Causeway*

Tzul causeway can be described as a core-outlier sacbe, as it leaves the core zone and moves through the less densely settled periphery before arriving at its destination (Shaw 2008:86-87). Like Mai causeway, Tzul causeway also starts at Structure 11 in the Pacbitun site core (Figure 5-13). Modern construction has destroyed parts of the Tzul causeway, especially where it crosses the road, but it re-emerges clearly visible on the southern side of the road (Figures 5-14 and 5-15).

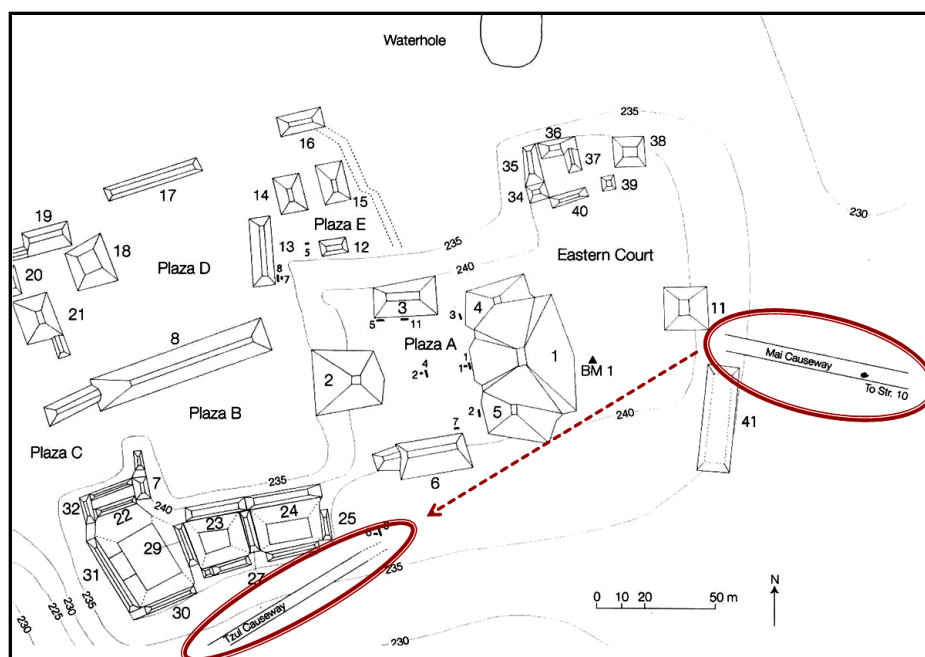


Figure 5-13: Mai and Tzul causeways in site core
(illustrated by Jennifer Weber, after Healy 2007)

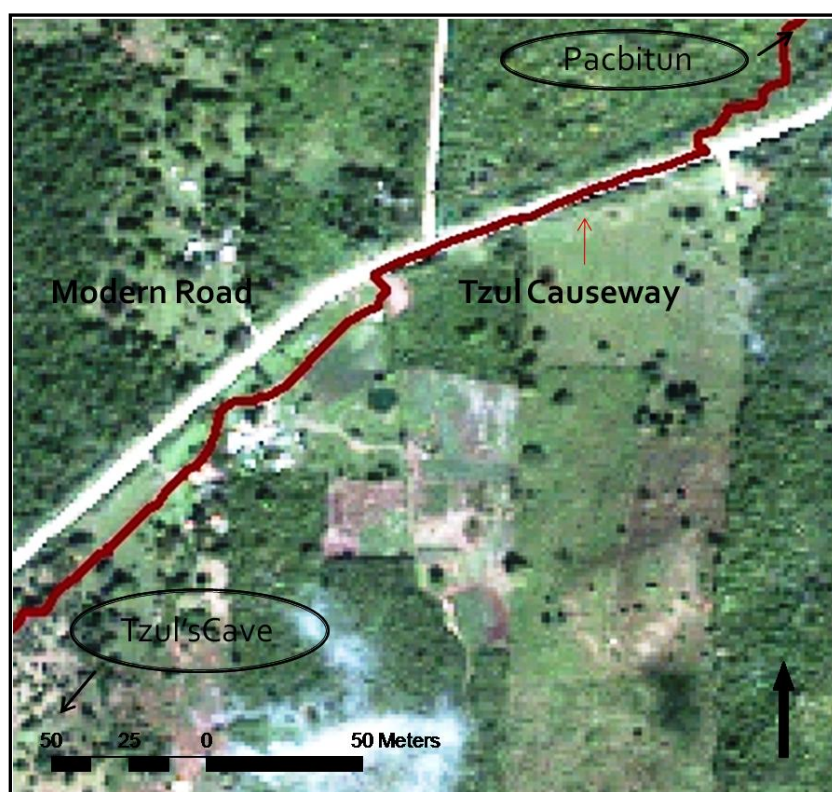


Figure 5-14: Portion of Tzul causeway undergoing modern road



5-15: Tzul causeway south of the modern road

Approximately 900 meters from the site core, the Tzul causeway intersects with another sacbe, which was named Tzib causeway (Figure 5-16). The Tzul causeway then continues into the foothills, running for about another 1.2 km until it terminates in front of Tzul's Cave. Overall, visibility was good but at times it was difficult to see certain sections, due to erosion. In total, the Tzul causeway is approximately 2.6 km long, as it extends from the site core to Tzul's Cave. An attempt to find a possible causeway connection between Tzul's Cave and Actun Merech, which lies approximately 900 meters to the east, produced a negative result.

5.2.2.3 Tzib Causeway

Tzib causeway was unknown to archaeologists prior to the 2010 field survey. Information about it was given by Joe Tzul who mentioned an intersection of causeways in the back of his house (Figure 5-16). Tzib causeway is much shorter, only about 600 m in length, and connects a plazuela group to a minor center (Figure 5-12). In terms of its length Tzib causeway would fall into the intrasite sacbe group, however it lies outside the site core.



Figure 5-16: Intersection of Tzul and Tzib causeways

5.3 Ceramic Analysis

As mentioned in Chapter 4, artifact collections were limited to controlled shovel tests and surface findings. Seven shovel tests were carried out at different locations along the causeways in order to obtain materials that might clarify the construction dates of the sacbeob. In addition, two shovel tests were conducted in housemound locations, namely housemound 27 and housemound 29. Both housemounds were chosen for shovel tests because of their close location to a cave and a causeway, respectively. Surface collections were undertaken in a plazuela group related to the Tzib causeway and a housemound, designated as housemound 36.

5.3.1 *Shovel Tests*

The shovel tests in the causeways were designated as “Shovel Test 1 – 7”, the shovel tests in the housemounds were named “Shovel Test Housemound 27” and “Shovel Test Housemound 29”.

5.3.1.1 *Shovel Test 1*

Shovel test 1 was put in the middle of Mai causeway ca. 6.4 meters east of the meeting point of Mai and Tzul causeways. This shovel test was at a depth of about 20 cm and produced only gravel, no ceramic materials were recovered.

5.3.1.2 *Shovel Test 2*

Shovel test 2 was placed at the connection point between the Mai and Tzul Causways adjacent to Structure 11 in the site core. This shovel test was positive and produced pottery ca. 20 cm below top soil. The two red sherds and one greyish one, however were too small to be properly typed (Figure 5-17).

5.3.1.3 *Shovel Test 3*

Shovel test 3 was placed in the middle of the Tzul- and Tzib causeway intersection. Here, gravel was present right on the surface. I excavated to a depth of 30 cm and collected five sherds. Four of them seem to be Savana Orange: Savana Variety, the other could not be properly identified (Figure 5-18).

5.3.1.4 *Shovel Test 4*

Shovel test 4 was placed in the Tzul causeway to the east of the intersection of Tzib and Tzul causeways. This shovel test produced five pottery sherds. Here, I excavated to a depth of 22 cm and could spot large foundation stones towards the bottom. The pottery consists of four body sherds of Cayo Unslipped: Variety Unspecified Red. The curved, fifth, piece could not be identified (Figure 5-19).

5.3.1.5 *Shovel Test 5*

Shovel test 5 was placed in Tzib causeway to the north of the intersection. Here, I excavated 40cm and found two pottery pieces, burned limestone, and flint. The two pottery pieces consist of one neck piece and one body piece, both of the Belize Red: Belize Variety type (Figure 5-20).

5.3.1.6 *Shovel Test 6*

Shovel test 6 was conducted into Tzul causeway to the west of the intersection. This shovel test produced one piece of pottery after 21 cm of excavation. The unslipped body sherd was too small to be properly identified but consisted of a light brown paste with lots of calcite and a dark core (Figure 5-21).

5.3.1.7 Shovel Test 7

Shoveltest 7 was put into Tzib causeway to the South of the intersection. Here, 12 pieces of pottery were recovered which increased in size as the test got deeper. I could identify one Alexander Unslipped: Croja Variety body piece, one Savana Orange, and several Belize Red: Belize Variety type sherds (Figure 5-22).



Figure 5-17: Shovel Test 2 - Tzul's/Mai causeways



Figure 5-18: Shovel Test 3 - causeway intersection



Figure 5-19: Shovel Test 4 - Tzul causeway



Figure 5-20: Shovel Test 5 - Tzib causeway



Figure 5-21: Shovel Test 6 - Tzul causeway



Figure 5-22: Shovel Test 7 - Tzib causeway

5.3.1.8 Shovel Test Housemound 27

The mound marked as Housemound 27 is located right next to Crystal Palace Cave and given the significance of this location, I chose this mound as a target for a shovel test. Its peculiar location right next to a ritually significant cave leads to speculation about the significance of this mound and the question of whether it was just a typical home or served some other purpose. In total, I recovered three ceramic sherds from this shovel test. One sherd presents a smoothed black surface, resulting from firing a possible buff colored olla vessel. The other two are brown/buff olla body pieces with large calcite inclusions (Figure 5-23).



Figure 5-23: Shovel Test Housemound 27

5.3.1.9 Shovel Test Housemound 29

Housemound 29 was encountered while following Tzul causeway. Due to its close location to the causeway, I conducted a shovel test here as well. As with Housemound 27, this location leads to the question of the significance of the mound itself. Here, I recovered two rim sherds. One was identified as Mount Maloney Black, the other as Cayo Unslipped: Variety Unspecified Red (Figure 5-24).



Figure 5-24: Shovel Test Housemound 29

5.3.2 Surface Collections

Surface collections were conducted in a plazuela group where the Tzib causeway terminates at its south end. Another surface find location was a mound encountered in close proximity to Crystal Palace Cave, designated as Housemound 36.

5.3.2.1 Surface Find – Plazuela Group

Since Tzib causeway terminates in a plazuela group at its south end, I choose this location to collect some surface pieces for further analysis and dating. I collected one thick body sherd, one piece of Dolphin Head Red: Dolphin Head Variety, and one Cayo Unslipped (Figure 5-25). In addition, a broken piece of a mano was collected.

5.3.2.2 *Surface Find – Housemound 36*

Another surface find was collected at Housemound 36, located in close proximity to Crystal Palace Cave. This rim sherd was identified as Cayo Unslipped: Variety Unspecified Red (Figure 5-26).



Figure 5-25: Surface collection - plazulea group



Figure 5-26: Surface collection - Housemound 36

5.3.3 Interpretation of Ceramic Collection

The presence of Savana Orange in the causeway intersection, only 20-30 cm below surface, and mixed in with later period sherds certainly demands some attention (Table 5-3). Considering that the causeway intersection lies only a few meters from a modern house and dirt road, and the area is subjected to farming, a disturbed context is certainly a possibility, as construction and farming processes might have very well taken place in the area over the past few hundred years. Since the periodic difference between Jenney Creek and Spanish Lookout (Table 5-3) lies at a maximum of 1800 years, the use midden fill material during the construction of the causeway seems most likely. However, part of the construction of the causeway could also date to earlier occupation periods, e.g. back to the Middle Preclassic, although, while this information is based on only a very small sample size, given the predominantly Late Classic

period ceramic counts, this is rather unlikely. Another explanation for Middle Preclassic pottery in the causeway might be the possibility of a Middle Preclassic house or other structure at the location, which was later abandoned and followed by the causeway built over it.

Table 5-3: Dating Periods for Ceramics

	Where	Result	Type	Complex	Period
Shovel Test 1	Causeway	Negative	n.a.		
Shovel Test 2	Causeway	Positive	Not identified		
Shovel Test 3	Causeway	Positive	Savana Orange	Jenney Creek	Middle Preclassic
Shove Test 4	Causeway	Positive	Cayo Unslipped: Variety Unspecified Red	Spanish Lookout	Late/Terminal Classic
Shovel Test 5	Causeway	Positive	Belize Red: Belize Variety	Spanish Lookout	Late/Terminal Classic
Shovel Test 6	Causeway	Positive	Not Identified		
Shovel Test 7	Causeway	Positive	Alexanders Unslipped: Croja Variety, Belize Red: Belize Variety, Savana Orange: Savana Variety	Spanish Lookout Jenney Creek	Late/Terminal Classic, Middle Preclassic
Shovel Test Housemound I	H27	Positive	Not Identified		
Shovel Test Housemound II	H29	Positive	Mount Maloney Black, Cayo Unslipped	Spanish Lookout	Late/Terminal Classic
Surface Collection I	Plazuela Group	n.a.	Dolphin Head Red: Dolphin Head Variety, Cayo Unslipped	Spanish Lookout	Late/Terminal Classic
Surface Collection II	H36	n.a.	Cayo Unslipped: Variety Unspecified Red	Spanish Lookout	Late/Terminal Classic

Savana Orange occurred during the late facet of Jenney Creek (Gifford 1976:62).

Belize Red type pottery extended during the entire phase of the Spanish Lookout, while Mount Maloney Black occurred mainly during the late facet of Spanish Lookout (Gifford 1976:226).

The Dolphin Head Ceramic Group: Variety Dolphin Head occurred during the early facet of Spanish Lookout (Table 5-4).

Table 5-4: Ceramic sequences for selected sites
Table by Jennifer Weber (after Gifford 1976)

Dates	Period	Barton Ramie	Pacbitun
AD 1400	Late Postclassic	New Town	
AD 1300			
AD 1200	Middle Postclassic		
AD 1100			
AD 1000	Early Postclassic		
AD 900	Late Classic	Spanish Lookout	Tzib
AD 800			
AD 800			
AD 700		Tiger Run	Coc
AD 600	Early Classic		
AD 500		Hermitage	Tzul
AD 400			
AD 300	Proto Classic	Floral Park	Ku
AD 200			
AD 100			
BC /AD		Mount Hope	
100 BC	Late Preclassic	Barton Creek	Puc
200 BC			
300 BC			
400 BC			
500 BC	Middle Preclassic	Jenney Creek	Mai
600 BC			
700 BC			
800 BC			
900 BC	Early Preclassic		
1000 BC			
1100 BC			
1200 BC			

Given the intensive agriculture in the area, the predominantly Late Classic ceramic finds in the periphery, identified as Cayo Unslipped and Belize Red, are certainly not surprising (Figure 5-27). As Healy and colleagues (2007) mention, the only evidence for Middle Preclassic occupation has been found in the epicenter of Pacbitun. Late Preclassic occupational evidence has only been found in 5% of the housemound excavations in the core zone (Healy et. al

2007:32). In contrast, almost every mound tested in the core and periphery had shown signs of occupation during the Late Classic (Healy et. al 2007:33).

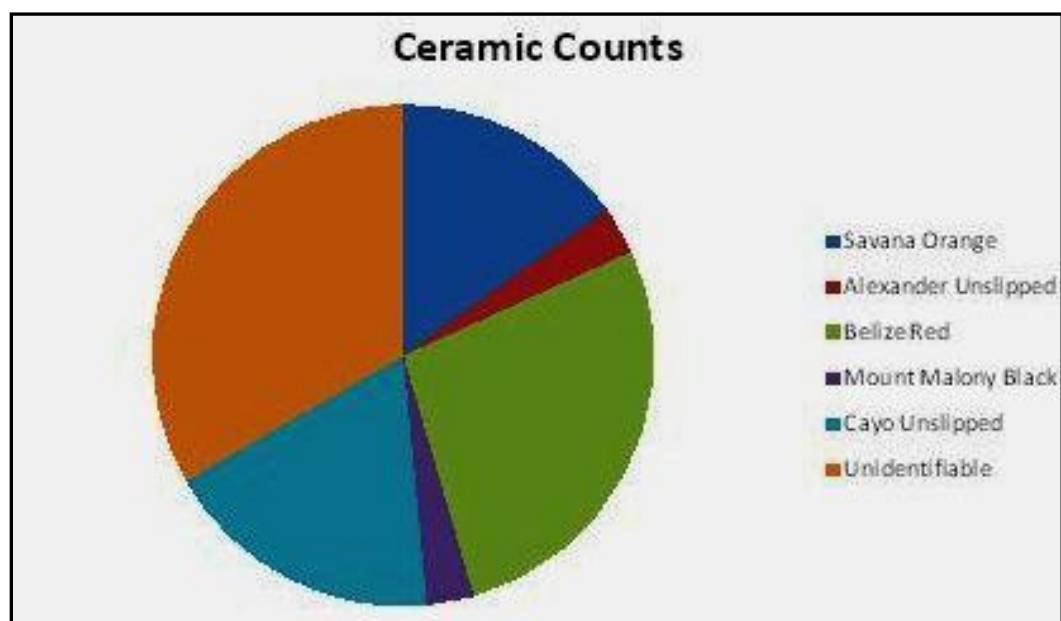


Figure 5-27: Ceramic counts from shovel tests and surface collections

5.3.4 Cave Ceramics

Cave research in Western Belize found that ceramic jars and jar sherds are some of the most common artifacts deposited within cave sites. As Moyes and colleagues (2009) state, ethnographically, jars can be divided into three functional groups: narrow-mouth jars for carrying water, wide-mouth jars for storage (e.g. water or maize seeds), and those with wide collars and low necks used for cooking. In addition, large jars were also used for cosmological connotations associated with the deities (Moyes et. al 2009). For descriptions of the caves, see Chapter 3.

5.3.4.1 *Actun Merech Ceramics*

At Actun Merech, only a few Late Classic pottery sherds (mostly Cayo Unslipped rim sherds) were found on various ledges in the back of the cave (Figure 5-28) (Powis 2010; Weber and Powis 2010). While no other pottery was encountered, we were told by one of the residents of San Antonio Village that the back room once contained three intact Late Classic period vessels, including one red slipped cylindrical jar, one red slipped deep bowl, and one polychrome dish. They were removed sometime in the late 1960s. In 2010, a 50 cm by 50 cm excavation unit was placed in Room I to determine if any other pottery vessels were deposited in the chamber. However, none were recovered (Powis 2010; Weber and Powis 2010).



Figure 5-28: Ceramic sherds located in Actun Merech (photo courtesy of PRAP)

5.3.4.2 *Actun Pech Ceramics*

As mentioned in Chapter 3, twenty-three whole and partial pottery vessels (including 16 ollas) were found throughout the cave. They dated in age from the Late Preclassic (ca. 100 BC) to the Terminal Classic (ca. 900 AD). The human remains, also mentioned in Chapter 3, were located adjacent to a number of whole and broken pottery vessels (e.g., Alexanders Unslipped, Garbutt Creek Red, Mount Maloney Black, Roaring Creek Red, Zubin Red) dating to the Late-to-Terminal Classic periods (Figure 5-29) (Powis 2010; Weber and Powis 2010).



Figure 5-29: Ollas in Actun Pech (photo courtesy of PRAP)

5.3.4.3 *Tzul's Cave Ceramics*

Tzul's Cave contains mostly Late Classic rim sherds, including one sherd that shows three pseudo glyphs, possibly depicting a serpent head, on a horizontal band encircling the rim. At the back (north end) of the cave (see Chapter 3) is a cache of 13 complete pottery vessels (Figure 5-30), all dating to the Late Classic period (Powis 2010; Weber and Powis 2010).



Figure 5-30: Olla encountered in Tzul's Cave (photo courtesy of PRAP)

5.3.4.4 *Crystal Palace Ceramics*

As mentioned in Chapter 3, Crystal Palace has not been properly mapped yet. Thus far, the vessels and sherds, coming from plates, bowls and ollas, encountered in the cave have all been preliminarily dated to the Late to Terminal Classic periods (Figure 5-31) (Powis 2010; Weber and Powis 2010).



Figure 5-31: Vessel encountered in Crystal Palace Cave (Photo courtesy of PRAP)

5.4 GIS Analysis

As mentioned in Chapter 4, to organize, visualize, and analyze my survey data, I used the ArcGIS 9.3. Remote Sensing data was granted through Geoeye Imagery, and Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM) data was obtained for free from the JPL-NASA website.

5.4.1 *Least Cost Paths*

Considering the presence of several ritually used caves in the Maya periphery, why would the Maya build a causeway to Tzul's Cave and not to Actun Pech or Actun Merech? Caves were an important aspect of the ancient Maya world (see Chapter 6). Hence, I focused on the Tzul causeway and its actual course, to see if that could reveal why it was constructed. Since the causeway runs into the mountains, the terrain becomes very steep at times. While walking the route, I was wondering if an easier course for the causeway could have been chosen, thus avoiding the steepest portions of the hill. If there was indeed an easier route to construct a causeway to Tzul's Cave, then maybe the route of Tzul causeway was chosen for ritual or other ideological reasons that regarded the topography of the terrain as only a secondary concern. Therefore, I decided to run a LCP from the Pacbitun site core to Tzul's Cave.

In order to calculate the least cost path analysis, I had to first create a slope file from my raster elevation data. Next, I created the cost distance, while creating an output raster in which each cell was assigned the accumulative cost to the closest source cell. The source cell here was the Pacbitun site core in the form of a single-point shapefile (ESRI 2010). The destination cell was Tzul's Cave, again marked as a single-point shapefile. Given the cost distance, I could then run the cost path analysis. Results showed a path running from the Pacbitun site core to the

southwest for approximately 2.2 kilometers before running straight south for approximately 388 meters to Tzul's Cave (Figure 5-32). When reviewing the surveyed Tzul causeway, it becomes apparent that the LCP follows the route of the actual causeway (Figure 5-33). Since the LCP was run solely based on slope data, this indicates that there is not an easier route following less steep elevation values from the valley to the cave. The causeway was indeed built following the most direct path through the terrain.

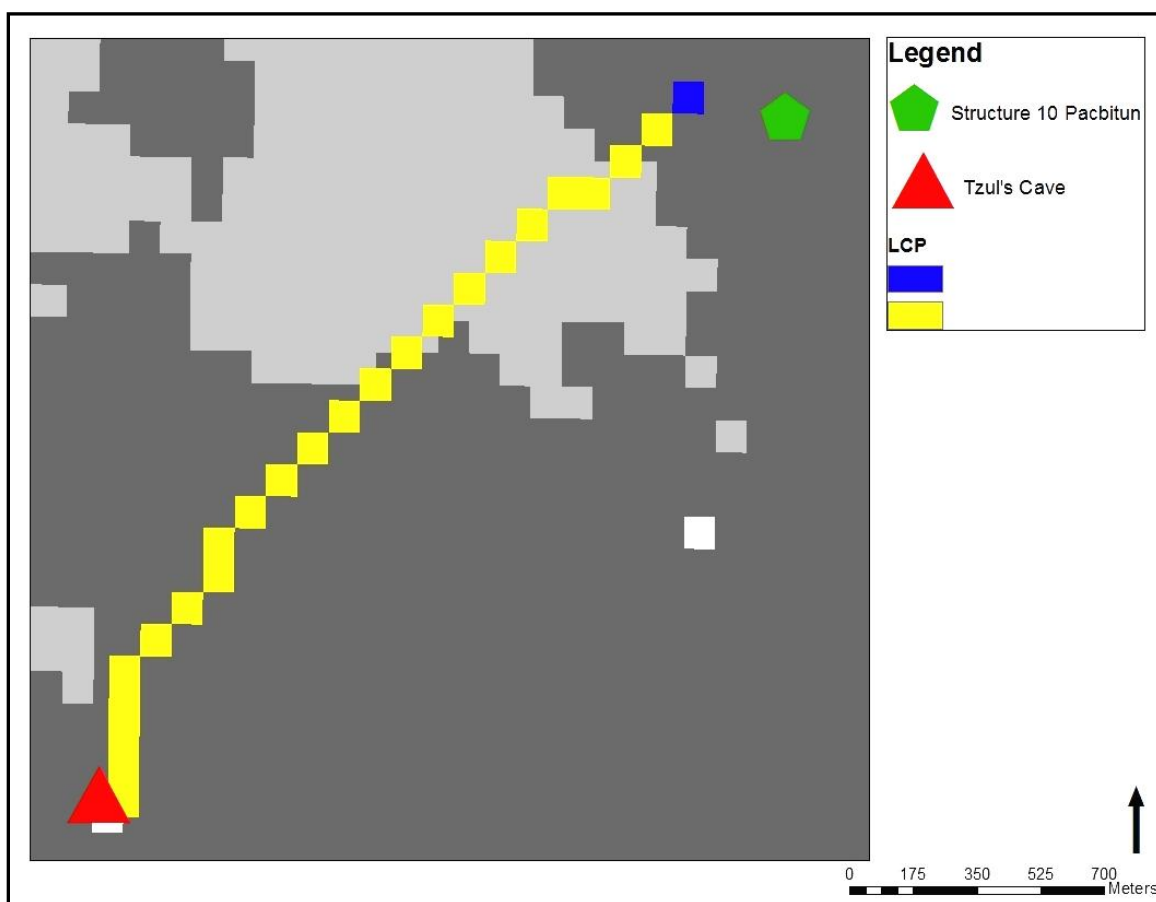


Figure 5-32: Least cost path analysis for route from Pacbitun to Tzul's Cave

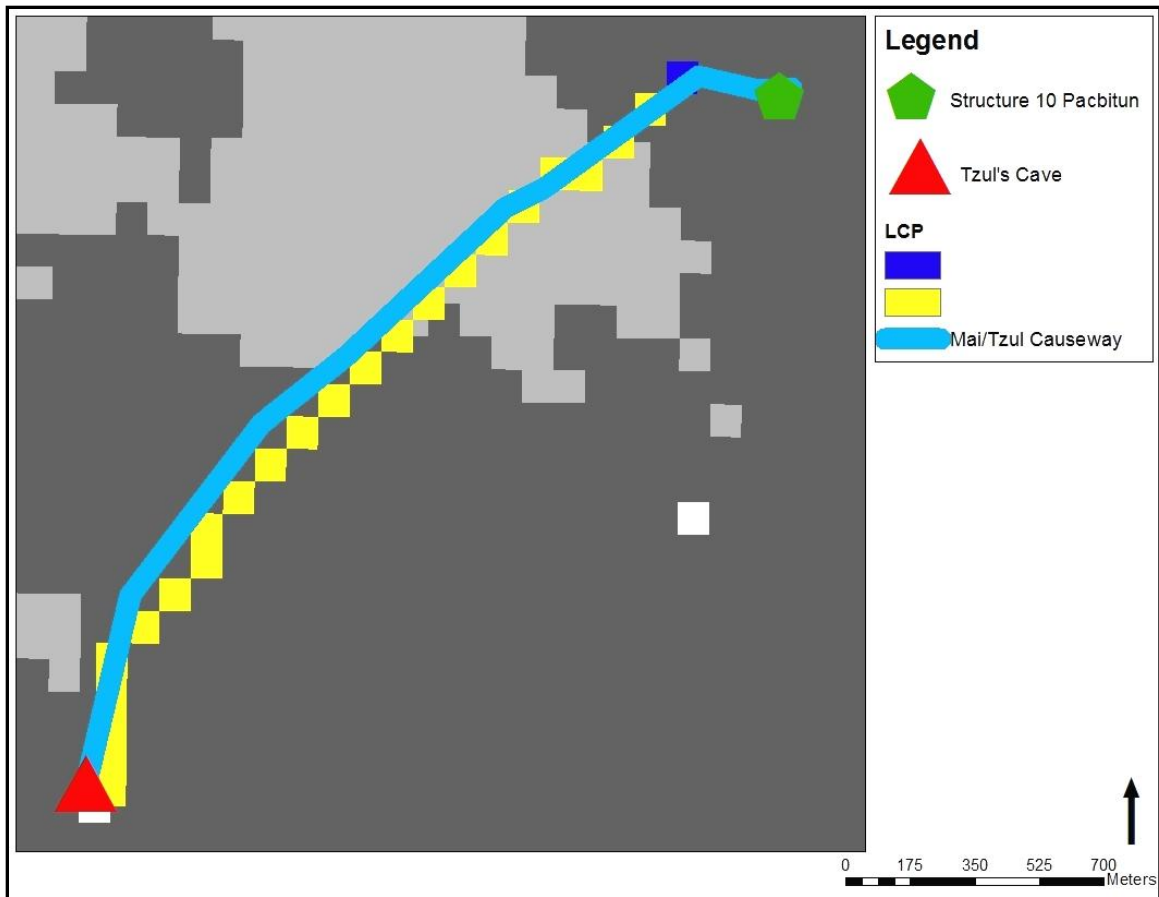


Figure 5-33: Least cost path analysis in relation to Tzul causeway

5.4.1.1 Cost Distance vs. Path Distance

In addition to the cost path analysis based on the cost distance, I also conducted a LCP based on the path distance. The path distance function is similar to the cost distance function, as it also determines the minimum accumulative travel cost from a source to each cell location on a raster (see Chapter 4). However, *how* the cost of moving from one cell to the next is computed differently. In addition to the accumulative cost over a cost surface, the path distance function also compensates for the actual surface distance that must be traveled as well as for the horizontal and vertical factors influencing the total cost of moving from one location to another (ESRI 2010). In short, the distance function adds additional factors beyond just the cost surface to account for actual travel distance over the terrain. These additional functions, called frictions, are horizontal and vertical cost factors. Horizontal cost factors are costs needed to change direction. This calculation is based on the degrees of two possible moving angle-turns of each cell. Vertical cost factors are based on the costs needed to overcome slopes and are derived from z values (Figure 5-34).

Cost Distance vs. Path Distance Calculation Parameters	
Cost_distance = Cost_Surface * Surface_distance	Path_distance = Cost_Surface * Surface_distance * {[Friction(a) * Horizontal_factor(a) + Friction(b) * Horizontal_factor(b)]/2} * Vertical_factor

Figure 5-34: Cost distance vs. path distance

The path distance function in ArcGIS' spatial analysis tool allows the user to enter the horizontal and vertical parameters in form of a file upload, before running the LCP. An example of adding a vertical parameter would be calculating travel velocity, such as Tobler's (1993) hiking function (see Chapter 4), over a slope and then adding those values to the path distance calculation.

In general, it can be assumed that since the path distance function allows for additional data input, it leads to a more complex - and thus more realistic - calculation of the LCP. This of course requires that horizontal and vertical variables are known. Since I did not, for example, record my walking speed or add angle calculations into my LCP data, I ran the path distance solely based on the elevation values derived from my data. Other than the cost distance that uses the value of each cell as the cost and then tries to accumulate the least cost to get from source to destination, here the values of each cell are used to calculate the actual surface distance that will be covered when passing between cells, while trying to accumulate the least travel cost. Thus, the algorithm would take into account that, while some cells might display a lower cost to get from one to the next, many changes in elevation will require longer to travel over, as it takes more energy. Having to overcome changes in elevation will therefore be assigned a higher value because it might take longer to travel through these areas, than just walking around them. The cost distance calculation on the other hand will ignore this, looking for the most direct route, at the lowest cost, it will choose a higher cost if that means a more direct path can be chosen.

I wanted to run the LCP based on path distance to a) demonstrate how variables can be included in computational analysis of archaeological data and b) to see how much the chosen path between Pacbitun and Tzul Cave would differ if the ancient Maya might have been concerned with finding the least cost distance route through the terrain to travel over and built a causeway on.

The results of the path distance showed a detour in its path to Tzul's Cave, since, other than the cost distance calculation, it does not simply try to find the shortest, most direct least cost path (Figure 5-35). Here, the route starts out running to the west before gradually dipping southwest to Tzul's Cave. Again, since the only other value I had besides latitude and longitude was elevation, as expected, the algorithm tried to find consistent elevation values, avoiding too many topographic fluctuations that would cost extra energy (ESRI 2010). It should be considered however, that the causeway might have been built, in part, to make travelling through the terrain easier in the first place. With this in mind, there would be no reason to follow even terrain because the constructed causeway would eliminate a lot of the extra energy to have to overcome dips and hills in the environment. Instead, the ancient Maya might have focused on the most direct path at the lowest cost, from Pacbitun to Tzul's Cave, for the causeway construction, in order to limit construction time and costs, labor forces needed, and to provide the quickest path to the destination for travelers.

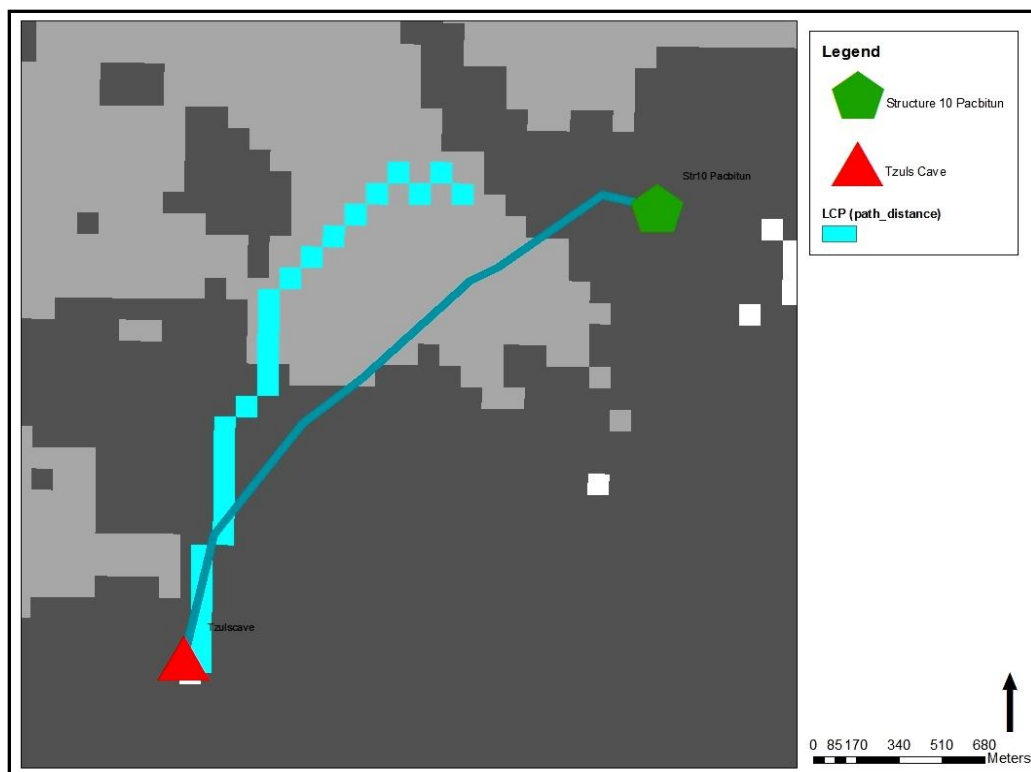


Figure 5-35: LCP based on path distance

5.5 Summary

The analysis process of the settlement survey data I collected in 2010 focused on (1) mapping the features I encountered in the periphery, (2) preliminary re-calculations of population estimates, (3) analysis of the ceramics from shovel tests and surface collections, as well as (4) the caves Actun Merech, Actun Pech, Tzul's Cave, and Crystal Palace, and finally, (5) least cost path analysis in relation to the causeway system.

A preliminary revision of the population estimates for Pacbitun, derived from the survey results and based on a nine square kilometer area for the site, adjusted the occupation total from 5377 persons to 3800 persons in the Late Classic. This confirmed the gradual decline of

settlement as one moves outside the site center, as well as apparent settlement dominance towards the southwest that had been noted in earlier surveys and is also reflected in my data (Healy et. al 2007). As mentioned, these preliminary calculations are subject to further research and are expected to undergo continuous revisions. Surface collections from selected housemounds, and shovel tests carried out in the causeways, were described and analyzed. Late Classic period ceramics were the ones most frequently found, which is in keeping with the history of the site.

Several GIS-based least cost path analyzed was described and analyzed. The GIS based least cost path analysis can help evaluate the components of movement and intention in these environments through predicting the most likely or unlikely route on which the ancient Maya might have build a causeway. The analysis of the Tzul causeway has shown that if the causeway had not been previously encountered, through running the LCP and then ground-truthing the result through a field survey, chances would have been good for it to be found. I have therefore shown that predictive modeling can contribute important information to archaeological analysis as a research tool, but also as a supportive analysis device.

6 DISCUSSION

6.1 Introduction

In this chapter I present four interpretive avenues based on the results of my field survey in 2010. These interpretations are targeted at the causeway system and include five different variables: (1) Pacbitun to Tzib causeway, (2) Tzib causeway to Tzul's Cave, (3) Mai and Tzib causeways, (4) Extensions of Tzul causeway, and (5) Tzul causeway as a pilgrimage route. The discussion includes the importance of caves in the ritual landscape and the various hypotheses concerning access control and pilgrimage routes to them. Finally, I address the possible role of Pacbitun as a religious site center and political entity.

6.2 The Causeway System at Pacbitun

Aside from the role of Tzul causeway as a ritual sacbe, there are other interpretive avenues to consider. As mentioned in Chapter 5, the purpose of causeways might have changed over time, using roadways for practical transport, water-management, communication, as well as political- and social purposes (Shaw 2008:121). In addition, Normark (2004) points out that if causeways are viewed as part of a distributed polyagent with its own polyagency, they can be related to both cause and effects in ancient settlements (Normark 2004:162). As he further states, cosmology, culture and typology often force different causeways together as a unit and when we later try to separate them in our analysis, they become just references to one another (Normark 2008:226). However, two causeways may not be part of the same cosmological principles; they may indeed differ in many ways.

I argue, that we see an example of such a multi-purpose causeway system whose use and meaning changed through time at Pacbitun, and possibly even displayed several meanings at once. A common assumption to make about a causeway that leads to a cave would be to argue for cosmological and religious ideologies that caused the construction. While this explanation might very well be applied to the course of Tzul causeway from the site center to Tzul's Cave, it does not address the encountered intersection, or why a causeway was built to Tzul's Cave but not any of the other caves in the periphery. By following an assemblage based approach, I argue, that while the decision to construct the causeways at Pacbitun may have been based on a certain ideology, the landscape and buildings that would later surround the intersection could have been connected to several actual ideologies, not just one (Normark 2008:233). For example, the earlier ideologies and materialities at the termini complex and plazuela group associated with Tzib causeway were changed or “overcoded” into a new assemblage or territory and ideology, forming the “ideologic intersection”. To further follow this analysis, I am dividing the peripheral area into two parts to illustrate the changing ideologies: (1) The construction of causeways from the site center to Tzib causeway and (2) the causeway construction from Tzib causeway to Tzul's Cave (Figure 6-1).

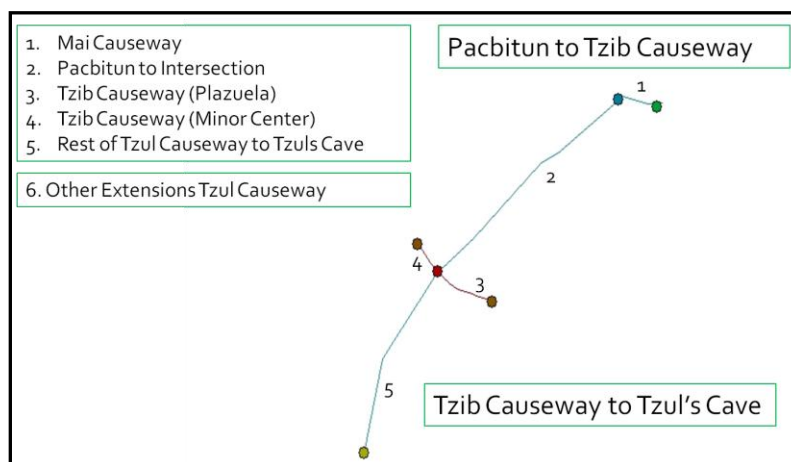


Figure 6-1: Hypothesized construction phases of causeway system

6.2.1 *Pacbitun to Tzib Causeway*

A causeway, with practical and symbolic functions would have been the perfect project for elites seeking to integrate and manage the outlying population (Shaw 2008:111). Intersections in causeways, are referred to as *hol can be* (*crossroads*) and often served as a way to connect terminal architectural groups with a more well-defined site core (Shaw 2008:73). As mentioned, it should be considered that the Tzib and Tzul causeway intersection was not an intersection at first but instead displayed the termination point of Tzul causeway. Shaw (2008:111) argues, that the process of building major causeways could have served as a way to unify workers and establish a collective identity that would further the establishment of the territory as a single polity. The Pacbitun elite might have had an interest in doing exactly that for a number of different reasons. The housemound distribution in the periphery of Pacbitun is clustered just south of the intersection of Tzul and Tzib causeways. More importantly, the Tzul causeway is also located in close proximity to four water basins, or *aguadas*, which are aligned with a spring and ancient dug well in the mountains. Close water sources are certainly vital for farming, and settlement in close proximity to them is a logical consequence found in ancient agricultural settlement patterns, as farmers will try to settle, if possible, where they need to in order to farm. Elites residing in the Pacbitun site core, most likely relied on food provided by the commoners and had an interest in securing their loyalty to the site center. Further, causeways probably were also utilized as a connection to water management not only in regards to farming but also the elite. A causeway running close by the water reservoirs ensured easy transportation of portable water back to the site center, especially since only one *aguada* is located in the site center, to the north of Plaza A (see Figure 3.5).

The causeway could have possibly first been intended as a connection to the commoner farms, displaying the special status of the elite, as a symbol of power, domination, and symbolic importance. Also, it could have served as a practical connection route for transportation between the farms and the site center. Tzib causeway, along with its minor center and plazuela group, could have been connected for this purpose at a later time, further establishing a visible and prominent link to the site center.

6.2.2 *Tzib Causeway to Tzul's Cave*

Causeways are often associated with ritual functions (Shaw 2008:121). The fact that Tzul causeway runs all the way from the Pacbitun site center to Tzul's Cave certainly serves as a platform for religious, as well as socio-political interpretations. As mentioned, ancient Maya causeways were often constructed to connect monumental architecture, as well as sites and settlements (Shaw 2008:65). Causeways in association with caves as we see at Pacbitun are less common but have been found, for example at Cahal Uitz Na in Belize, where a 780 meter long causeway connects the site to Aktun Nak Beh (Shaw 2008:79).

Caves certainly played an important role for the ancient Maya. In ancient Mesoamerican religion, the landscape was a critical concept, as the earth and all of its topographic features were considered to be alive and, as living beings, to interact in human affairs (Stone 1995:21). As Moyes and colleagues (2009:177) have noted, caves and mountains are especially potent places of the sacred earth, which is considered to be the primordial source of all abundance and fertility in Mesoamerican thought. In various Maya myths, the earth itself was seen as the body of a divine being (Stone 1995:21). This divine being was part of a landscape which included three

components, the middle world, the underworld, and the heavens. Here, the earth is depicted as the middle world, characterized in the form of a crocodilian being floating in a primordial sea. The sea, as the underworld, is home to supernatural beings, and its presence is manifested in bodies of water like lakes, oceans, cenotes, and rivers. Rivers might spill across the earth surface or flow through caves, underground. The heavens, paradise for ancestors, are also home to supernatural beings (Ashmore 2004:171). In association with mountains, caves were seen as houses, cosmic entry and exit points (e.g., to the underworld or Xibalba), places of transformation, and sources of fertility and material wealth, as well as sources for water (Stone 1995:34-40). The fact that many caves provide access to water sources certainly played into their significance as part of the ritual landscape. Storm clouds often form around mountains in which caves are located. Rain and water are critical for agriculture, particularly maize. Brady and Prufer (2005:369) have stated that for an agriculturally-based society, fertility is an immediate and never-ending concern in relation to crops, hence the most important elements for crops are soil and rain which, as mentioned, often occur around mountain ranges housing caves. Consequently, caves and mountains were believed to house rain gods and were associated with origin myths.

Some see cave rituals as combined with contextual factors such as historical events or environmental conditions that may have affected ritual practice. Among the ancient Maya, ritual performances, particularly those related to water control and agricultural success, are considered to have political implications fundamental to the rise and fall of the elite. Documented changes and characteristics of rituals in and around caves should then be able to provide information regarding the role of ritual in broader context, for instance possible external influences like

political change or environmental stress on the society (Moyes et. al 2009:3). For example, during her work at Chechem Ha in western Belize, Moyes (2009) noted that Late Classic ceramic counts seemed to have increased and consisted of more numerous complete or partially intact vessels, predominately large jars. Jars in caves are most likely referenced to rain poured from the sky and are appropriate offerings to rain gods. The increase of the jars during this time (AD 700 – 900) suggests that the deities were possibly given special attention and/or treatment, pointing to harsher environmental conditions and climatic stress (e.g. drought) (Moyes et. al 2009). At Pacbitun, environmental pressures could have caused the motivation to extend the Tzul causeway from the intersection to Tzul's Cave, portraying a shift from a political to a religious ideology. In this case the elite would have a strong interest in portraying their connection to the gods in front of the commoners.

6.2.3 *Mai and Tzib Causeways*

As mentioned, the intersection of the Tzul and Tzib causeways could have been a simple consequence of connecting the minor center and plazuela group on either side of Tzib causeway to the Pacbitun site core. As a consequence, the encountered intersection might just be a display of an over-coded array of assemblages. This of course would leave us with the question why the intersection of Tzib and Tzul causeways is where it is, since, to date, no other significant features have been encountered at this location.

Mai and Tzib causeways are very similar as they are both relatively short and connect architectural features. In order to establish which feature was built first, the causeways or the buildings, excavation and further analyses must be conducted. However, sometimes hints

towards construction periods can be derived from the causeway alignment itself. Since ancient Maya causeways were often constructed to connect monumental architecture and most of them follow straight lines, sometimes showing angle changes (Shaw 2008:65).

Shaw (2008) argues that the roads themselves may follow basic geometric principles, as they seek to connect two points in the shortest distance, consequently using the least effort and cost by maintaining a true course (Shaw 2008:67). This would suggest a one-term building phase for all causeways, meaning that the each causeway production was pre-determined, planned, and executed without ever changing or adjusting the construction plan. However, Shaw (2008) also acknowledges human error and technical adjustments in regards to the environment causing angle shifts, influencing road construction. Trombold (1991:235) calls these adjustments “sharp angle jogs”, stating that they appear in many causeways and may in some instances be compensations for the inaccurate determination of an intended direct line between two points. At Pacbitun, I noticed these angle jogs at Mai causeway (Figure 6-2), as well as Tzib causeway (Figure 6-3).

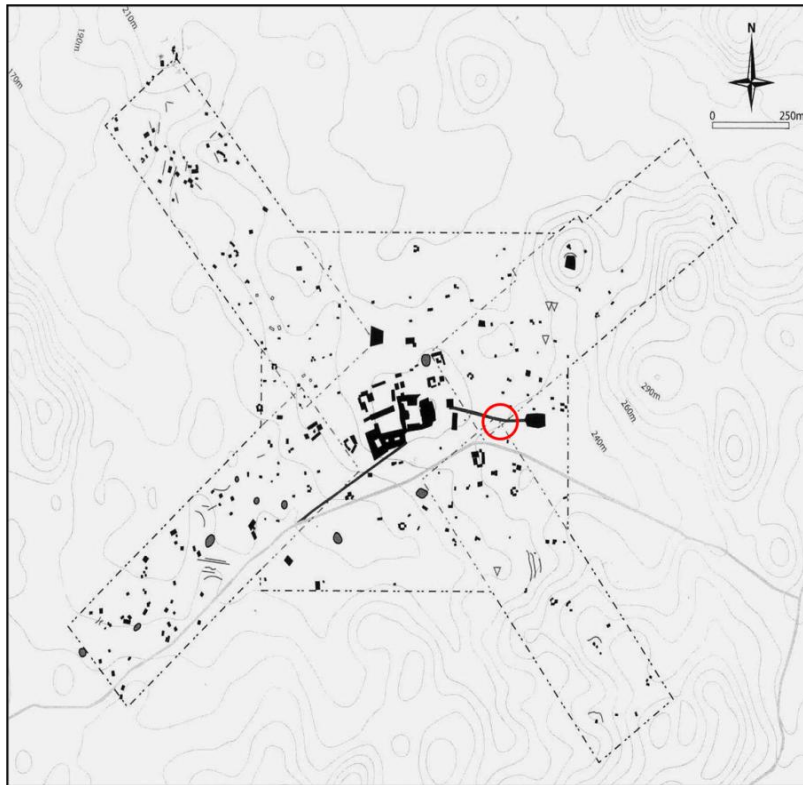


Figure 6-2: Angle jog Mai causeway

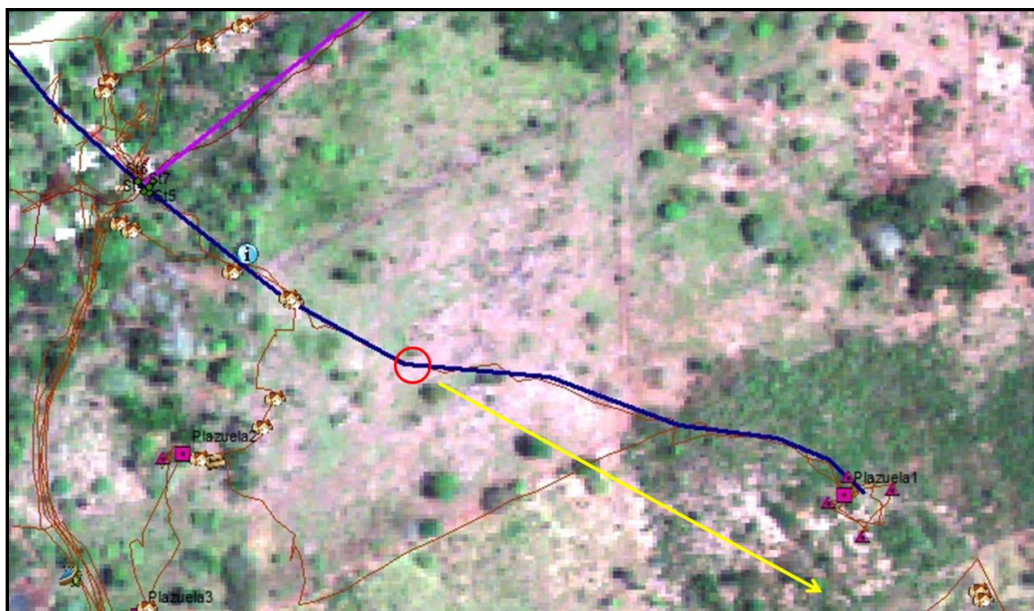


Figure 6-3: Angle jog Tzib causeway

6.2.4 Extensions of Tzul Causeway

Another scenario to consider is that the causeway was never a finished product. I argue that, if Tzul causeway extended over time, the Maya elite at Pacbitun might have had an interest to continue including other architecture and minor centers over time. Included in my survey was a minor center, named Pol Sak Pak, which lies approximately 2.8 kilometers southwest of Pacbitun, in the Maya mountains. With an elevation of about 400 meters, it is the highest architectural group encountered in the periphery thus far. Given the course of Tzul causeway, I wondered if it could have possibly been meant to continue on towards Pol Sak Pak. Therefore, I ran a least cost path analysis from the causeway intersection to the minor center. The results support this possibility, as the least cost path runs through Tzul's Cave on its way to Pol Sak Pak (Figure 6-4).

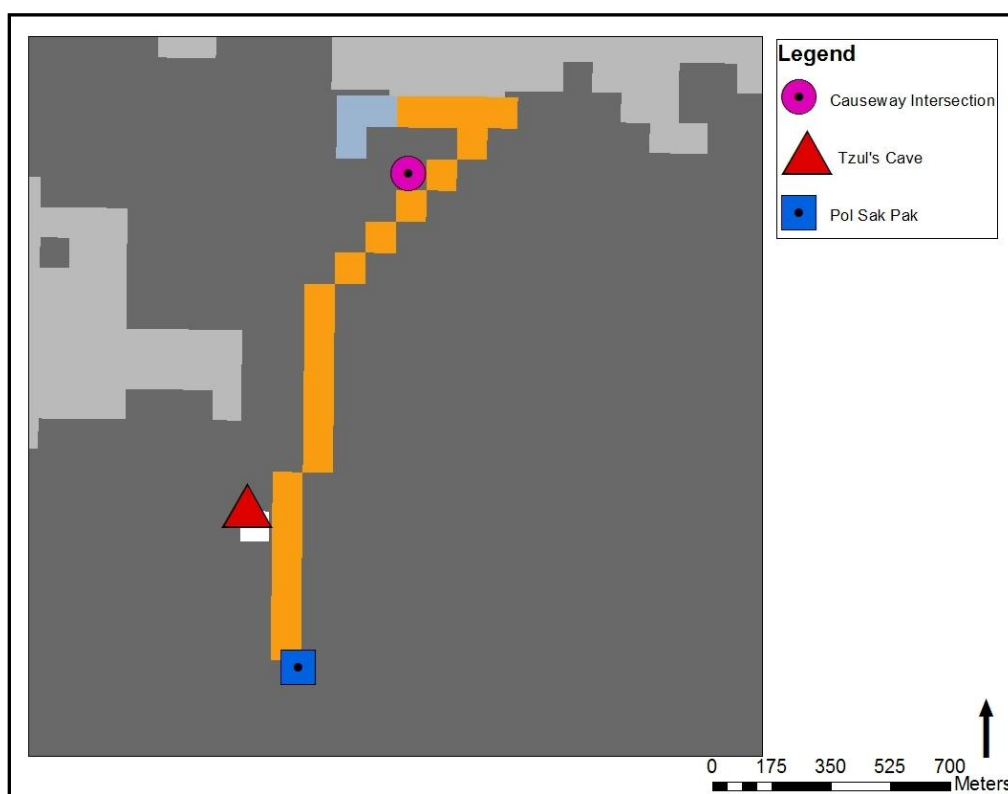


Figure 6-4: LCP to Pol Sak Pak

6.2.5 *Tzul Causeway as a Pilgrimage Route*

Of course, it must be considered that Tzul causeway was built in one construction term solely for the purpose of connecting Pacbitun to Tzul's Cave. As I have mentioned, the religious importance of caves might have played into the socio-political relationships between the elite and commoners as well. It has been argued, that for the ancient Maya, access to or control over sacred spaces and associated rituals served as a fundamental strategy for displaying, legitimizing, and negotiating social power (Prufer and Brady 2005). Here, the placement of monumental architecture over or near caves implied control over these sacred areas by the elites, who provided the financial backing for the construction of the monumental architecture, and also utilized them (Prufer and Brady 2005). For example, while caves and cave ceremonies were used by both commoners and elites, elites could construct causeways to influence the pilgrimage to the cave (Prufer and Brady 2005).

Stone (2005) argues that since caves and other topographic features have inherent powers to open communication with spirits and ancestors, and could invoke a spiritual sense of the past which could not be duplicated by the built environment, it was necessary for the elite and the commoners to renew their ties with the sources of sacred power found across the landscape. Hence, pilgrimages to these natural sanctuaries were exploited by the elite to buttress their claim of divine status (Stone 2005:135). If the elite residing in Pacbitun were interested in displaying and reinforcing their power to the commoners residing in the periphery, Tzul causeway would have been an adequate way to do so. Although this power would have not precluded commoners from using the causeway, as it is located in close proximity to modest housemounds. This could

indicate that the elite might have had an interest in pursuing good relations with the commoners, providing them with a causeway to a cave and thus, possibility to engage in religious rituals.

6.2.6 *The Role of Pacbitun*

Due to its close relationship to an abundance of caves (15+ in one section of a three km area), I have raised the question about the role of Pacbitun in a religious context (Weber and Powis 2010). Paul Healy (2007) has noted that the site might have been originally founded around 800 BC for its access to not only good agricultural lands, but also to granite and slate sources located nearby. However, I propose an alternative founding of the site for religious reasons. Obviously, this is something that needs to be tested. At present, use of the caves seems to date mainly to the Late to Terminal Classic period. Actun Pech has Late Preclassic ceramics, but Pacbitun was founded around 800 BC. To support this proposition, much earlier use of the caves in form of earlier period ceramic evidence would need to be found (Weber and Powis 2010).

6.3 Conclusion

In this section I have presented various interpretation avenues of the results of my field survey in 2010. These include the importance of caves and the various hypotheses concerning access control and pilgrimage routes to them. In addition, I have addressed possible analysis processes targeting the causeway system. Tzul causeway could have possibly first been intended as a connection to the commoner farms, symbolizing political ideologies. Tzib causeway along with its minor center and plazuela group could have been connected at a later date, in order to establish a visible and durable link to the site center. An extension to Tzul's Cave could have

played into various aspects of this hypothesis, either further symbolizing the elite connection to the ritually charged cave or providing access to the cave for the commoners, again displaying dominance in the periphery. Finally, I addressed the possible role of Pacbitun as a religious site center, rather than a political entity.

7 CONCLUSIONS AND RESEARCH RECOMMENDATIONS

Research around the periphery of the ancient Maya site of Pacbitun has revealed various natural and cultural features between the site core and its hinterland caves. Based on the results of the 2010 field survey, I was able to identify several socio-political and agricultural attributes that facilitated the regional analysis process. The primary objectives of future landscape analysis around Pacbitun should be to 1) ascertain the construction periods of the encountered causeway system and its corresponding architectures, 2) further determine the periodic utilization and possible control of access to the caves, and 3) continue to trace the development of Pacbitun as a major ceremonial center.

To further investigate the use and time frame of the settlement system in and around Pacbitun, the causeway system and corresponding architectures need to be further investigated through excavation. The same goes for architecture that is located in close proximity to the caves. Therefore, I propose archaeological investigations into Structures 10 and 11 at the Pacbitun site core, since Mai and Tzul causeways start and terminate here respectively, excavations in these locations will aid in dating the structure, as well as investigate the possible construction date of the causeways. Further, shovel tests into the Mai and Tzul causeways in the site center, as well as excavation into the causeway intersection (Tzul and Tzib causeways) will provide information on construction periods, possible ritual significance, and construction purpose. In addition, excavations in the minor center and plazuela group at the end of the Tzib causeway will contribute to this as well. In regards to the caves, I suggest excavations into the mound adjacent to Crystal Palace Cave, as it was encountered in such close proximity to the cave and might have served as a special purpose building. Investigations here will help us further

explore the date and purpose of the building, as well as possible use-access of the cave itself. Finally, excavation in the plazuela group and chultun, both of which were encountered in close proximity to Tzul's Cave and Tzul causeway, will contribute to our knowledge of access and periodic usage of both features.

The discovery of numerous housemounds, terraces, caves, plazuela groups, aguadas, and causeways during the survey of Pacbitun's periphery demonstrates the various entanglements of the ritual landscape of the ancient Maya. While many questions are still unanswered, this research has set the stage for further analysis of the site and demonstrated various possible avenues to analyze the features that were encountered in the periphery of Pacbitun. Future investigations will hopefully contribute to our deeper understanding of the ancient Maya who inhabited this landscape.

8 REFERENCES

- Ashmore, Wendy (editor)
1981 *Lowland Maya Settlement Patterns*. University of New Mexico Press, Albuquerque.
- Ashmore, Wendy
2004 Classic Maya Landscapes and Settlement. In *Mesoamerican Archaeology*, edited by Julia A. Henderson and Rosemary A. Joyce, pp. 169-191. Blackwell Publishing, Maldon.
- Ashmore, Wendy
2009 Mesoamerican Landscape Archaeology. *Ancient Mesoamerica* 20:183-187.
- Ashmore, Wendy and Willey, Gordon R
1981 A Historical Introduction to the Study of Lowland Maya Settlement Patterns. In *Lowland Maya Settlement Patterns*, edited by Wendy Ashmore, pp. 3-18. University of New Mexico Press, Albuquerque.
- Awe, Jaime, Nikolai Grube and David Cheetham
2009 Cahal Pech Stela 9: A Preclassic Monument from the Belize Valley. *Research Reports in Belizean Archaeology* 6:179-189. Belmopan, Belize.
- Ball Joseph W. and Jennifer T. Taschek
1991 Late Classic Lowland Maya Political Organization and Central-Place Analysis: New Insights from the Upper Belize Valley. *Ancient Mesoamerica* 2:149-165.
- Banning, E.B.
2002 *Archaeological Survey*. Plenum Publishers, New York.
- Batton, David C.
2006 Least-Cost Pathways, Exchange Routes, and Settlement Patterns in Prehistoric East-Central New Mexico. *Proceedings of the 34th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA)* 167-174. Fargo, United States.
- Billman, B. R. (editor)
1999 Settlement Pattern Research in the Americas: Past, Present, and Future. In *Settlement Pattern Studies in the Americas—Fifty years since Virú*, edited by Billman, B. R. and G. M. Feinman pp. 1-8. Smithsonian Institution Press, Washington.
- Boos, Silke, Sabine Hornung, and Hartmund Mueller
2010 *Considering Uncertainty in Archaeological Predictive Modelling: A Case Study in southern Rhineland-Palatinate (Germany)*. Paper presented at the 30th European Association of Remote Sensing Laboratories, Paris France.

Brady, Edward J. and Prufer Keith M. (editors)

2005 *In the Maw of the Earth Monster: Mesoamerican Ritual Cave Use*. University of Texas Press, Austin.

Bullard, William R.

1960 Maya Settlement Pattern in Northeastern Peten, Guatemala. *American Antiquity* 25:355-372.

Carballo, David M. and Thomas Pluckhahn

2007 Transportation corridors and political evolution in highland Mesoamerica: Settlement analyses incorporating GIS for northern Tlaxcala, Mexico. *Journal of Anthropological Archaeology* 26:607-629.

Cardoso, Hugo F.V.

2003 The Search for a Paradigm in Archaeology Evolutionary Theory and the "Selectionist" School of Thought. *Nexus* 16:50-74.

Chase, Arlen F.

2004 Politics, Political, and Social Dynamics: Contextualizing the Archaeology of the Belize Valley and Caracol. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 320-334. University Press Florida, Gainesville.

Chase, Arlen F., Diane Z. Chase, John F. Weishampel, Jason B. Drake, Ramesh L. Shrestha, K. Clint Slatton, Jaime J. Awe, William E. Carter

2011 Airborne LIDAR, Archaeology, and the Ancient Maya Landscape at Caracol, Belize. *Journal of Archaeological Science* 38:387-398.

Chase, Arlen F. and James F. Garber

2004 The Archaeology of the Belize Valley in Historical Perspective. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 1-14. University Press Florida, Gainesville.

Clarke, David L.

1978 *Analytical Archaeology*. Columbia University Press, New York.

Conolly, James, and Mark Lake

2006 *Geographical Information Systems in Archaeology*. Cambridge University, New York.

Dalla Bona, Luke

1994 A Report Prepared for the Ontario Ministry of Natural Resources. In *Volume 3: Methodological Considerations*. Lakehead University: Center for Archaeological Resource Prediction, Thunder Bay, Ontario.

DeLanda, Manuel

2006 *A New Philosophy of Society*. Ashford Colour Press Ltd, Gosport, Hampshire.

Deleuze, Gilles

2004 *The Logic of Sense*. Columbia University Press, New York.

Dobres, Marcia-Anne and John E. Robb (editors)

2000 Agency in Archaeology: Paradigm or Platitude. In *Agency in Archaeology*, edited by Marcia-Anne Dobres and John E. Robb, pp. 3-18. Routledge, London

Dornan, Jennifer L.

2002 Agency and Archaeology: Past, Present, and Future Directions. *Journal of Archaeological Method and Theory* 9:303-328.

Driver, W. David. and James F. Garber

2004 The Emergence of Minor Centers in the Zones between Seats of Power. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 287-304. University Press Florida, Gainesville.

ESRI ArcGIS Desktop 9.3

2010 Spatial Analyst, Electronic Document,
<http://webhelp.esri.com/arcgisSDEsktop/9.3/index.cfm?TopicName=welcome>, accessed March, 2011.

Fields, Virginia M.

2004 The Royal Charter at Xunantunich. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 180-190. University Press Florida, Gainesville.

Ford, Anabel

2004 Integration among Communities, Centers, and Regions: The Case from El Pilar. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 238-256. University Press Florida, Gainesville.

Fox John W., Garrett W. Cook, Arlen F. Chase, and Diane Z. Chase,

1996 Question of Political and Economic Integration. *Current Anthropology* 37:795-801.

Garber, James F. (editor), M. Kathryn Brown, Jaime J. Awe, and Christopher Hartman

2004 Middle Formative Prehistory in the Belize Valley: An Examination of Architecture, Material Culture, and Sociopolitical Change at Blackman Eddy. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 25-47. University Press Florida, Gainesville.

Garrison, Thomas

2007 Ancient Maya Territories, Adaptive Regions, and Alliances: Contextualizing the San Bartolo-Xultun-Intersite Survey. Unpublished Ph.D. Dissertation, Department of Anthropology, Harvard University, Cambridge, Mass.

Gifford, James C.

1976 *Prehistoric Pottery Analysis and the Ceramics of Barton Ramie in the Belize Valley*. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, Mass.

Glover, Jeffrey B.

2006 The Yalahau Regional Settlement Pattern Survey: A Study of Ancient Maya Social Organization in Northern Quintana Roo, Mexico. Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Riverside.

Hahn, Robert

2010 *Archaeology and the Origins of Philosophy*. State University of New York Press, Albany, NY.

Hammond, Norman and Wendy Ashmore

1981 Lowland Maya Settlement: Geographical and Chronological Frameworks. In *Lowland Maya Settlement Patterns*, edited by Wendy Ashmore, pp. 19-36. University of New Mexico Press, Albuquerque.

Healy Paul F., Rhan-Ju Song, and James M. Conlon

1996 Actun Petz: Preliminary Survey of a Cave Near Pacbitun, Belize. In *Belize Valley Preclassic Maya Project: Progress Report on the 1995 Field Season* 12:139-152. Trent University, Peterborough, Ontario.

Healy, Paul F, Bobbi Hohmann, and Terry Powis

2004 The ancient Maya Center of Pacbitun. In *The Ancient Maya of the Belize Valley*, edited by James F. Garber, pp. 207-227. University Press of Florida, Gainesville.

Healy, Paul F.

2007 The Anthropology of Mesoamerican Caves. *Review in Anthropology* 36:245-278.

Healy, Paul F., Christophe G.B. Helmke, Jaime J. Awe, and Kay S. Sunahara

2007 Survey, Settlement, and Population History at the Ancient Maya Site of Pacbitun. *Journal of Field Archaeology* 32:17-38.

Helmke, Christophe and Jaime Awe

2008 New Site Description and Structure Designations at Baking Pot, Belize. In *The Belize River Valley Archaeological Project: A Report on the 2007 Field Season* 5:81-102. Belmopan, Belize.

Hutson, Scott R.

2010 *Dwelling, Identity, and the Maya. Relational Archaeology at Chunchucmil*. AltaMira Press, New York.

Iannone, Gyles

2004 Problems in the Definition and Interpretation of “Minor Centers” in Maya Archaeology with Reference to the Upper Belize Valley. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 273-286. University Press Florida, Gainesville.

Joyce, Rosemary A.

2004 Mesoamerica: A Working Model for Archaeology. In *Mesoamerican Archaeology*, edited by Julia A. Hendon and Rosemary A. Joyce, pp. 1-42. Blackwell Publishing, Maldon.

Joyce, Rosemary A.

2004 Unintended Consequences? Monumentality as a Novel Experience in Formative Mesoamerica. *Journal of Archaeological Method and Theory* 11:5-29.

Johnson, Matthew

1999 *Archaeological Theory: An Introduction*. Wiley-Blackwell, Oxford, New York.

Kantner, John

2008 The Archaeology of Regions: From Discrete Analytical Toolkit to Ubiquitous Spatial Perspective. *Journal of Archaeological Research* 16:37-81.

Kolb, Charles C., Thomas H. Charlton, Warren DeBoer, Roland Fletcher, Paul F. Healy, Robert R. Janes, Raoul Naroll, Daniel Shea

1985 Demographic Estimates in Archaeology: Contributions from Ethnoarchaeology on Mesoamerican Peasants. *Current Archaeology* 26:581-599.

Kvamme, K.L.

1995 A View from Across the Water: The North American Experience in Archaeological GIS. In *Archaeology and Geographical Information Systems: A European Perspective*, edited by Gary R. Lock, Zoran Stančić, pp. 1-14. Taylor and Francis Ltd., London.

Leventhal, Richard M. and Wendy Ashmore

2004 Xunantunich in a Belize Valley Context. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 168-179. University Press Florida, Gainesville.

Lopiparo, Jeanne

2005 *Multiscalar Approaches to Complexity: Structure, Agency, and the Dialectical Production of Society*. Position paper for the conference, “Practice Theories in Archaeology,” organized by Rosemary Joyce and Jeanne Lopiparo. Convened at the Townsend Center for the Humanities, University of California, Berkeley, May 6-7, 2005.

Magnoni, Aline

2006 Population Estimates at the Ancient Maya City of Chunchucmil, Yucatan, Mexico. *Proceedings of the 34th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA)* 175-182. Fargo, United States.

Marcus, Joyce

1976 The Size of the Early Mesoamerican Village. In *The Early Mesoamerican Village*, edited by Kent V. Flannery, pp. 79-90. Academic Press, Inc, New York.

McAnany, Patricia A.

2010 *Ancestral Maya Economies in Archaeological Perspective*. Cambridge University Press, Greenwich.

McKillop, Heather

2006 *The Ancient Maya*. W.W. Norton & Company Ltd., New York.

McNatt, Logan

1996 Cave Archaeology in Belize. *Journal of Cave and Karst Studies* 58:81-99.

Moyes, Holley with Jaime J. Awe, George A. Brook, and James W. Webster

2009 The Ancient Maya Drought Cult: Late Classic Cave Use in Belize. *Latin American Antiquity* 20:175-206.

Normark, Johan

2004 Sakbihs and Polyagency- The Architectural Causes of Human Activities in the Cochuah Region, Quiniana Roo, Mexico. *Current Swedish Archaeology* 12:141-168.

Normark, Johan

2006 *The Roads In-Between: Causeways and Polygenative Networks at Ichmul and Yo'okop, Cochuah Region, Mexico*. GOTARC Series B, Volume 45. Department of Archaeology, Goteborg University, Goteborg.

Normark, Johan

2008 The Triadic Causeways of Ichmul: Virtual Highways Becoming Actual Roads. *Cambridge Archaeological Journal* 18:215-238.

Ortner, Sherry B.

2001 Practice, Power and the Past. *SAGE Publications*, 1:271-278.

Parsons, Jeffrey R.

1972 Archaeological Settlement Patterns. *Annual Review of Anthropology* 1:127-150.

Parsons, Jeffrey R.

1990 Critical Reflections on a Decade of Full-Coverage Regional Survey in the Valley of Mexico. In *The Archaeology of Regions*, edited by S.K. Fish and S.A. Kowalewski, pp.7-31. Smithsonian Series in Archaeological Inquiry. Smithsonian Institution Press, Washington.

Patton, Paul

2010 *Deleuzian Concepts*. Stanford University Press.

Powis, Terry G.

2009 Pacbitun Preclassic Project: Report on the 2008 Field Season. *Reports submitted to the Institute of Archaeology, National Institute of Culture and History*, Belmopan Belize.

Powis, Terry G.

2010 Preliminary Investigations of Three Cave Sites in the Periphery of Pacbitun, Belize. *Research Reports in Belizean Archaeology* 7:153-161.

Prufer, Keith M. and James E. Brady (editors)

2005 *Stone Houses and Earth Lords: Maya Religion in the Cave Context*. University Press of Colorado, Boulder.

Sanders, William T.

1999 Three Valleys: Twenty-Five Years of Settlement Archaeology in Mesoamerica. In *Settlement Pattern Studies in the Americas—Fifty years since Virú*, edited by Brian R. Billman and Gary M. Feinman, pp.12-21. Smithsonian Series in Archaeological Inquiry. Smithsonian Institution Press, Washington.

Shaw, Justine M.

2008 *White Roads of the Yucatàn*. The University of Arizona Press, Tuscon.

Smith, Michael E. and Marilyn A. Masson (editors)

2000 *The Ancient Civilizations of Mesoamerica*. Blackwell Publishers, Malden.

Shennan, Stephen

2004 Analytical Archaeology. In *A Companion to Archaeology*, edited by John Bintliff, pp. 3-120. Blackwell Publishers, Malden.

Stone, Andrea J.

1995 *Images from the Underworld: Naj Tunich and the Tradition of Maya Cave Painting*. University of Texas Press, Austin.

Stone, Andrea J.

2005 Scribes and Caves in the Maya Lowlands. In *the Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by James E. Brady and Keith M. Prufer, pp. 135-148. University of Texas Press, Austin.

Taschek Jennifer T. and Joseph W. Ball

2004 Buenavista del Cayo, Cahal Pech and Xunantunich: Three Centers, Three Histories, Once Central Place. In *The Ancient Maya of the Belize Valley. Half a Century of Archaeological Research*, edited by James F. Garber, pp. 191-206. University Press Florida, Gainesville.

Thomas, David Hurst

1999 *Down To Earth*. Harcourt Brace College Publishers, Fort Worth.

Trombold, Charles D.

2001 *Ancient Road Networks and Settlement Hierarchies in the New World*. Cambridge University Press, Cambridge.

Weber, Jennifer and Terry G. Powis

2010 The Role of Caves at Pacbitun: Peripheral to the Site Center or Central to the Periphery? *Research Reports in Belizean Archaeology 2010*. Belmopan, Belize.

Verhagen, Philip

2007 *Case Studies in Archaeological Predictive Modeling*. Leiden University Press.

Wheatley, David, and Mark Gillings

2002 *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. Taylor & Francis Inc., New York.

Willey, Gordon R.

1956 The Structure of Ancient Maya Society: Evidence from the Southern Lowlands. *American Anthropologist* 58:777-782.

Williams, Nick

1996 An Introduction to Cave Exploration in Belize. *Journal of Cave and Karst Studies* 58:69-75.

Wise, J. Macgregor

2005 Assemblage. In *Gylles Deleuze: Key Concepts*, edited by Charles J. Divale, pp. 77-87. Cromwell Press, Trowbridge.