THESIS

WALLED COMPLEJOS: AN INVESTIGATION OF MULTI-ROOM DOMESTIC STRUCTURES AT ANGAMUCO, MICHOACÁN, MEXICO THROUGH LIDAR AND GIS

Submitted by

Louise M. Steele

Department of Anthropology and Geography

In partial fulfillment of the requirements

For the Degree of Master of Arts

Colorado State University

Summer 2021

Master's Committee:

Advisor: Christopher T. Fisher

Stephen J. Leisz
David Bunn

ABSTRACT

WALLED COMPLEJOS: AN INVESTIGATION OF MULTI-ROOM DOMESTIC STRUCTURES AT ANGAMUCO, MICHOACÁN, MEXICO THROUGH LIDAR AND GIS

The archaeological site of Angamuco is an ancient Purépecha city in the Lake Pátzcuaro Basin in Michoacán, Mexico. Occupation of the city spans at least a millennium, with the height of occupation in the Middle Postclassic period (1000-1350CE). Angamuco has a densely-built landscape with architectural features covering the entirety of the 26 km^2 archaeological site.

This thesis seeks to investigate the presence and patterning of multi-roomed domestic complexes known as walled complejos. Through the use of LiDAR and geospatial analysis such as pseudo-Red Relief Image Map and hot spot analysis, this investigation was composed of three individual samples of architecture across the site which were compiled and analyzed as a composite dataset. This resulted in 73 unique walled complejos being identified across the urban settlement of Angamuco. These structures vary widely within the sample, in size, form, and location within the site. Walled complejos range in shape from circular to oblong and kidney shaped, and from 500m^2 in area to 8000 m^2. A comparison of multi-roomed domestic structures from Mesoamerica and the American Southwest are used to develop an interpretation on the walled complejos at Angamuco. The data suggest that these were domestic structures used across multiple social classes at Angamuco, supporting previous interpretations that walled

complejos were homes for both the elite and non-elite. Furthermore, these results support the interpretation of Angamuco's multi-nucleated urban organization.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Chris Fisher, for the opportunity to be a part of the LORE-LPB research team and your valuable insights along the way. Thank you to my committee members, Stephen Leisz and David Bunn. A special thank you goes out to Celena Westberry, Lawrence 'Bear' Beals, Rodrigo Solinis-Casparius, and the rest of the LORE-LPB and CARS lab members. I would not have made it through this thesis without the support and commiseration of my cohort members, especially fellow archaeologists Marie Matsuda, Paul Buckner, and Ray Sumner. Hannah Trevino and Elliot Mueller, your friendship and positivity that have extended far beyond East Lansing continually encourage me. I would like to thank from the bottom of my heart my partner, Joseph Bednarczyk, who has offered me unending support, encouragement, and reassurance during this long process. To my parents and brother, for the lifetime of encouragement to follow this path and continual support in this endeavor, I truly cannot thank you enough.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Introduction

The archaeological site of Angamuco is a densely-built ancient city in the Lake Pátzcuaro Basin (LPB) in Michoacán, Mexico on what is known as a *malpaís* (badland) the regional name for a volcanic flow landform. Angamuco represents an urban settlement at the height of its occupation in the Middle Postclassic period (1000-1350AD), but there is evidence of occupation at the site for a much longer range of time from the Classic period through to Spanish contact (250-1530AD) (Fisher et al. 2019; Solinis-Casparius 2019). Investigations at the site began in 2009, but with the expanse of the settlement appearing to be limitless, the project took their survey efforts to the sky to be able to fully capture the extents of the ancient city. Through the use of LiDAR, the site has been mapped with an area of 26 km^2 with an estimated 40,000 structures (Fisher et al. 2019; Harris 2019).

1.2 Objectives

This thesis seeks to investigate the presence and patterning of multi-roomed complexes known as walled complejos. These structures have a set of defining features that appear to be loosely followed across the city: thick walls of any shape surrounding multiple smaller buildings, an altar, a plaza, and located near monumental architecture such as pyramids. While the Legacies of Resilience – Lake Patzcuaro Basin (LORE-LPB) Project has a typology of buildings and foundation shapes for the site, each walled complejo is different and thus it takes a trained eye to be able to spot them. There are likely thousands of these complejos but as of yet the project has not investigated the data to identify them from the LiDAR dataset (Fisher, personal communication) In previous literature, the walled complejos have been considered elite houses or in some cases potentially *casas de papas* (priest's quarters), but we are at present not definitive on the use of these spaces; this thesis hopes to change this.

Research questions for this thesis:

1. *What are the walled complejos? Do the actual walled complejos in the data match the current ideal set of features?*

Our definition at present for a walled complejo is a thickly-walled compound of multiple buildings, typically in a vaguely circular shape, with a plaza, an altar within the plaza, and likely close to monumental architecture such as pyramids. If the walled complejos in the data match our ideal definition, we would expect to find mostly circular, walled compounds that include each of the core components of the architecture type. If they do not match our definition, then we would expect there to be variation in their presentation; with some walled complejos including all of the components, and others including only a few of the characteristics.

2. *Are there spatial patterns within the walled complejos? Is there any clustering present? Are there trends in form?*

If spatial patterns are present within the walled complejo dataset we would expect to see clear clustering or grouping of the walled complejos based on characteristics in relationship to physical locations within the site. Examples of potential spatial patterns could be clustering of larger area walled complejos in one area, every walled complejo identified being located within a specific area of the site, or even dispersion of walled complejos across the site. Clustering of the walled complejos will be investigated using hot spot analysis; this methodology will return hot or cold spot clustering if they are present in the dataset. Trends in form would be exhibited in the dataset if the unique shapes or organization of walled complejos appear to be similar throughout the dataset or have patterning in certain subsets of the identified walled complejos. If there are no trends in form, we would expect all walled complejos to be completely unique and share little organizational schema across the dataset.

3. *Do the walled complejos align with expectations for domestic structures?*

If the Angamuco walled complejos align with our expectations of domestic structures, the dataset would exhibit similar characteristics to the domestic structures analyzed at archaeological sites across Mesoamerica and the American Southwest. Through cultural comparison we can establish core characteristics of domestic structures that are present throughout the broader world that Angamuco lies within, and from those characteristics establish if the walled complejos do or do not exhibit those features.

4. *How does this information change or uphold our current understanding of the ancient city of Angamuco?*

As the walled complejos have not previously been investigated, this thesis will bring a new understanding of this architectural type to the built knowledge of the city. If this thesis finds that the walled complejos are domestic structures for both the elite and the non-elite, it will uphold our current interpretation of these structures and how they were utilized at Angamuco. However, if this investigation finds that they are not domestic structures, or potentially only domestic structures for a specific class or area of the site, then our understanding of the walled complejos would change and thus their contribution to how we view the city would be altered.

1.3 The *Relación de Michoacán*

Documents of the Spanish colonial period are often used in tandem with archaeological evidence to understand the history of the Lake Patzcuaro Basin in Michoacán. The *Relación de*

Michoacán (will be referred to going further as just the *Relación*), is a colonial document written between 1539 and 1541 during the Spaniards initial occupation of Michoacán. This document is heavily biased due to its original function as a report for Catholic Spaniards to justify and rationalize the complete colonization of a region. Thus, the information taken from such a document needs to be read and interpreted within its original context and not as an unbiased journalistic report of the proceedings in the basin. The *Relación* describes the religious practices, origin myth, and daily life activities of the Purépecha living in the Lake Pátzcuaro basin of Michoacán at the time under the rule of the Purépecha Empire centered at Tzintzuntzan. While this document is heavily biased, archaeologists can gain some understandings of social organization, traditional religious practices, and ways of life from this text. From the illustrations in the document, archaeologists can infer information about the built landscape in the Lake Pátzcuaro basin at the time of Spanish colonization.

1.4 Methods

LiDAR, light detection and ranging, is a laser-based remote sensing technology. The scanner can be used aerially, mounted on a plane, drone or other airborne or spaceborne platform, or it can be utilized terrestrially, with handheld or backpack-mounted scanners as someone walks through or around what they are intending to scan. The light from the scanner is sent to the surface, and the time it takes to return to the platform is converted to distance using the speed of light. The lasers sent from the scanner are able to penetrate dense vegetation, which allows archaeologists and other remote sensing scientists to effectively "digitally deforest" a location to strip off the vegetation and view the bare earth and built environment features. The returns are stored in a point cloud format (.las) that can be filtered to show digital representations of the tree canopy, with the first returns, or the earth's surface, with the ground or last returns.

There have been two flights of LiDAR (Light Detection and Ranging) scanning done over the site of Angamuco and its surrounding area off the malpaís, the first in 2011 and the second larger flight in 2015. These flights have provided high resolution point cloud data detailing the specific elevations of ground level landforms across 35km^2 in the eastern portion of the Lake Patzcuaro Basin. Early field investigations at Angamuco determined that the site was larger than originally thought and it was determined that remote sensing would be the best plan to document such a vast area of land accurately and efficiently. With LiDAR the site is now mapped at 26 km^2, a documentation endeavor of this scale would have taken decades in the past, but instead has only taken two days' worth of flights and time.

Critical to the methodology of this thesis is the use of spatial analysis within geographic information systems software, known as GIS. A GIS project allows various types of geospatial data to be visualized together and displayed concurrently. Archaeological data is inherently spatial, especially so when it is created from remotely sensed elevation data. This thesis uses LiDAR data, alongside various visualizations, spatial analysis, and annotated polygon layers to attempt to create a clear digital copy of the truth on the ground at Angamuco.

1.5 History of LiDAR and Geospatial Analyses in Archaeology

Remote Sensing in archaeology began long before the first satellites were launched. In 1839, photography was introduced to the world and by 1858 photographers had attached their cameras to tethered balloons to achieve a near birds-eye view of the earth's surface (Leisz 2013:201). As airplanes gained popularity, so did the mounting of cameras on top of them especially for military and surveying tasks (Leisz 2013). During the First World War, military surveys in Mesopotamia by the British revealed the "remains of an ancient city" (Samarra) and the ‘outline of a series of detached forts’” (Beazeley 1919 cited in Leisz 2013). With this discovery, Beazeley (1919, p. 330) writes that:

> “Had I not been in possession of these air photographs the city would probably not have been merely shown by meaningless low mounds scattered here and there, for much of the detail was not recognizable on the ground.”

While the low mounds were visible, Lieutenant-Colonel Beazeley (1919) and his men weren’t able to see the broader pattern. Aerial survey allowed them to see the mounds in conjunction with soil color differences which elucidated the outline of irrigation systems and forts (Beazeley 1919). Unfortunately, Beazeley writes that his plane was shot down and captured before he was able to make a detailed survey so the publication only has sketches from his memory.

Aerial surveying continued in this manner until after World War II. Throughout Europe this new technique revealed dykes, camps, forts, and villages that had left traces on the landscape too faint to see when standing on them but clear enough to be seen when looking from a distance (Crawford 1912, 1926; Leisz 2013). Like Beazeley, Crawford (1926, p. 342) notes that hints to the earthen works in southern England were “invisible to the observer on the ground, or which appear to him only as a confused tangle” but from the air it was possible to construct an accurate plan. Crawford (1926, p. 344) had “no doubt” that what he saw in the landscape was a part of a larger pattern, and “that when a larger series of air-photographs is available for reference, these instances will become more numerous.” Analysis of settlement systems, like the ones Crawford is expecting to find here, remain a central tenet of landscape archaeology and the use of remotely sensed data continue to play a major role in those investigations.

In Central America, where extensive ground surveys were already underway for archaeological projects, aerial photography was conducted by Carnegie Institution of Washington's surveys of the Maya region in British Honduras (Belize), Guatemala, and southern Mexico (Ricketson and Kidder 1930). Extensive and comprehensive surveys in Mesoamerica have always been laborious because of its dense jungle cover; thus, archaeologists have historically been eager to adapt new technologies that simplify the process. Ricketson and Kidder (1930) call the "extreme difficulty and slowness of ground travel and the inability of the explorer, because of the density of the vegetation, to gain a comprehensive idea of the topography of the region" to be amongst the greatest hindrances of research in this region.

Large settlement patterns, roads, and infrastructure were now visible in relation to each other. The power of taking isolated archaeological data and making it relational created the opportunity for new understandings to arise.

The introduction of LiDAR allowed archaeologists to see through vegetation and digitally scan the ground's surface at a resolution that had never been achievable with remote sensing technology before (Chase and Weishampel 2016; Chase and Chase 2017; Fisher and Leisz 2013; Hare et al. 2014). Chase et al. (2012:12916) argue that this technology "permits archaeologists to document the landscape in the same way that it is experienced by people -- in multiple dimensions." Landscape is dynamic and synthetic; being able to visualize them beyond a static map enables archaeologists to best understand the power of a place. LiDAR's impact on archaeology has been so profound that most consider it to have brought about a paradigm shift in how archaeological research and interpretation is conducted (Chase et al. 2012).

In what was already considered a dense and extensive landscape, the complexity and breadth of Mesoamerica's archaeological record has increased by the order of magnitudes with LiDAR data. Consistently, LiDAR illuminates settlement patterns in Mesoamerica that would be unfathomable to the likes of Ricketson and Kidder (Canuto et al. 2018; Chase and Weishampel 2016; Chase et al. 2011; Fisher et al. 2016, 2017; Hutson 2015). In 2016, an investigation into the Mosquitia region of Honduras was conducted to answer questions of pre-contact settlement density, the spatial organization of these settlements, and the impact that this occupation made on the natural environment (Fisher et al. 2016). Taking the form of a classic settlement pattern analysis, this study then flips the script when LiDAR is the focal point; the traditional methods of spatial statistics coupled with LiDAR show how powerful this new tool can be. This investigation covered 122.8 km^2 of the *Valle de Fortaleza* with 3.5 billion laser pulses leading to almost 900 archaeological features, such as mounds, canals, and plazas, to be identified. This density of data thus empowers archaeologists to focus on the interpretation rather than the collection.

The implementation of LiDAR in archaeology has undoubtedly broadened the scale at which the discipline thinks. The ability to scan kilometers of dense vegetation that would take decades to excavate in a matter of hours provides archaeology with an almost embarrassment of riches. Archaeologists are now encountering problems of 'big data' and should be cognizant of the fact that LiDAR is not a perfect scanner, and even if it was, shapes in the topography can have multiple meanings. A fear is that the further we divorce ourselves from the field, the further we divorce ourselves from connecting and focusing on the human part of anthropological archaeology.

1.6 Thesis Outline

This thesis is organized in the following manner:

Chapter Two will serve as background information to the rest of the thesis. This chapter will establish a foundation of urban organization theory in Mesoamerica, present past research focused on urban contexts in the Lake Pátzcuaro Basin and the site of Angamuco. Mesoamerica has a rich history of urban settlements, and this tradition and theoretical perspectives on urbanism will be outlined here. This chapter will also present a brief history of the archaeological research that has been conducted in the Lake Patzcauro Basin (LPB) prior to the Legacies of Resilience (LORE-LPB) project investigations at Angamuco.

Chapter Three will be focused on what walled complejos look like at the site of Angamuco and explore what multi-roomed domestic structures look like at other archaeological sites. Regional comparisons can be used to help strengthen an interpretation of the archaeological record. In this case, we can look at how multi-room domestic structures present at other archaeological sites, across varying times, locations, and groups of people, to see how they are interpreted with anthropological questions. This chapter will include a look at structures from across the Maya region, pueblos of the American Southwest, the Toltec capital of Tula, the Zapotec of Oaxaca, and apartment structures of Teotihuacan.

Chapter Four will lay out the methods utilized for this thesis, beginning with the data sources used. This thesis relies on LiDAR data for archaeological investigation, and thus all subsequent spatial and other analyses are built from the two LiDAR scans flown over the ancient city. Identification of walled complejos was completed using multiple visualizations of the LiDAR data in ArcGIS. Hot spot analysis was implemented to identify if there was any spatial patterning in the sample.

Chapter Five will outline the results of the methods followed in Chapter Four. This chapter will present the metrics of the sampling conducted for this thesis in detail. In tandem with the quantitative data obtained, this chapter will display some of the qualitative observations such as general spread of the walled complejos and figures of individual structures. Additionally, the results of the hot spot analysis will be presented here.

Chapter Six will present a discussion and interpretation of the results from Chapter Five. Discussion on individual metrics will be presented as well as interpretations drawn from the complete dataset. This discussion will cover what the results of this investigation tell us as far as interpretation of walled complejos across the site; furthermore, how these results impact our understanding of multi-nucleated urbanism at Angamuco will be discussed.

The conclusions of this thesis will be drawn in Chapter Seven. A summary of the thesis work and investigation will be presented here. The research questions posed in Chapter One will be addressed and answered in this concluding chapter.

CHAPTER 2: BACKGROUND

2. 1 Introduction

This chapter will establish a foundation of urban organization theory in Mesoamerica, present past research focused on urban contexts in the Lake Pátzcuaro Basin and the site of Angamuco. As this thesis is seeking to understand a specific set of built features within the context of an ancient urban settlement, it makes sense to present the foundational works that theorize ancient Mesoamerican urbanization patterns and how our perception of these spaces has changed through decades of archaeological investigations. Furthermore, insights gained from archaeological sites surrounding Angamuco can provide context to our own investigations.

2.2 Mesoamerican Urban Tradition

The theory of the Mesoamerican Urban Tradition (Sanders and Webster 1988) assumes a standardized form and known grammar that applies to ancient settlements across the whole of Mesoamerica and across well over three thousand years. The expression of urbanism in Mesoamerica is therefore considered to be distinct from the “Old World” expression of urban settlements. This typological approach thus overemphasizes similarities and undervalues the variability across sites. Nonetheless, the definition of urbanism in Mesoamerica has continued to shape our understanding of densely populated and complex settlements across the region and needs to be addressed here.

The Sanders and Webster (1988) definition of Mesoamerican Urban Tradition is heavily influenced by 1930s sociological understandings of cities; the definition is therefore skewed largely towards demographics instead of more traditional archaeological evidence such as architecture or settlement organization. Wirth (1938 as cited in Sanders and Webster 1988) defines a city as having three major features: large population size, dense population nucleation, and high internal heterogeneity, this is a reference to the "range of lifestyles" that come with varying socioeconomic levels and group affiliations within an urban settlement.

The Mesoamerican Urban Tradition, as coined by Sanders and Webster, also utilizes the Fox Model (1977, as cited in Sanders and Webster 1988) which is very similar to geography's Central Place Theory and organizes cities into three types: regal-ritual, administrative, and mercantile. The primary role and function of regal-ritual settlements is ideological; they have inherent prestige and status stemming from the state rule or other organizing power that controls the state religion. Administrative centers are more complex (heterogeneous), denser, and larger than regal-ritual centers. As the name implies, these settlements function primarily as political centers and typically are the capitals of political systems. Of particular interest is the architectural variety in administrative centers, structures in these cities have a variety of functions from domestic to bureaucratic. Mercantile cities are centers of trade and industry, however little attention is paid to this type by Sanders and Webster as they consider it to only be weakly displayed or not at all present in Mesoamerica. The authors claim that there are only examples of regal-ritual and administrative within Mesoamerica; The Maya site of Copán as a regal-ritual city and both Teotihuacan and Tenochtitlan of the Central Basin as examples of administrative cities.

However, it is noted by critics that this model may not be useful for the region, as "almost *all* Mesoamerican cities (except for a few) are lumped into one type with little further discussion" (Smith 1989:455). The classifications presented by Sanders and Webster (1988) put densely populated cities into 'administrative' and those with complex architecture are 'regal-ritual,' but it is indeed difficult to find a Mesoamerican urban settlement without a complex architectural style or an amount of monumental architecture that would place it into the 'regal-ritual' classification. This brings into question not only the use of Fox model within Sanders and Webster (1988), but further the use of urbanization models based on 'Old World' settlements rather than Mesoamerican cities themselves. The ancient urban landscape of Mesoamerica was highly variable in size, form, density, organization, and architectural style. These cities are not so indistinguishable from one another that they all fit into the same category of urbanism. Additionally, Sanders and Webster (1988) are relatively exclusive with which settlements can be classed as 'urban' in their model, this is far too narrow for the reality of Mesoamerican urbanism; not all cities were as gridded and clear-cut as Teotihuacan, but rather existed on a spectrum of 'rural' to 'urban' with a variety in size, form, etc. (Smith 1989).

In recent years the definition of urbanism in the archaeological context has shifted towards a focus on activities present in these spaces rather than solely on their physical representation on the landscape. Smith (2007:4) defines urbanism as "centers whose activities and institutions (i.e. – economic, administrative, or religious) affect a larger hinterland" and that cities are urban centers with numerous urban functions. These definitions differ vastly from the definitions Sanders and Webster (1988) rely on. There is no mention of architectural style here or the built differences between urban and hinterland settlements. Furthermore, there has been a push for archaeologists to apply theoretical perspectives beyond early sociology and geography; namely the push has been for post-structuralism theory such as Bourdieu's *habitus* by (Smith 2011).

A central theoretical approach to archaeological understanding of the built environment is Architectural Communication Theory (Smith 2011). Here, we can assume deliberate statements about identity, status, wealth, power, and other traits are communicated through buildings and cities at large. This approach is utilized so often that it is rarely cited or specifically named but instead treated as a base level assumption of any archaeological site. When applied to urban contexts, this most often comes into play as the idea of 'monumentality' or the power inherent in the planning, construction, and maintenance of monumental architecture. This can be further applied to dwellings where there are clear disparities in wealth or privacy, as someone had the relative agency to separate their space from others through physical control (walling off land, for example) of that space.

Architectural Communication Theory also gives us the framework of construction having syntax and grammar. There is a known way to build within each group of people. There are correct ways to construct your house or the physical space around your dwelling. Patterns exist in conceptions of privacy or public space. These do not necessarily have to be determined by those in power in a top-down manner, but can be more colloquial and exist in a more bottom-up manner.

Furthermore, Generative Planning Theory can be applied to sites such as Angamuco where the settlement organization does not appear to come from a central authority or from a top-down framework. This theoretical approach focuses on the residential and the bottom-up processes or urban growth. Furthermore, this framework is typically applied to vernacular architecture, which is architecture that is built from local knowledge and material. Generative Planning Theory asserts that although these settlements do not follow an orthogonal grammar, they are not chaotic or random but rather that they are planned by those doing the physical construction and would likely meet their needs in a more efficient way than a top-down structure would allow.

The current understanding of urbanism at Angamuco is that it is organized in a multi-nucleated manner. A multiple nuclei city has several discrete nodes instead of being organized around a single center (Harris and Ullman 1945). Angamuco's many temple complexes dispersed across the entirety of the site further point to its multi-nucleated organization; there is no clear single central point within the city to have either concentric zones or outward extending sectors to support the models of concentric zone or sectors (fig. 2.1) (Harris and Ullman 1945).

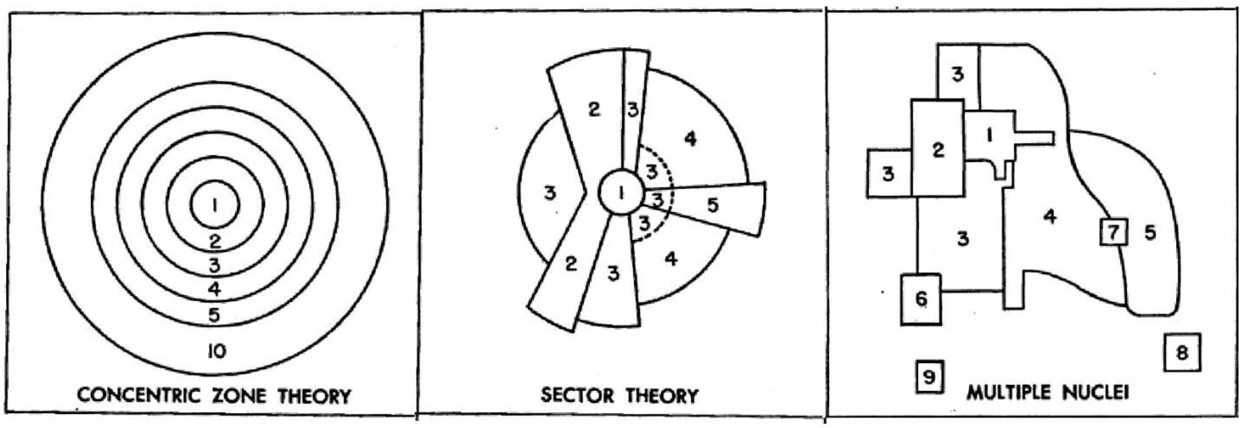

Figure 2.1: Generalized urban organization patterns (adapted from Harris and Ullman 1945)

2.3 Lake Pátzcuaro Basin

Much of the documentary evidence of the Tzintzuntzan kingdom comes from the Spanish colonial documents that were written in the early contact period of the middle 16th century. Archaeological research in the Lake Pátzcuaro Basin have largely focused on the empirical capital of Tzintzuntzan with scattered surveys and small excavations on islands and villages. The basin is largely influenced by the presence of the central Lake Pátzcuaro, and most settlements were either coastal or very near to the water (fig. 2.2). Islands and water travel were, and still are important features of this lake basin.

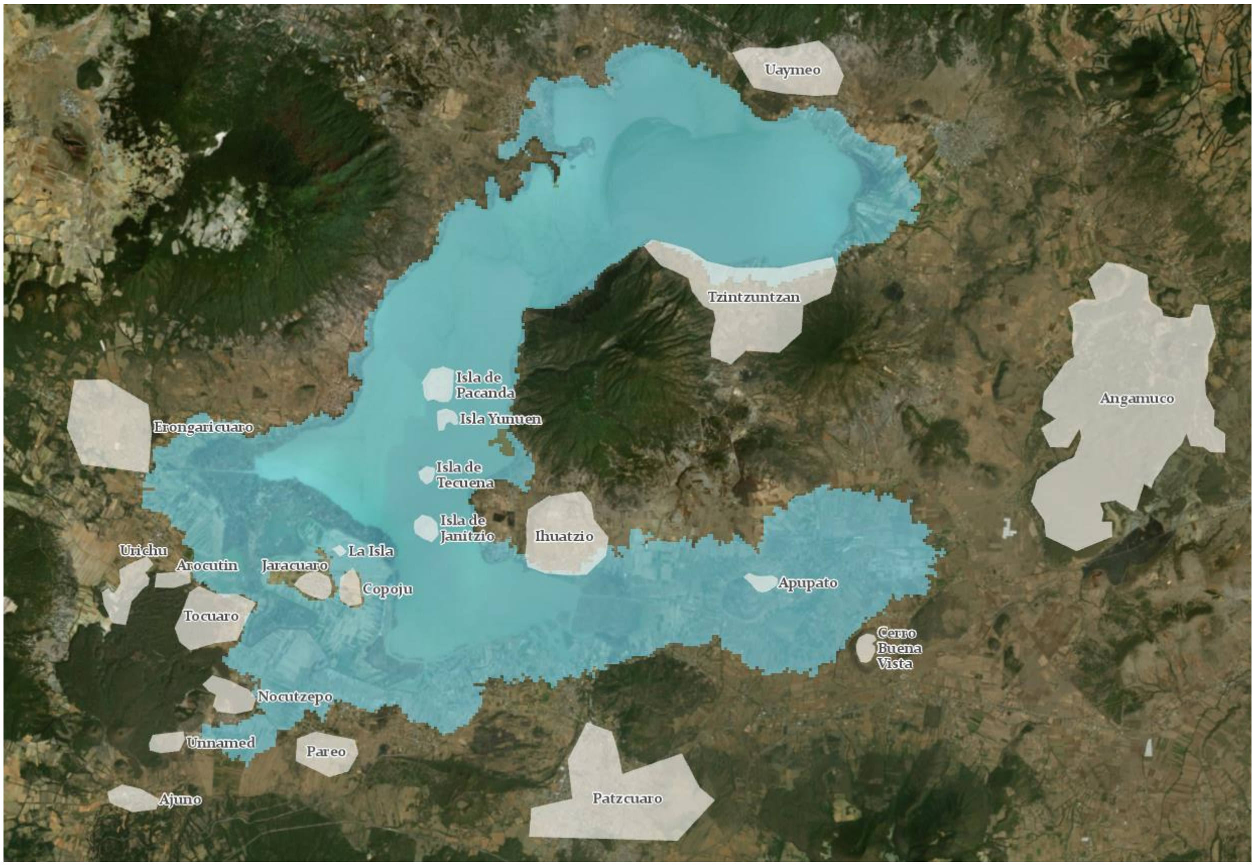

*Figure 2.2: Known archaeological sites in the Lake Pátzcuaro Basin*** (Adapted from Steele and Westberry 2020).*

It has been widely considered that the state of Michoacán lacked a state-level society until the emergence of the Purépecha (Tarascan) Empire in the Late Postclassic period (1350-1525CE) (Pollard 1980, 2004; Williams 2020). This empire was centered around the capital of Tzintzuntzan on the shores of Lake Pátzcuaro. Tzintzuntzan was largely considered archaeologists to be the first instance of urbanism in the region, but findings at Angamuco have brought this into question. During the Postclassic period there were a series of migrations into the basin: the *chicimec, nauhua,* and the *uacúsecha* (Afandor-Pujol 2015; Craine and Reindorp 1970; Pollard 1993) .The *uacúsecha* eventually gave rise to the royal lineage of the Tzintzuntzan kingdom (Pollard 1993). There has been much debate over the veracity of these migrations and the relative influence with which they had over the region (Malmström 1995; Pollard 1993).

The growth of the capital city is largely attributed to political power and associated tribute paid to the city, rather than a growth from market or economic power over the region (Pollard 2004). As this city is the only example in the region, Pollard (2004:30) views the prehispanic Purépecha culture as "basically nonurban" with Tzintzuntzan being the exception. The Late Postclassic is characterized by the creation of new common elite culture of status markers, unification of polities across the basic and beginning markers of state emergence (Pollard 2018). The city has been estimated to have been populated by up to 35,000 people and to have covered almost 4 km^2 (Pollard 1977, 1993, 2004). The city contained distinct residential, manufacturing and public zones (Pollard 1993). The best fit urban model for the city is the concentric pattern with low, middle, and high status zones moving from outskirts to center of the city, a classic ordering of the zones for early cities (Pollard 1977).

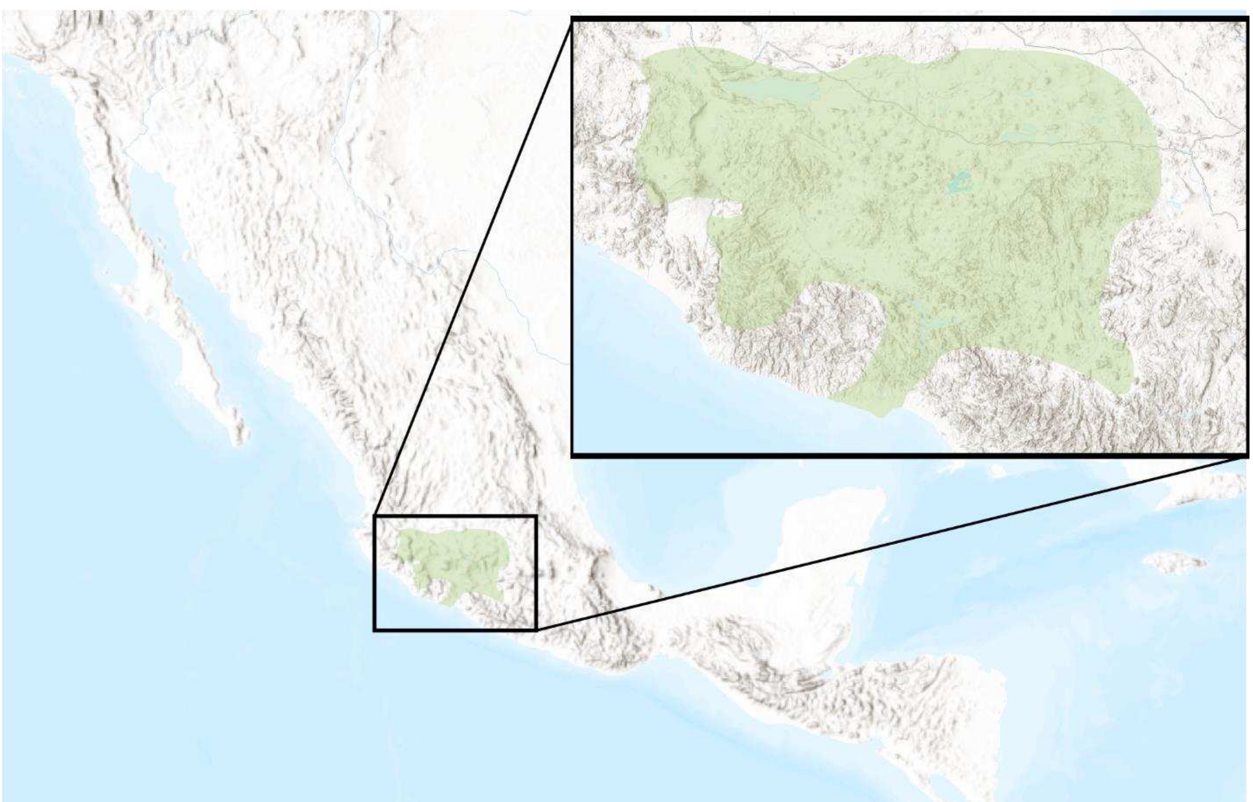

Figure 2.3: Purépecha ethnographic area, modified from Solinis-Casparius (2019)

2.4 Angamuco

The site of Angamuco is on the Eastern edge of the Lake Pátzcuaro Basin. This urban center is located on top of a mid-Holocene lava flow, known as a malpaís (Fisher et al. 2017). During the late Postclassic it is estimated that Angamuco was no more than two kilometers from the lake's edge [see fig 2.1 above] (Steele and Westberry 2020). Survey work and excavations took place from 2009 through 2012 (Fisher et. al 2019). The size of the site was not known until LiDAR was flown in 2010 and 2016, which revealed a built landscape spanning 26 km^2 (Chase et al. 2012; Fisher 2011; Fisher et al. 2016, 2017, 2019; Fisher and Leisz 2013).

The site was likely occupied beginning in the Late Preclassic period, around 300 CE (Solinis-Casparius 2019) and was occupied through the Late Postclassic with the arrival of the Spanish. At this time, the Spanish conquered the region and built *haciendas* on the site, utilizing some of the built infrastructure into their own architecture (Fisher, personal communication). Ceramic assemblages from excavation units across the site were used to build a chronology for relative dating of occupation at the site (Cohen et al. 2018, 2019; Cohen 2016); this evidence points to the Middle Postclassic period as the densest occupation at the site and the period of highest modification of the landscape (i.e. construction). In the architectural typology of the site, Fisher et. al (2019) give the following architectural chronology:

1. Epi Postclassic and Early Postclassic (600-1200CE): characterized by sunken patio complexes.
2. Middle Postclassic (1200-1350CE): several distinct nodes of construction characterized by rectilinear pyramid complexes.
3. Late Postclassic (1350-1525CE): dominated by Purépecha Imperial architecture, a style that is dominated by circles and squares, with at least two distinct nodes.

Further, this typology establishes specific shapes and names for the architectural forms found at Angamuco which previously was not consistent between excavation years. Broken down into above-ground and ground-level features, the typology describes 12 major categories of architecture with almost each major category containing further distinctions within leading to about 60 distinct forms within the site. This typology was based on field-verified documentation of over 7,000 features.

The feature class closest to the walled complejos focused upon in this thesis are the *edificios compuestos* or composite buildings. These are structures with multiple *edificios* and other singular forms combined to make a multi-roomed feature. However, a 'complejo' is not an architectural form recognized in the 2019 Angamuco typology. The individual components of a walled complejo, which will be discussed further in Chapters 3 and 4, are each described in detail within the typology.

Fisher et. al (2017) describes Angamuco as a multi-nucleated city, as opposed to a single centered urban pattern, which would make it fairly unique in the grand scheme of Mesoamerican urban organization. There are only a few examples of this style of urban organization in the Mesoamerican archaeological record, but they do exist and are largely considered to be planned settlements even though they do not present the standard orthogonal patterning that most expect of planned urban organization. Sites that exhibit this multi-nucleated organization include Tula, the Toltec Imperial capital of the Early Postclassic, Cantona, El Palacio, and likely the settlement of Pátzcuaro, just across the lake from Angamuco. This patterning is also seen in modern cities such as Atlanta, Chicago, and Los Angeles. This model of city is organized in a way where distance between dwellings and the public infrastructure is minimized, so people do not need to all travel to one central temple or market but rather only need to go to their neighborhood infrastructure.

2.4.1 Angamuco Architectural Typology

The walled complex or walled complejo at Angamuco does not have a formal definition at present, but its components are defined in the architectural typology (Fisher 2009, 2010; Fisher et al. 2019) that is standard across all archaeological survey, excavation, and digital work for the project. The typological flowchart for the LORE-LPB project at Angamuco details more than 60 distinct architectural forms that recur across the site, spanning from simple walls through to the monumental pyramid forms. The typology created in 2009 for the initial survey/mapping season at Angamuco, based off of previous work at the nearby site of Apúpato in 2007 (Pezzutti 2010). The typology has been updated and expanded as work has continued at the site of Angamuco. The architecture at Angamuco is stacked, uncut stone which lacks preserved mortar and walls were likely finished with adobe/plaster at the time of occupation (Fisher et. al 2019).

Walls are the most basic ground feature at the site, typically composed on a single course of stacked stone and no thinner than 50cm wide. The *huatziri*, or raised roads, were multifunctional, acting as both roadways, boundary markers, and at times were outside walls to complejos; these structures are typically 2.5m tall, can have one or two stepped courses, and are constructed with outside facing stones surrounding a core of rubble or smaller stones, seen in figure 2.4 below (Fisher et. al 2019, Solinis-Casparius 2019).

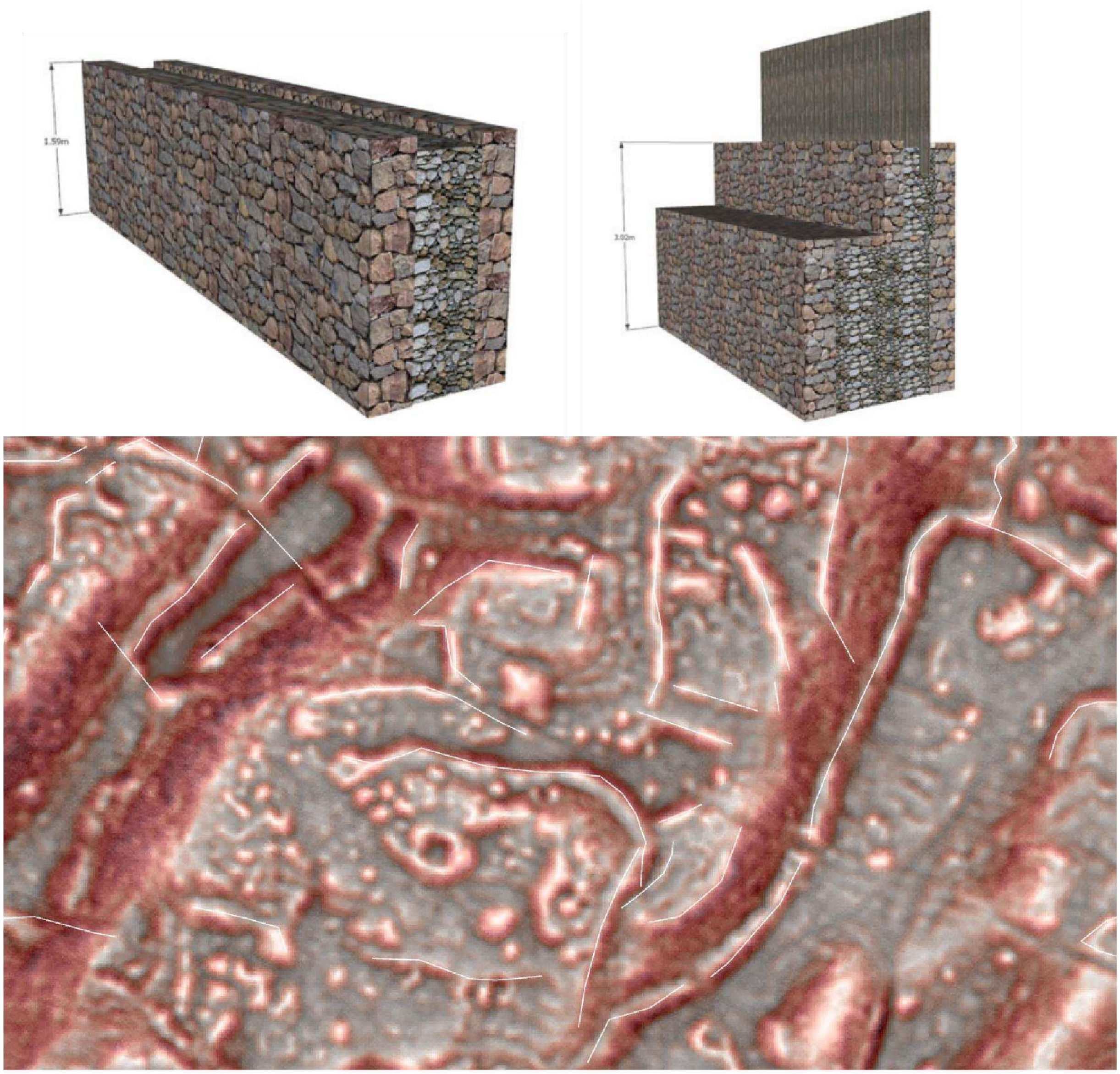

Figure 2.4: Examples of huatziri: Top are two reconstructions of two potential types of huatziri (modified from Fisher et al 2019 and Solinis-Casparius 2019); bottom image shows huatziri outlined in white over Pseudo-Red Relief Image Map^{+}

There are four formal types of square buildings at Angamuco, differentiated by the number of walls, their orientation to one another, the shape of the structure, and the presence/absence of a clear entrance. Type A *edificios* have three walls and an open fourth side. Types B and C have four walls with an opening in one wall that creates the entrance to the structure; Type B is rectilinear in shape and the more common Type C is square. The fourth type is the *cuarto*, or the room. These are four complete walls that lack a clear entrance. These are often found in clusters that are associated with larger architectural complexes (Fisher et. al 2019). The complexes of rooms do not appear to have a defined structural grammar to make them similar to one another in a formal way (Fisher et. al 2019).

Plazas and patios are types of intentionally cleared, often flattened or leveled, negative space. A plaza is a ground-level feature that is cleared, level and open, usually more than 10 m^2 and can have surrounding walls or stone or earth; Often these spaces form connections between architecture, with buildings clustering around the edges to form what are called plaza groups (Fisher et. al 2019, Bush 2012). Sunken plazas are similarly rectangular open spaces but have three or four steps on all four sides and are likely associated with residential spaces rather than public spaces due to their restriction of access (Fisher et al 2019, Bush 2012). Altars are found either in the center of these plazas or at the entrances/exits of road systems. The most common type of mound at the site is the altar, which is a small stepped rectilinear feature; These are composed of at least three *cuerpos* (steps) (fig. 2.5).

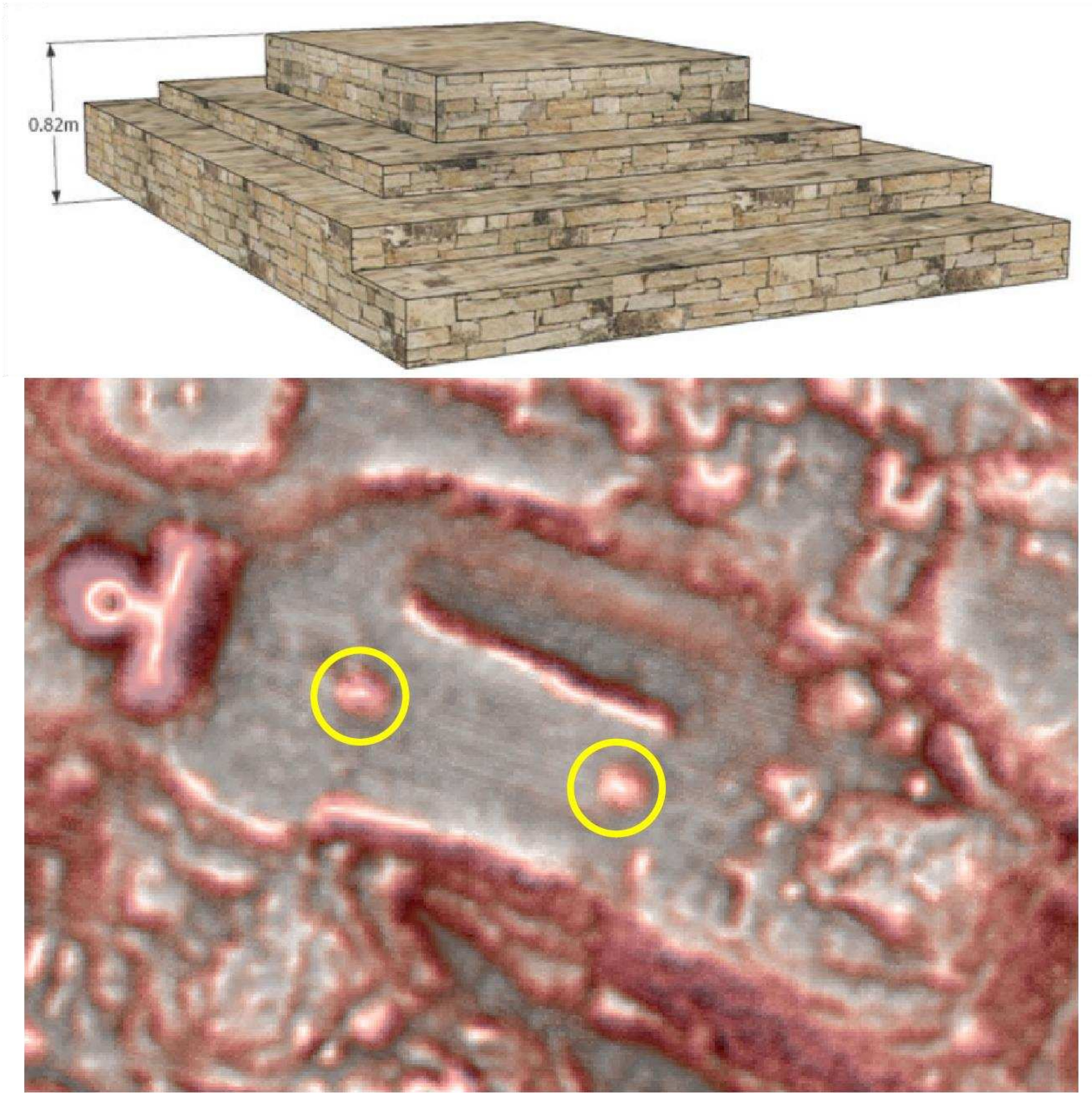

Figure 2.5: Example of Altar (top)Reconstruction of an altar from a residential context (modified from Fisher et. al 2019)(bottom) Pseudo-RRIM+ two altars outlined in yellow within a plaza adjacent to a yacata

The monumental architecture at Angamuco is dominated by the two forms of pyramids, *yacatas* and rectilinear pyramids. *Yacatas* are a distinct Purépecha form of pyramid that consist of conjoined circular and rectilinear elements that are connected at the center by a short linear platform making a keyhole shape (Fisher et. al 2019). Access to these structures occurred via stairs either on the sides of the rectilinear portion or on the open face; stairs to the ground level do not appear to be associated with the circular portion of the pyramid. Rectilinear pyramids are more common at the site and have a longer primary axis than secondary. These are accessed via a staircase that runs alone the primary axis and over the basal platform (Fisher et. al 2019). These multi-stepped pyramids occur throughout the site and appear to anchor civic-ceremonial nodes or neighborhoods (Fisher and Leisz 2013, Fisher et al 2019).

2.4.1 Past research on Angamuco

There has been continuous research at Angamuco since the initial archaeological investigation (Fisher 2011; Fisher et al. 2019). Much of the research done at Angamuco has been focused on documenting and mapping features of the site through LiDAR data combing and interpretation. Thus far, the Legacies of Resilience – The Lake Pátzcuaro Archaeological Project (LORE-LPB) and CARS lab have been able to identify road networks, pyramids, water management infrastructure among other features; but there is still much to be done (Bush 2012; Cohen 2016; Friedl 2019; Harris 2019; Simpson 2019; Solinis-Casparius 2019; Urquhart 2015). This section will briefly present what work has been at Angamuco and what insights we have gained from those projects.

Due to the nature of the data available, almost all work of recent years has been focused on identifying features of the built landscape through various spatial analysis algorithms within a GIS and processes. In recent years theses and dissertations have established knowledge on road networks, water management, and organization of pyramids among other things. This focus on the built environment has thus led to a growing understanding of the social or political organization of the people who created this highly modified landscape. There have been instances of field verification to support this research, but by and large the work done to understand Angamuco has been remote and relied upon the LiDAR data. With each instance of

LiDAR data analysis, we can implement those layers into a GIS and springboard off of the interpretation established to dig into more complex questions and analyses.

Solinis-Casparius (2019) produced an in-depth road network analysis of the site, including over six thousand road segments, pathways, and intersections. These segments were classified based on morphology, construction, configuration, 'experiential properties' and centrality within a formal network analysis done through ArcGIS. Once mapped within the LiDAR data, these roads were field verified through multiple seasons of excavation. Investigations in the field determined that there were at least three phases in time of road construction at the site of Angamuco as well as varying levels of formality to the roads. This is not unlike what we see at other urban sites, both ancient and modern. Further, these phases support the interpretation that the height of occupation, and thus the height of construction, at the site was in the Middle Post Classic (1000-1350CE). There is an identifiable road hierarchy at Angamuco based on both network characteristics (betweenness and redundancy) and on road width (four categories based on width: pasillos, senderos, caminos, and calzadas).

This work had exponentially expanded our understanding of the relative connectedness of the site. Angamuco was organized into nesting units of spatial division: districts (largest), neighborhoods, and complejos. Each of these divisions was given a central node so it could be input into a formal network analysis within the GIS program, where algorithms can take nodes and paths, which were the mapped roads, and determine routes and quotients of connectedness. This analytical tool determined that 92.7% (666 of 685) of the architecture clusters were accessible via the road networks from other nodes; those that were not accessible were either at the fringes of the site or one instance of an extremely central complejo that was likely intentionally inaccessible due to its proximity to ceremonial and religious centers. These groupings of households are spread across the entire lower malpaís, and thus the connectivity of them implies connectivity of the site as a whole. This has not been extended into the upper malpaís, most archaeological investigations at Angamuco do not go beyond this lower section as the modern disturbances have greatly impacted what LiDAR is able to show us.

A final conclusion to draw from the work of Solinis-Casparius (2019) is the formality and planning found within the road network of Angamuco. Evidence of massive construction, modification, and maintenance of the roads tells us that these were not ephemeral, unplanned byproducts of daily movement across the site but rather a coordinated effort of organization. Classical definitions of urbanization and urbanism in the ancient world typically allude to an orthogonal or grid-like planning schema and rely on the presence of state-level society. The road network produced and verified by Solinis-Casparius (2019) show that there can be a high level of planning, mass public work construction (seen especially with the number of raised roads throughout the site), and formal connectedness between nodes in a site without needing to have a Teotihuacan-like grid or a Tenochtitlan-esque state level society. This dissertation supports the assertion that Angamuco was an urban settlement in the Middle Post Classic, albeit a decentralized one.

The pyramids at Angamuco were mapped and investigated by (Friedl 2019). The large number of pyramids (n = 26) found throughout the city indicates both a large amount of man hours, and therefore some sort of organizing power, and a multi-nucleated or decentralized pattern or urbanization at Angamuco. The pyramids do not appear to be clustered in any way within the site, but are rather spread out across the site, potentially indicating a more neighborhood level of temple/religious/ritual building rather than a centralized temple complex similar to that is exhibited at other Mesoamerican centers like Tzintzuntzan or Teotihuacán. The vast scale of monumental architecture across the expanse of the city would further imply some sort of power to plan the construction at such a scale.

Water management within Angamuco was explored by Simpson (2019). The vast number of wells and reservoirs that can be seen from LiDAR data indicate a high level of water management was present at Angamuco during the height of occupation in the city. There are several natural springs that were exploited, likely for household water use and small-scale agriculture on the site. The large-scale reservoirs would signify more public or centralized management of water for the city.

An investigation to calculate the number of built features within the city was undertaken by Harris (2019). Using automation algorithms within ArcGIS it was determined that the city of Angamuco has currently ~70,000 built features still visible to LiDAR scans flown in 2014. This does not include subsurface features as they cannot be mapped remotely with LiDAR nor does it account for the number of features that have been destroyed in the roughly thousand years between the occupational height of Angamuco and when it was remotely sensed. However, this work does attempt to account for features that have deteriorated into a state that would be seen by a computer as separate entities.

The spatial context of buildings and their relationships to each other are important to the archaeological record. From this information, archaeologists can interpret function of structures and of architecture groups. Spatial organization and architectural patterning at the site were investigated by Bush (2012) and Urquhart (2015). Bush (2012) investigated the architectural patterning of Angamuco to determine if any distinct clustering existed, and if it did, if these clusters could inform us about the type of urbanism that exists at Angamuco. This work led to four building group types identified: patio groups, plazuela groups, plaza groups, and multi-plaza groups (Bush 2012). Further, it was determined that the site of Angamuco did exhibit patterning, and coordinated arrangement of space but it was not highly planned, i.e. above the individual structure level, due to its lack of orthogonal grid system. Utilizing colonial and ethnohistoric documents, Urquhart (2015) investigated the spatial organization of social groups at Angamuco according to early colonial tax documents and comparing those divisions to architectural clustering at the site. It was determined that the social structure and groups of households, called ocambecha in the colonial documents, preceded the Spanish conquest and likely the Late Postclassic Purépecha Empire based out of Tzintzuntzan, as the architecture from the Middle Postclassic at Angamuco tends to cluster in groupings of the same size (Urquhart 2015).

CHAPTER 3: COMPLEJOS

3.1 Introduction

The preceding chapters have laid out the foundational background context for this thesis and the data that will be implemented in this investigation. This chapter seeks to define walled complejos as they present at Angamuco. Furthermore, these architectural forms will be compared to their best-fitting cognates across the archaeological record of the broader Mesoamerican and American Southwest landscape. Through a clear definition of walled complejos and an understanding of how similar structures are interpreted, this thesis seeks to best interpret the multi-roomed domestic structures at the site of Angamuco.

3.2 Angamuco

The walled complejos at Angamuco are a distinct architectural form from any other structure at the site. These thickly walled, multi-roomed complexes are present throughout the expanse of the site. Of the examined features, no two walled complejos are identical in construction; size, form, and organization all vary widely. They do not appear to fully match any instances of multi-roomed domestic structures from around the region, either. The most agreed upon interpretation prior to this investigation is that these complexes were both elite and non-elite homes, likely a single lineage or family. There are five main criteria for a complejo in the context of this thesis:

1. Multi-room complexes (*edificios compuestos*)
2. Thick walls, encompassing or nearly encompassing the complex
3. Clear plaza

4. Presence of an altar within the plaza
5. Proximity to monumental architecture

An example of a walled complejo at Angamuco alongside an idealized line drawing of the structure can be seen in figure 3.1 below, with each of the five characteristics of the complex labelled; the monumental architecture that this complejo is nearest is the I-shaped ballcourt to the south of the structure, to the right of the number five in the pseudo-Red Relief image.

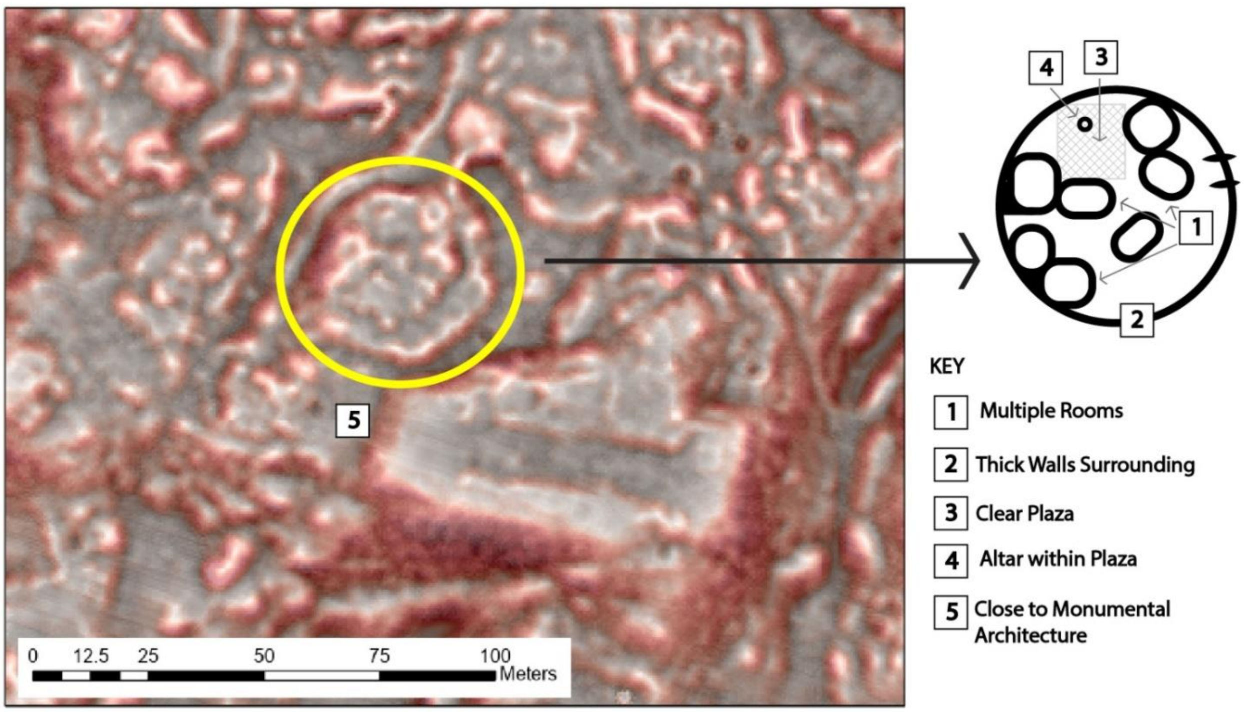

Figure 3.1: (left) Identified walled complejo circled in yellow on a pseudo-Red Relief Image Map+ (right) line drawing of idealized walled complejo with the five major components labelled

Past work at Angamuco has implemented the term complejo in differing ways. The shifting definition of complejo has changed from an informal cluster of architecture, to a formal grouping of architecture. This thesis will be using the terms "walled complejo" and "walled complex" to make a distinction from previous work and to place emphasis on critical presence of an encompassing wall around the architecture cluster.

Through an investigation of architectural planning done by Bush (2012), it was determined that Angamuco has evidence of coordinated arrangement of structures and the presence of formal building groups, such as plaza or patio groups, demonstrate planned coordination of space (Bush 2012:80). Prior to LiDAR the site was not mapped in its entirety, and therefore this patterning appeared to be only low-level planning and not indicative of a large-scale, city-wide organized architectural scheme; thus, Bush (2012:81) interprets the planning of these sub-neighborhood units to be the only coordination of space at the site and without a grid system or single central epicenter the city was lacking "high-level" planning. However, with the clarity of LiDAR data, it is no longer appropriate to consider Angamuco an unplanned settlement simply because it lacks orthogonality or a single epicenter spatial pattern. Aforementioned studies of the road networks (Solinis-Casparius 2019) and scale of built environment features (Harris 2019) further display the relative complexity and coordination of space at Angamuco, which points to planned urbanization rather than ephemeral building and natural, unplanned urban sprawl. Further, Bush (2012) notes that the only multi-building complexes that could have been for elite residences are the multi-plaza groups, instead of the smaller patio-, plazuela-, and plaza groups that this thesis is interpreting as potential elite residences.

Understanding of intentional organization was built upon by Urquhart (2015) where sub-neighborhood divisions (*complejos)* were explored in relation to bureaucratic divisions, called *ocambecha* units, utilized by the Purépecha Empire. In the context of this work complejos are defined as the "smallest-identifiable unit above the level of individual structures at the site" which are typically clusters of architecture separated from each other by roads, walls, or other architectural features. Furthermore, these are less formal than neighborhoods as there is not necessarily a common public space, such as a plaza, shrine, patio, or reservoir, to unify the unit (Urquhart 2015).

These sub-neighborhood units were defined and outlined through Object-Based image Analysis (OBIA) and then compared to an expert-derived, hand-drawn map of the same features to determine if the OBIA was an appropriate method for outlining these spatial units. The OBIA iterations identified 1,112 objects while the expert map identified 685. This investigation tells us that the spatial divisions of complejos are clear but it does not reveal any information about the function of these spaces; the clarity of theses division tells us that these were significantly distinct from the other architectural features found within the same space.

Instead of drawing from Eurocentric models of urbanism, Urquhart (2015) consciously chooses to understand the Purépecha organization scheme through the Nahua *altepetl* model. The Purépecha cognate to this model is the *ireta* system, which utilizes the indigenous word for pueblo, and builds off of the descriptions given in the *Relación*, which called Purépecha communities "pueblos" (Urquhart 2015:52). These *ireta* appear to be, at least in physical structure, to be similar to the Nahua *altepetl* and both were called "pueblo' in Spanish language colonial documents.

The *ocambecha* unit was described in these same colonial documents as a spatial taxation unit under the Purépecha Empire. However, if these units match the *complejos* described by Urquhart (2015) at Angamuco then an argument can be made that these spatial, and thus social, divisions existed before the Purépecha Empire. After completion of the OBIA and subsequent comparison with the expert-derived maps, Urquhart determines that the archaeological unit of the complejos at Angamuco does match in size with the *ocambecha* of the *Relación*. When taken into account with the knowledge that occupation at Angamuco largely predates the Empire, Urquhart (2015:133) concludes that the *ocambecha* unit could have been co-opted, rather than created by, the empire.

3.3 Tzintzuntzan

Much of our archaeological understanding of the Lake Pátzcuaro Basin stems from the work of Helen Pollard, who has been publishing about the region since the 1970s (Pollard 1977, 1980, 1993, 2018). This work has largely been centered on the site of Tzintzuntzan, the imperial capital of the Late Postclassic Empire in the region. Pollard (2004) describes a structure called Edificio F from the lower slopes of the main settlement platform, Cerro Yaguarato, which appears to match the definition of the walled complexes observed at Angamuco. The structure contains four contiguous rooms, with one larger than the rest, a paved patio, an altar, and two stone terraces; the structure measured 27 by 24 meters. It is difficult to differentiate between walls and terraces in the archaeological record, especially considering that at times a structure could function as both simultaneously. If we consider these terraces to be walls, Edificio F meets all of the qualifications of a walled complejos as defined at Angamuco. Pollard (2004) interprets these structures as homes for the "low branches of the high status" and points to the *Relación* for support with this argument; in the *Relación* the residences of the elite are often drawn as multiple room dwellings while those of commoners are always shown as a single room house (Afandor-Pujol 2015; Craine and Reindorp 1970)

3.4 Regional comparisons

It is important to note the difference between types of complex dwellings in the archaeological record; an apartment, a house group, and a walled complex may serve similar functions but are not morphologically the same. Four main types of dwelling will be discussed here: the house group, the contiguous house, the walled compound, and the apartment building.

The house group is composed of two or more closely related residential structures that typically surround a shared open space, i.e. a patio, but are not necessarily arranged formally (Smith 2014). A contiguous house shares at least two outer walls with an adjoining house but retains its own entrance to an exterior space, such as a road (Smith 2014). Like the name suggests, a walled compound is distinguished by its walled enclosure around one or more dwellings and a shared open space (Smith 2014). Finally, an apartment building is differentiated from the contiguous houses because it has only one shared entrance/exit to exterior space for multiple dwellings within a single building (Smith 2014).

Each of these structure types have been identified in the Americas in the archaeological record and can thus be utilized in this thesis to better understand the walled *complejos* observed at Angamuco through regional comparisons. This section will outline an examples of multi-roomed domestic structures found in the archaeological record across Mesoamerica and the American Southwest.

3.4.1. The Maya

An architectural form that is oft-discussed when comparing Mesoamerican architectural groups are the patio groups of the Classic Maya. These groups consist of several rectilinear buildings surrounding a shared patio, which can be raised or enclosed to control access. A clear example of these groups comes from the Late Classic site of Copán in Honduras, which was a densely populated settlement (Sheehy 1991). Figure 3.2 Shows a map of an elite residential zone called Las Sepulturas and a line drawing of the architecture within one of these patio groups. Archaeological evidence points to occupation of these structures for generations, and in some cases up to 400 years (Sheehy 1991).

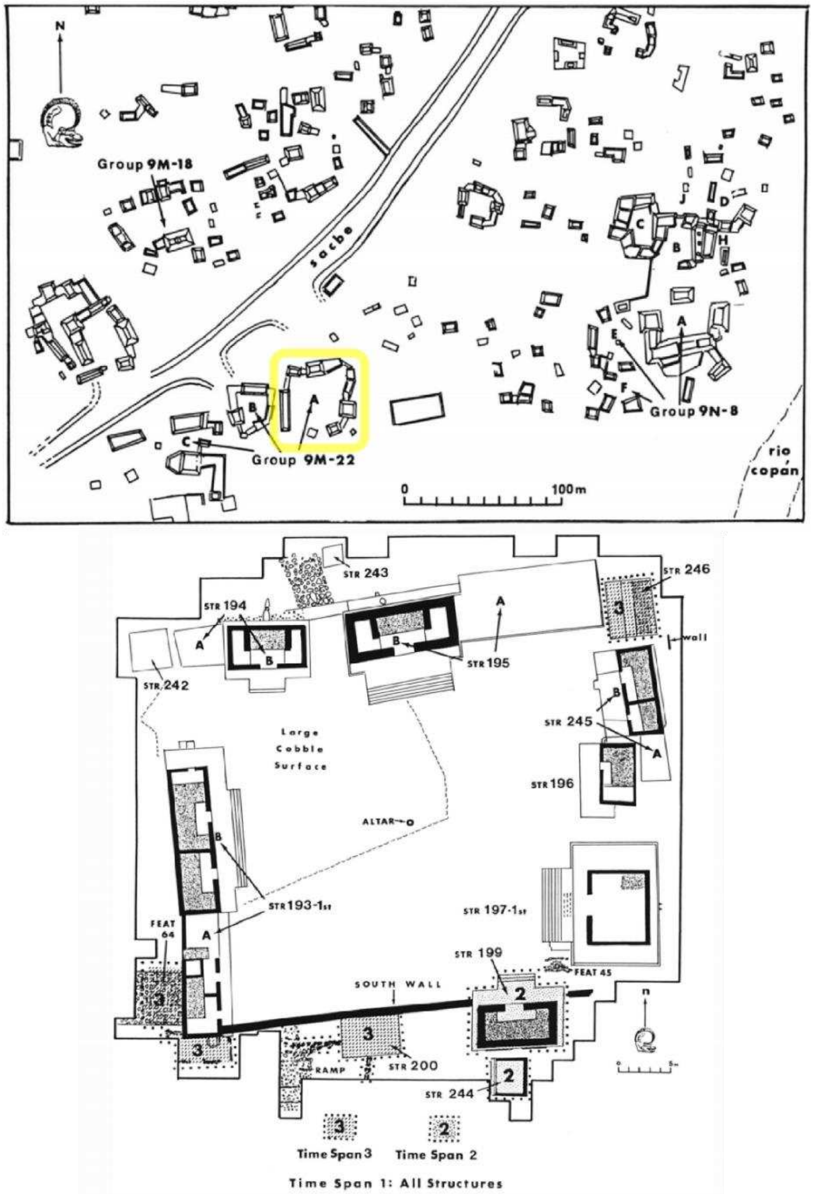

Figure 3.2: (top) Map of Las Sepulturas residential zone of Copan, Honduras (bottom) Example of Late Classic Period Maya Patio group 9M-22-A from Copan, Honduras (adapted from Sheehy1991)

More like the walled complejos seen at Angamuco than the patio groups are the houselots seen in Maya settlements across time and space. These are seen throughout the Classic and Postclassic period at a variety of sites. The houselot in this context is composed of multiple rooms or platforms, associated open space, and a wall that encircles the compound (figs. 3.3, 3.4). It is also common to find small pyramids or altars within the patios of these houselots. This architectural grammar is followed across the much of the Maya region, however the spatial patterning within the site and the relative size are not consistent throughout. The most common interpretation of houselots is that they were inhabited by extended familial groups (Folan et al. 2009; Magnoni et al. 2012). Houselot compounds have not been attributed to any specific social status; having elite, middle, and common contexts present in the archaeological record (Folan et al. 2009; Hare et al. 2014; Magnoni et al. 2012). Across multiple studies, there does not appear to be strict spatial patterning of these houselots within settlements as far as relative status or size in relation to the center of the settlement or distance to monumental architecture like the Maya *sacbes* (Folan et al. 2009; Hare et al. 2014; Hutson et al. 2006; Magnoni et al. 2012).

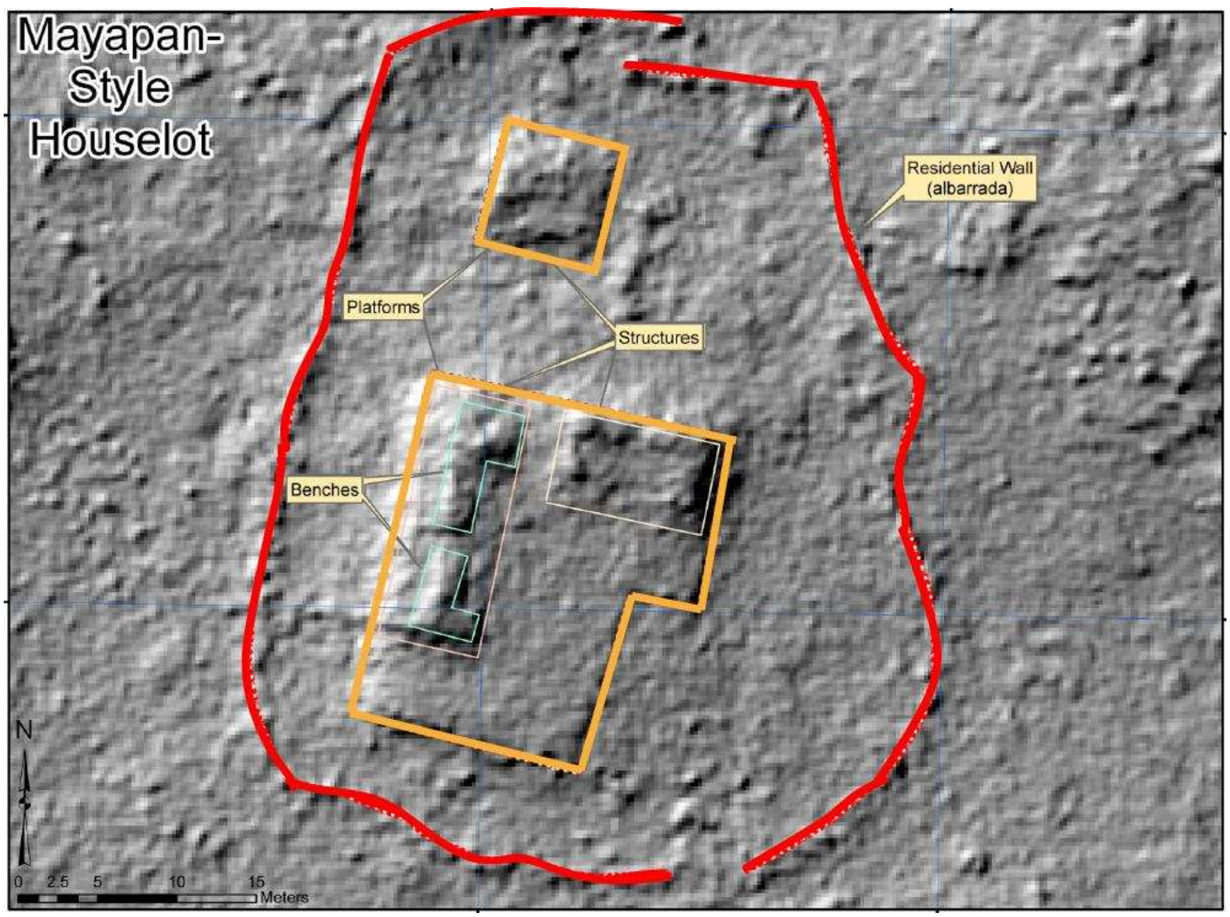

Figure 3.3: Example of a walled Postclassic Maya houselot at the site of Mayapán (Adapted from Hare et. al 2014)

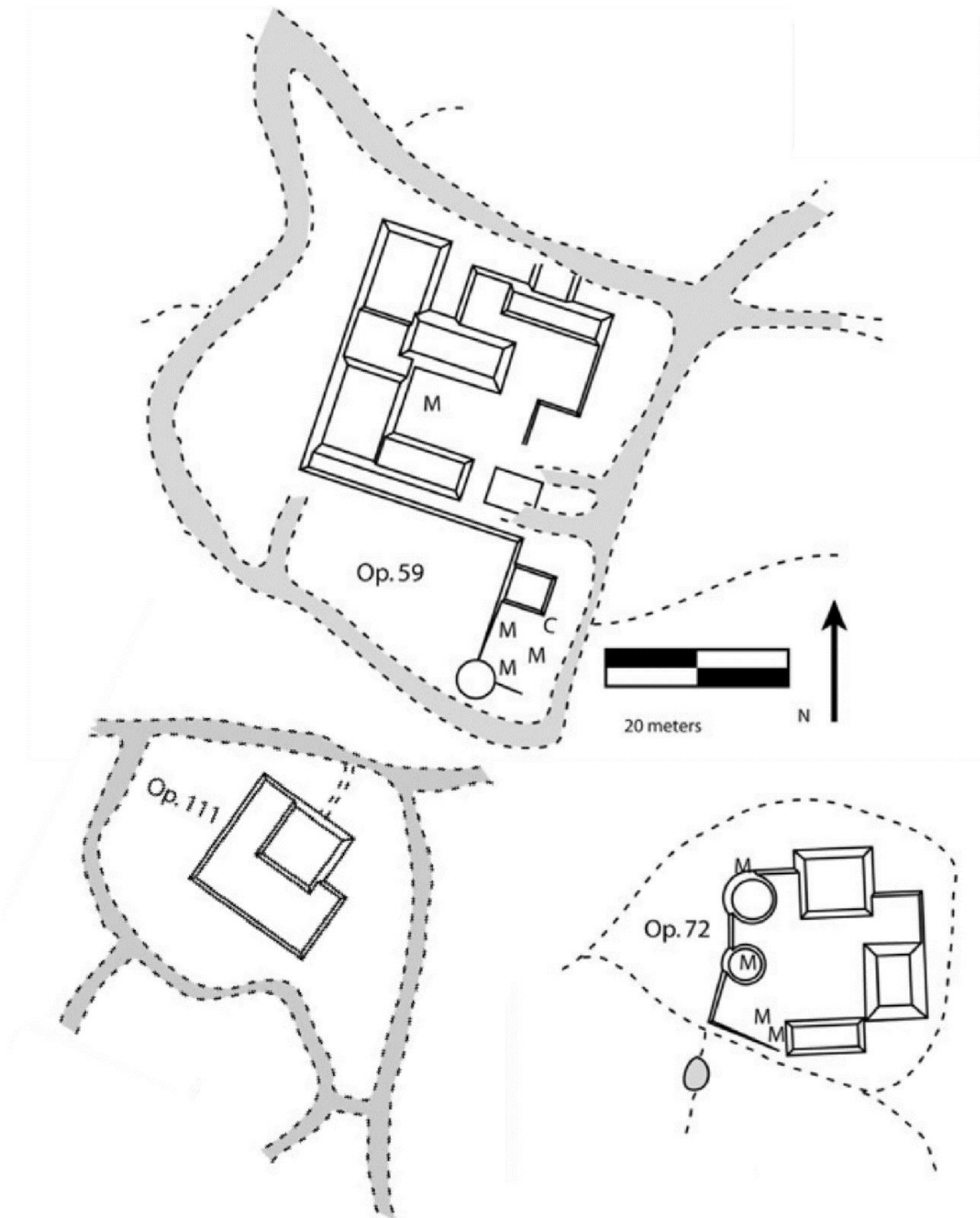

Figure 3.4: Three examples of houselots at Chunchucmil (adapted from Magnoni et. al 2012)

The site of Chunchucmil in Yucatan, Mexico was one of the densest Classic period Maya sites, with an estimated 43,000 people in a 25km^2 site (Magnoni et. al 2012). Architecture at the site shows a city that was densely built and highly accessible through a system of roads and *sacbes* (Magnoni et al 2012). Site survey documented almost 400 distinct bounded houselots, a number similar to estimates of walled complejos at Angamuco. The houselots at Chunchucmil are highly varied in size and number of individual structures located within the walls. In the broader scheme of urban organization at Chunchucmil, there did not appear to be any correlation between houselot size and the distance to the center of the site (Hutson et al. 2006; Magnoni et al. 2012). These factors lend the city of Chunchucmil to be an interesting comparison to Angamuco within the Maya region; both are not known religious or political capitals in their respective region but is a densely populated and highly modified urban center.

A final Maya domestic form to discuss in this section is the multi-room domestic structure of the elites at Aguateca in Guatemala. These structures are typically 3-5 room houses oriented around a shared plaza with other similar structures (Inomata et al. 2018). The archaeological evidence suggests there were single family residences rather than multi-family domiciles due to the lack of redundant room functionality that would be expected if each room of the structure was treated as a singular home rather than the composite structure as the home (Inomata et al. 2002).

3.4.2 The American Southwest

The roomblock is one of the smallest forms of multi-room domestic structures in the American Southwest. These can be clearly seen at Crow Canyon in the Pueblo I Period (700-950AD); in this context the roomblock is a single story domicile with several rooms that share walls with pit houses situated directly across a shared plaza (Crow Canyon Archaeological Center 2014). However, roomblocks can present in multi-storied and terraced structure later in time (Cameron 1999). The more complex later roomblocks still preserve the several rooms and shared walled plan of the earlier single story presentation (Cameron 1999; Crow Canyon

Archaeological Center 2014). Roomblocks were occupied by a single household and were likely constructed in an organized fashion from the village level rather than ad hoc by the individual family (Cameron 1999). At Grasshopper Pueblo, archaeological evidence points to the multi-room houses being occupied by the more established, older, and relatively wealthier families, i.e. those who had access to accumulate power over that much space (Reid & Whittlesey 1982 as cited in Cameron 1999).

The larger, more aggregate domestic structures of the Southwest are the village-scale Pueblos, like that of Acoma Pueblo, Pueblo Bonito or Mesa Verde (fig. 3.5). Each of the three aforementioned Pueblo examples have unique contexts in which they were built: Pueblo Bonito is situated a wide canyon basin called Chaco Canyon, the Sky City of Acoma Pueblo is located on top of a mesa, and the Cliff Palace at Mesa Verde is built into the cliff face. Each of these represent a contiguous house, where each dwelling shares at least two outer walls with its neighbors (Smith 2014). In Pueblos of this scale, the conjoining walls are continuously expanded upon and arranged around a common public space where domestic, craft, and ritual activities take place; this is fundamentally much like the roomblocks but are exponentially larger, at times consisting of hundreds of rooms rather than less than a dozen seen in the roomblocks (Cordell et al. 2007; Smith 2014). Furthermore, these are not domestic structures that are occupied by a single household but are instead an entire kinship group of hundreds (Cameron 1999, Cordell et al 2007) Although, it should be noted that within the complex room network of a large Pueblo families did occupy more than one room thus making it a conglomerate of many multi-roomed homes (Judd 1964). So, while there are structural similarities between the roomblock and the Pueblo in their initial construction, they are fundamentally functionally distinct.

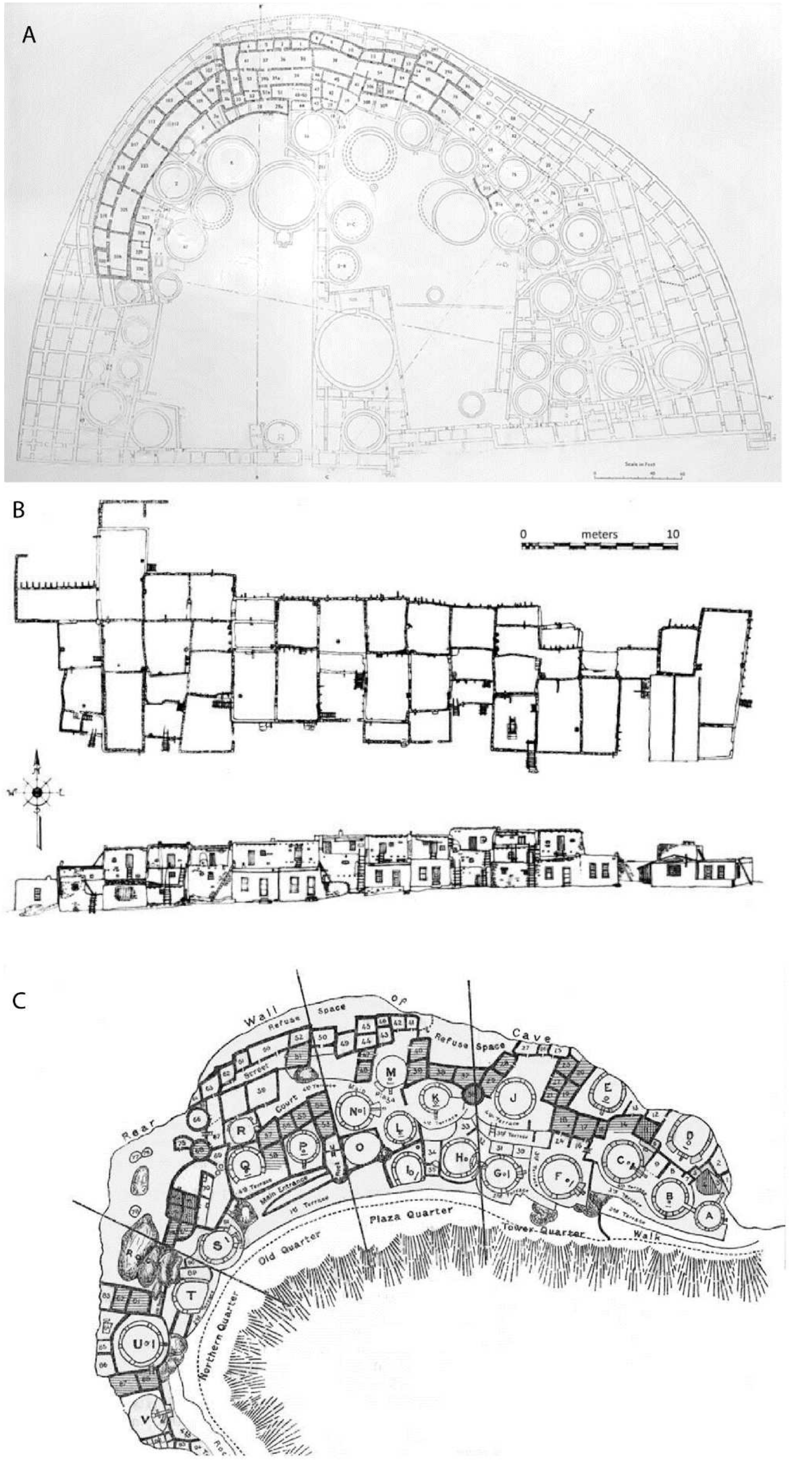

Figure 3.5: Examples of three Southwestern Pueblos: A) Pueblo Bonito (adapted from Judd 1964) B) Acoma Pueblo Sky City (adapted from Smith 2014) C) Mesa Verde Cliff Palace (adapted from NPS R.G. Fuller Survey)

3.4.3. The Zapotec

In the state of Oaxaca, during the height of influence of the Zapotec and Monte Albán, multi-room domestic structures arranged around central patios are commonly built atop architectural terraces due to the hilly nature of the region (Feinman et al. 2007; Feinman and Nicholas 2013; Licon 2003; Rodríguez 2006). Modifying hilltops and constructing architectural terraces began as early as the Middle Formative Period (700-300BC) and continued in popularity up until the Late Postclassic Period (Ad 1200-1500) (Feinman and Nicholas 2013; Kowalewski et al. 2017). These sometimes palatial structures were composed of several rooms adjacent to the sides and corners of a central patio, often times including an underground tomb beneath the patio, and relatively square in overall shape (fig 3.6) (Feinman and Nicholas 2013; Licon 2003). These structures were built on top of terraces and display evidence of multiple phases of rebuilding as the occupation shifts; evidence of rebuilding includes replastering and repair to walls which over time can make the wall thicker (Feinman et al. 2002:265). It is typically interpreted that these residences were occupied by less than a dozen people, likely composing a single family (Licon 2003). Furthermore, these homes were occupied for several generations, as indicated by the burials and tombs commonly found under the floors of the patios and rooms (Feinman and Nicholas 2013; Licon 2003).

Figure 3.6: Elite Residences at El Palmillo in the Ejutla Valley of Oaxaca, outlined in yellow (modified from Feinman and Nicholas 2013)

3.*4.4 Teotihuacan*

Within the Basin of Mexico, Teotihuacan offers up similar structures to the *complejos* we see at Angamuco. These walled, multi-roomed complexes have been considered apartments since their documentation in the 1970s (Millon 1970; Smith 2017). The apartments at Teotihuacan have large, open patios that are encompassed by rooms to form the dwelling (fig. 3.7). Smith (2017) notes that this aligns with the broader Mesoamerican pattern of rooms or dwellings arranged around a patio. However, the "configuration of multiple patio groups enclosed within a continuous outer wall was a Teotihuacan innovation" (Smith 2017:184). These multiple patio groups would have housed dozens of people and in a much smaller footprint than traditional house mounds. Further, the apartments at Teotihuacan are considered to be non-elite homes, rather they are the homes of the common people of the city. The interpretation of class differentiation at Teotihuacan is typically based on the proximity of the dwelling to the Avenue of the Dead and other monumental architecture within the religious/ritual core of the city rather than architectural differentiation.

Figure 3.7: Intermediate-status, or middle social class, apartment style residences at Teotihuacan (adapted from Smith et al 2019)

The apartments at Teotihuacan are often interpreted as housing one lineage or one specific group of craftspeople. Often, the apartment structures at Teotihuacan are used to emphasize the corporate nature of the city, with many immigrants and ethnic groups making up one, highly planned, and highly influential settlement. Thus, while both of the examples of domestic structures share commonalities with the *complejos* at Angamuco (plazas, multiple rooms, shared altar, separation of space from the public via walls), they do not share interpretations on their function with the *complejos* which are seen to be single-family, likely elite, homes in contrast to the multi-family or even multi-lineage homes exhibited at Teotihuacan and Pueblo Bonito.

3.4.5 The Toltec

At the Post Classic site of Tula, the proposed Toltec capital in the modern state of Hidalgo, Mexico, apartments, formal house groups, and apartment groups are all present in addition to the more expected single house unit. These offer some similarities to the *complejo* but, like other regional comparisons, differ in both form and function. The apartment at Tula is a free standing structure that is larger than the single house and contains multiple households; the apartment group is a formal, physically closed arrangement of several apartment structures arranged around a central courtyard. The house group, like the apartment group, is a formally arranged group of singular houses around a central plaza that is physically separated from structures around the group (Santley and Hirth 1993).

The formal grouping of houses or apartments does bear similarities to the walled complejo with the central plaza, altar within the plaza, and physical separation that suggests a public/private divide between those within the group and those outside. However, these individual structures appear to be more reminiscent of the apartments at Teotihuacan than the Angamuco walled complejo, the similarities with Angamuco lie only with the organization of a complex around a plaza and not within the actual organization of the rooms. Further, while Tula has large buildings with plazas that vaguely resemble walled complejos, Williams (2020) interprets these as communal structures that were likely used for feasting and that the whole of Tula “lacks elite structures such as palaces” and only has a few temple-pyramids. When put together, Williams (2020) suggests that the construction choices at Tula emphasize secular activity and corporate leadership, rather than a highly stratified society based around religion-ritual hierarchies (Heabin 2012 in Williams 2020). Therefore, these would be a more appropriate cognate for the apartments at Teotihuacan, the Mesoamerican corporate city model.

CHAPTER 4: METHODS

4.1. Introduction

The preceding chapters have set up a foundational understanding of Angamuco and surrounding archaeological sites with similar architectural types. In this chapter, the methods for identifying and analyzing the walled *complejos* will be outlined. This includes the spatial analysis and geospatial tools used for projection and visualization of the base files as well as the integration of GIS layers from previous work done with the Angamuco data. These layers of data are stacked on top of each other to create a dynamic map for analysis.

4.2. LiDAR Data

The LiDAR data of Angamuco was collected during two flights, one in 2010 and the other in 2015. The first flight encompassed the lower malpaís, or 9 km^2; this scan was flown and processed by Merrick & Company (Fisher et. al 2011; Fisher 2018; Fisher and Leisz 2013). The 2015 scan was flown and processed by the National Center for Airborne Laser Mapping (NCALM) and the University of Houston. This scan covered 35 km^2 to include the entirety of the *malpaís*, its surrounding area as well as the Itzira Ahuacuti *malpaís* to the west of the Angamuco *malpaís* which includes the archaeological site of Urichu (Uricho Viejo) (Fisher 2018; Harris 2019).

The resolutions of the two scans are currently utilized as a combined point cloud dataset. The second flight was projected in WGS-84, but the first flight was not initially projected. The data from the first flight was re-projected by Juan Carlos Fernandez-Diaz from the University of

Houston/NCALM in 2016, which allowed the two point cloud datasets to be merged (Fisher 2018).

4.3 Visualizations

All LiDAR data for this project is initially in point cloud form, and while this is useful for understanding seeing the raw scan of the trees, modern architecture, and the surface it is not ideal for archaeological feature identification. Thus, this data is typically transformed into raster datasets to be easily manipulated in GIS programs such as ArcGIS. The processing of point cloud data into a digital elevation model (DEM) was done in Global Mapper. The .las files (point cloud) were imported and projected in UTM Zone 14N. Next, the point cloud was pared down to only the last returns/ground returns to exclude any points that hit trees, shrubs above the surface; this process is sometimes referred to as digital deforestation. The ‘cleaned’ point cloud is then transformed into a DEM via triangulated irregular network (TIN) and a grid of .25m was manually specified. This file was then exported as a float/grid file to be used with other GIS software. The rest of the visualizations and analysis of the LiDAR data is then derived from this DEM layer.

A slope, or topographic slope, is one of the simplest visualization techniques for geospatial data. To produce a slope raster in ArcGIS, the Slope tool in 3D Analyst is used. This tool identifies the steepness at each cell of a raster surface from the input elevation data. Steepness is determined using a 3 by 3 cell neighborhood that calculates the maximum change in value from each cell to its neighbors. The results are output as a slope raster that displays the steepness of a surface. An example of this can be seen in figure 4.1, box C.

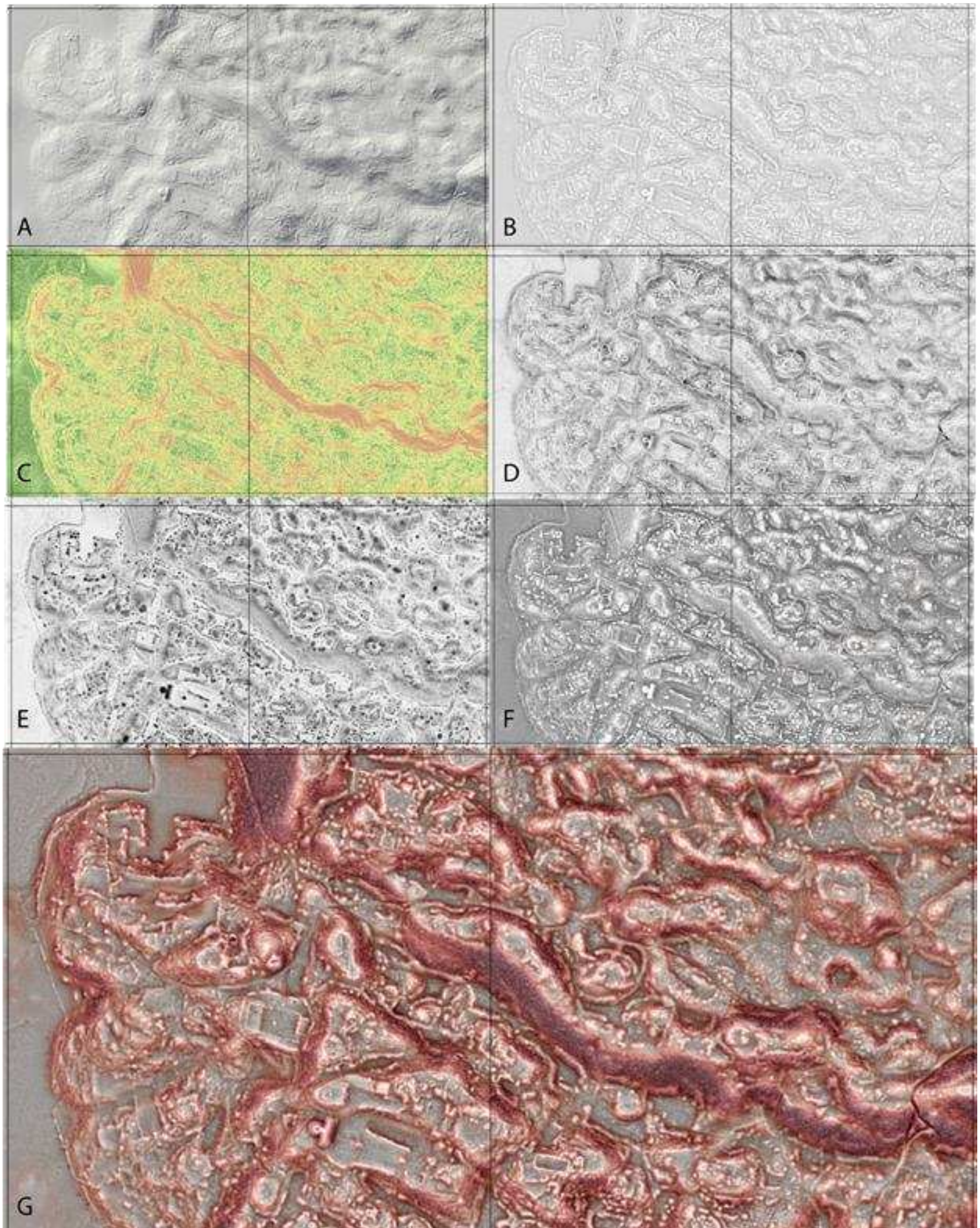

Figure 4.1: Comparison of Visualization Techniques: A) Hillshade++ B) Simple Local Relief Model (SLRM) C) Slope D) Positive Openness E) Negative Openness F) I-Factor G) pseudo-Red Relief Image Map (RRIM) +

A hillshade raster was also used to visualize the LiDAR data for this project. This tool is also within the 3d Analyst toolbox of ArcGIS. Here, elevation is input alongside the chosen azimuth and altitude of the sun the user wants to 'shade' or 'illuminate' the DEM with. The output is a surface that is shaded/illuminated by the sun from that specific azimuth and altitude, thus creating a 3D representation of the surface. An example of the hillshade created with the Angamuco LiDAR data can be seen in figure 4.1, box A.

4.3.1. Pseudo-Red Relief

Red Relief Image Maps (RRIM) were developed to produce a shade-free 3D image without needing any stereopsis or additional devices, thus these maps can effectively highlight both large-scale land features and fine structures simultaneously (Chiba et al. 2008). This method relies on three parameters: positive openness, negative openness, and the aforementioned topographic slope. Positive openness represents the convexity of a surface while negative openness represents the concavity of the surface (Chiba et al 2008). These two parameters are used to set the i-factor, which is defined as:

$$I = (O_p - O_n)/2$$

where O_p is positive openness and O_n is negative openness (Chiba et al. 2008). To complete the RRIM, i-factor is displayed in a greyscale color ramp with a topographic slope layer displayed in a red color ramp.

Using the Relief Visualization Toolbox (RVT) developed by Zakšek et al. (2011), the DEM was imported as a .tiff file and positive and negative openness were built. These layers were then imported into ArcGIS. The i-factor layer is then built using Spatial Analyst toolbox and the Raster Calculator tool. The i-factor is layered at 50% transparency over an aforementioned slope raster that is displayed in a red color ramp. The two layers together thus create a pseudo-RRIM.

As the LiDAR data can only display what is visible above ground, there will be archaeological features that cannot be seen remotely and would require excavation to be observed. Approaching LiDAR data from many directions with differing visualization techniques is our best way at present to gain as much information as possible from this data for archaeological research.

4.4. Tiles/Areas selected for Investigation

This project is focused on the investigation of walled architectural compounds at the site of Angamuco. As previously discussed, other theses from the LORE-LPB project have focused on architecture and its relative clustering or patterning at the site. Thus, this thesis will build upon their work to understand the specific architectural feature type of the walled complejo. Furthermore, the work from these theses will be implemented into the investigation process for this thesis as they have annotated and outlined architectural features across the site which are influential on our understanding of the walled complejos.

Shapefiles from Urquhart (2015) will provide the basic polygons of architectural clustering at the site; these are object-based image analysis (OBIA) derived polygons that identify architectural clusters across the site. The shapefile layers for main roads, huatziri (raised roads), and pyramids will be utilized to further annotated the site for visual interpretation of architecture (Friedl 2019; Solinis-Casparius 2019).

The investigation of walled complexes will be focused on the presence/absence of these architectural types within the Urquhart (2015) architectural clusters. Once presence/absence is noted, additional features of the walled complex will be measured and described. To perform an unbiased sample of the complejo polygons from Urquhart (2015), the Ferguson (2011) Random Features toolbox was implemented to select 100 from the 756 Urquhart polygons. The resulting selection created a new GIS layer which was then the basis of analysis, see figure 4.2 below.

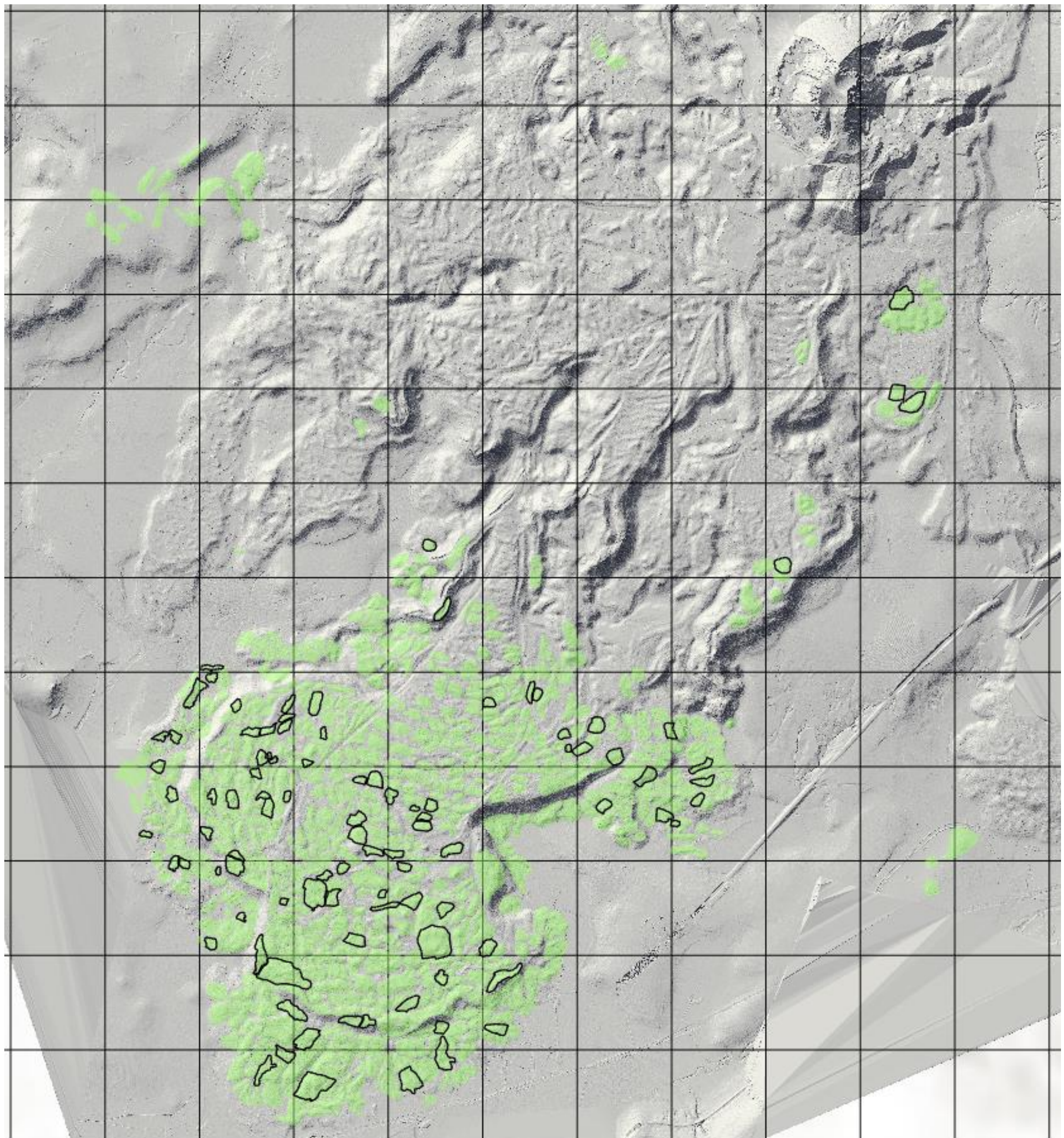

Figure 4.2:Selected complejo units from Random Features toolbox outlined in black, displayed over a hillshade and 500m gridlines

4.5 Identification of complejos

For each of the randomly selected complejos, analytical checklist was used to note if the complejo included a walled complex using five features that define that architectural type. Those features are as follows:

1. Presence of enclosure walls
2. Multiple-room complexes (*edificios compuestos)*
3. Contains a central plaza
4. Altar within the central plaza
5. Relatively close to monumental architecture (i.e. main or raised roads, pyramids)

Each parameter for a walled complejos was given a quantifiable feature to be measured and compiled for this investigation. Those quantitative factors were based on the Angamuco Architectural Typology (Fisher et al. 2019) and will be explained further after the architectural typology is detailed as it forms the basis for our understanding of these archaeological forms identified in the LiDAR data.

4.5.1 Analytical Checklist

Each of the components that define a walled complex were associated with a feature that was quantified, measured or counted, during the identification phase. The analytical checklist was as follows:

1. Thickness of walls (m)
2. Diameter of complejos (longest axis)
3. Area of complejos (m^2)
4. Number of rooms (count)
5. Altar size (m), relative location (cardinal direction)
6. Size of plaza (m^2)
7. Distance to monumental areas (m)

These features were identified visually, quantified, and then added to an excel sheet. The excel sheet was then exported as a csv and a join was performed to link the information directly to the shapefile for future work.

Thickness of the walls was estimated with the measure tool in ArcGIS. This was taken at three locations around the walled complejo and the middle value was taken as the width of the wall. Diameter was similarly taken with the measure tool in ArcGIS. Instead of three measurements, it was taken from multiple points depending on the shape to determine the longest possible axis for the walled complejos. The area was automatically calculated by ArcGIS when the polygon was created as they were polygon Z types. This automatic area was used in the checklist as the complejos total area.

Utilizing the previously outlined architectural typology flowchart, the number of ground level buildings and above ground building platforms were counted to determine number of rooms. The resolution of the data allowed for some of these features to be identified further and to be placed into more specific subtypes but this was not possible for the majority of architectural features within the walled complejos.

The altars and plazas were measured when they were clearly visible. Plazas were counted as the main levelled open space within a complejos, typically being the only one, and area was taken using the measure tool from ArcGIS in square meters. The altars were identified as mounds within these plazas and their width was measured in meters. The relative location within the plaza was also recorded for the altars, given in cardinal direction.

Distance to monumental architecture was measured from the outside walls to the polygon or polyline of pyramids, main roads, and *huatziri*. Both the main roads file and the *huatziri* are shapefiles from the work of Solinis-Casparius (2019). Distance was measured as a straight line distance from the nearest point on the walled complejo to the nearest point on the monumental architecture polygon. In the case of complejos near multiple sections of roads and *huatziri,* distance to all was measured and taken into account. There are at least 26 pyramids at the site of

Angamuco (Friedl 2019). Distance from the outside wall of a walled complejo to the nearest edge of the pyramid was taken with Euclidean distance through the measure tool. If multiple pyramids appeared to be similarly close to the walled complejos, all were measured but the smallest distance was used for the summary statistics of the sample. Pyramids are the largest and also clearest monumental architecture at the site, so the distance to the nearest pyramid was used as the measurement for this parameter; when a walled complejo was within a close distance to multiple pyramids, the additional measurements were recorded in the database comments.

Initial investigations resulted in all walled complejos falling within 300m of a pyramid. To clarify if this was due to the relative spread of the pyramids or due to potential clustering of walled complejos near monumental architecture, two buffers were performed on the pyramid polygons. The initial buffer of 300m was created to visualize the potential clustering of the walled complejos around the locations of the pyramids (fig. 4.3). Upon inspection of this buffer, a 500m buffer was created to investigate if these pyramids were semi-regularly spaced across the ancient city (fig 4.4).

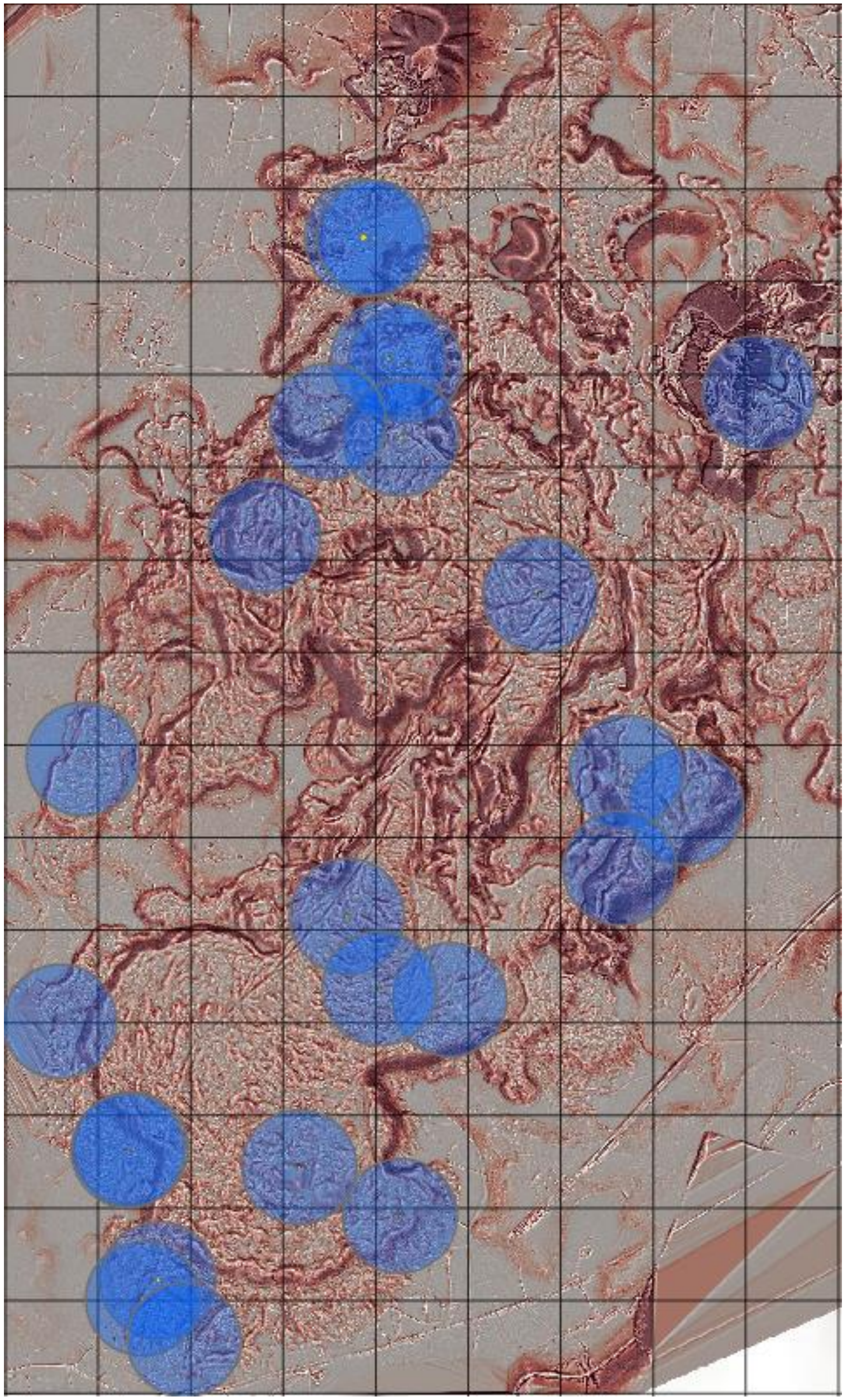

Figure 4.3:300 meter buffers with Friedl (2019) pyramids as center points, displayed over pseudo-RRIM+

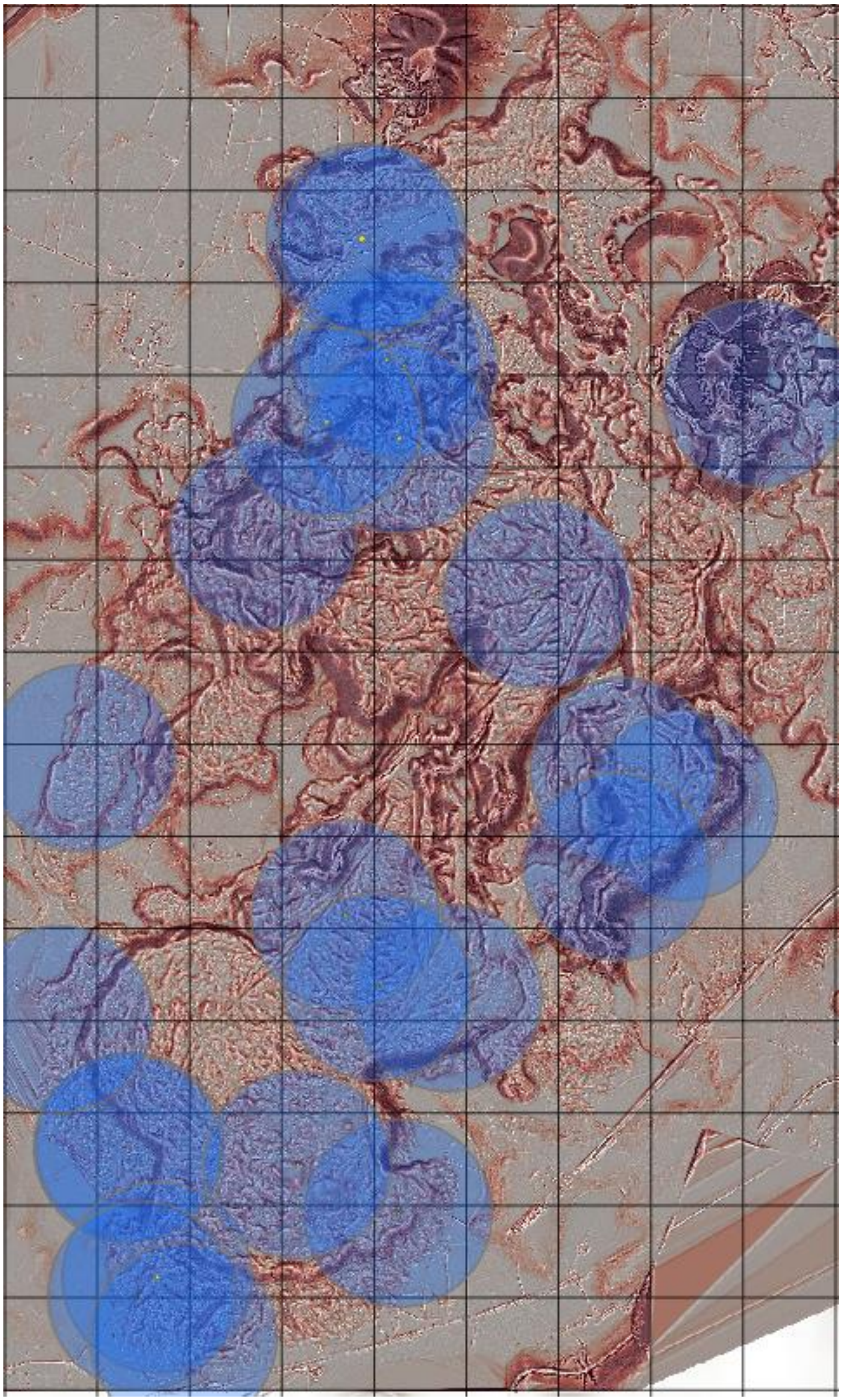

Figure 4.4: 500m buffers with Friedl (2019) pyramids as center points, displayed over pseudo-RRIM⁺

The spread of the 500m buffers covered the lower malpaís almost entirely, leaving only one area to the center west uncovered (fig. 4.5). Upon investigation of this uncovered area, a large modified hilltop with a grand side-staircase was seen. This modified hilltop matches the typical measurements of a rectilinear pyramid at Angamuco, around 30m by 50m. Furthermore, the staircase connects the monumental architecture directly to the main road below. Considering these details and consultation with the project director, Dr. Christopher Fisher, this monumental architecture was determined to be a potential rectilinear pyramid (fig. 4.6).

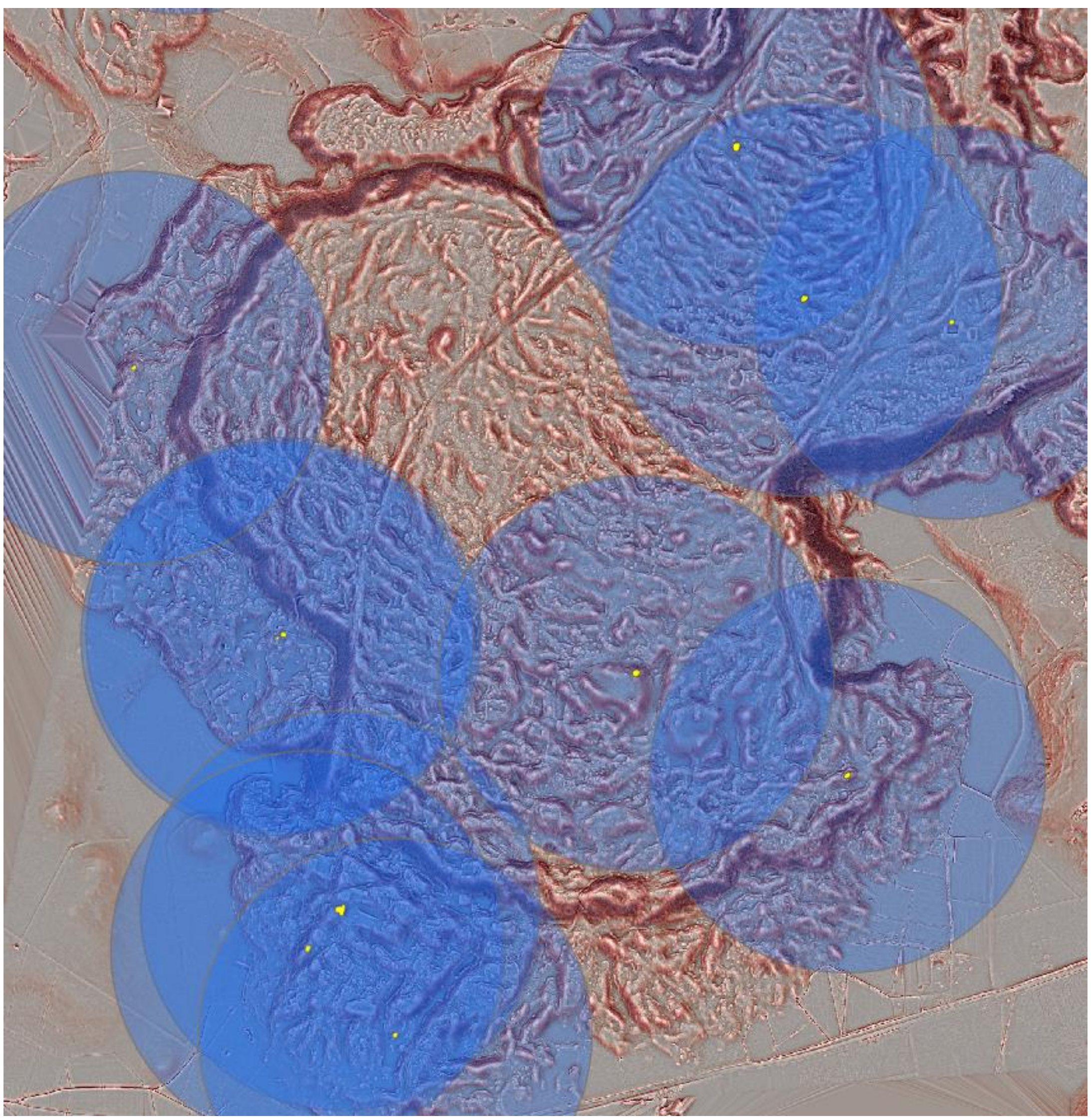

Figure 4.5: 500m buffers on lower malpaís, illustrating the spread of pyramids (Friedl 2019) and the area of the lower malpaís that is not covered by the buffers; displayed over pseudo-RRIM⁺

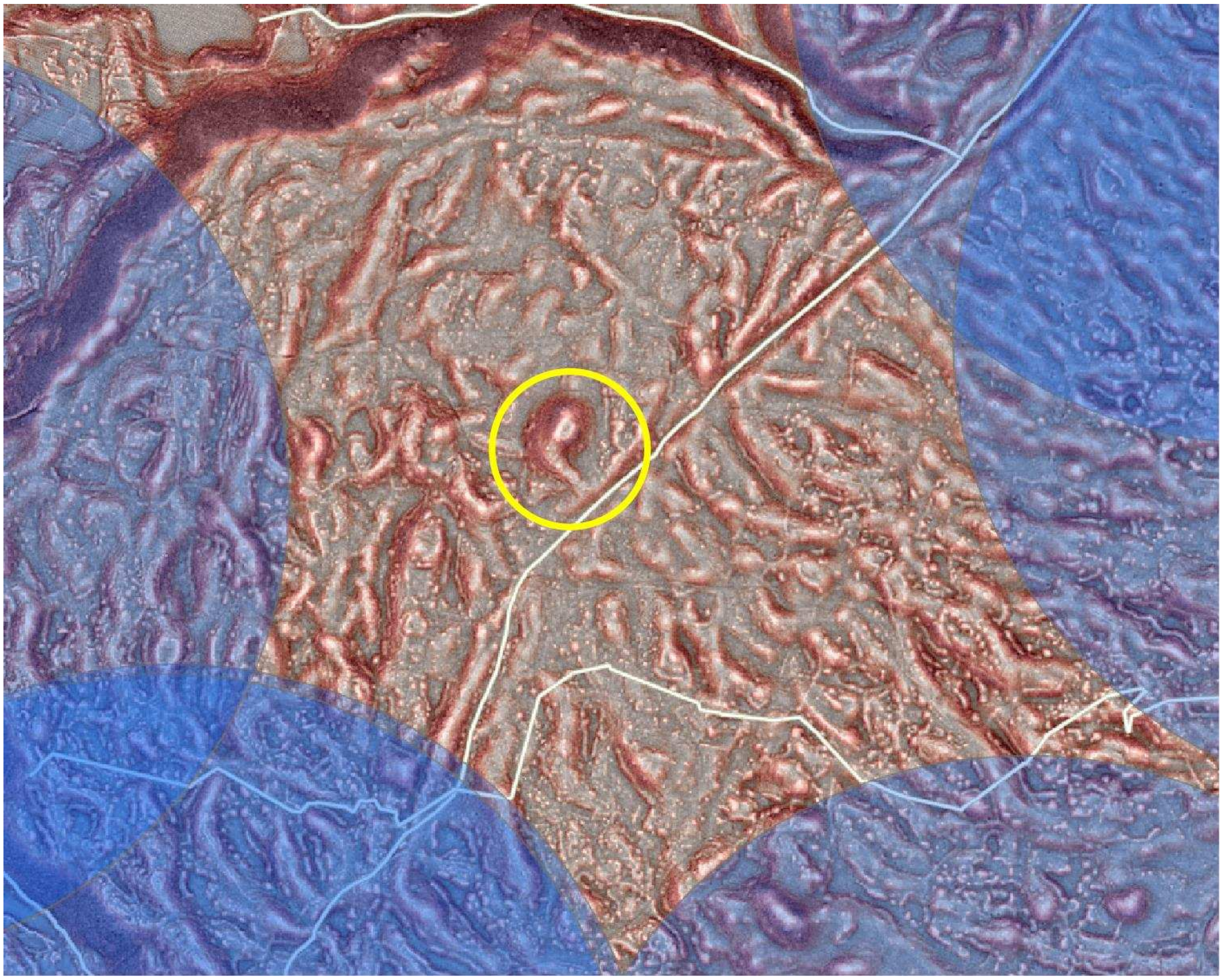

Figure 4.6: New potential pyramid circled in yellow, visualized with pseudo-RRIM$^+$ and main roads in white from Solinis-Casparius (2019)

The new potential pyramid was buffered at 300 and 500 meters to visualize its location in relation to the other pyramids at the site as well as to see the spatial patterning of all pyramids at the site. The 500 meter buffer of the new potential pyramid fit within the buffers of the Friedl (2019) pyramids to completely encompass the lower malpaís of the site (fig 4.7).

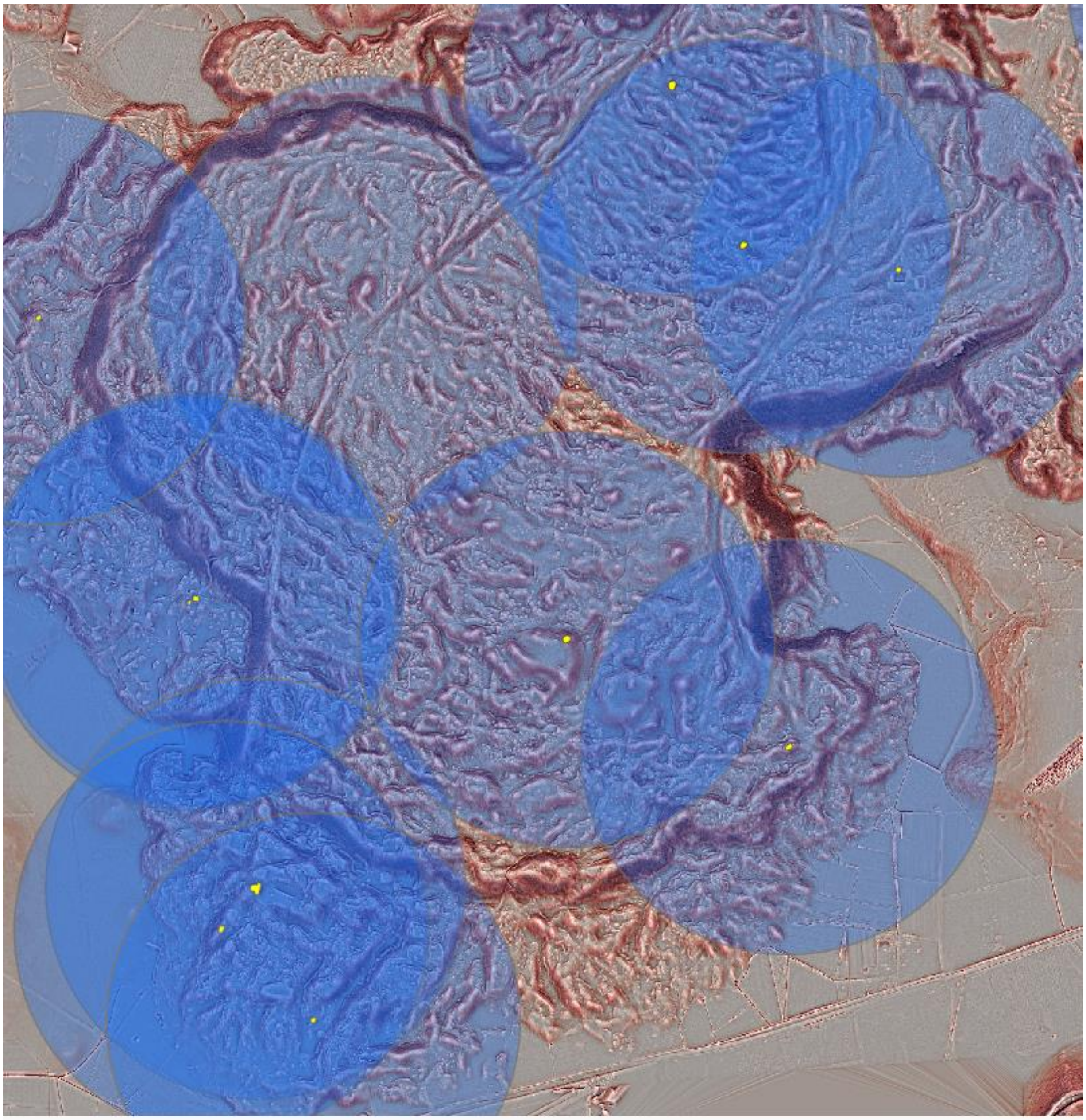

Figure 4.7: Lower malpaís with both the new pyramid and the Friedl (2019) pyramids buffered at 500m over a pseudo-RRIM⁺

4.6 Digital Test Pits

Beyond the random sample of the Urquhart (2015) polygons, I conducted ten “test pit units” which were placed around the site in areas that were missed in the random sample. An area could have been missed in the sample due to the lack of polygons in that location as not all theses from the LORE-LPB project have investigated the entire malpaís, or had polygons but were missed because of the random sampling. These selected grid squares, or test pits, are shown in figure 4.8 below. A test pit unit in this context is defined as 500m grid squares, which means these test pits expand the surveyed/analyzed area an additional 5km^2.

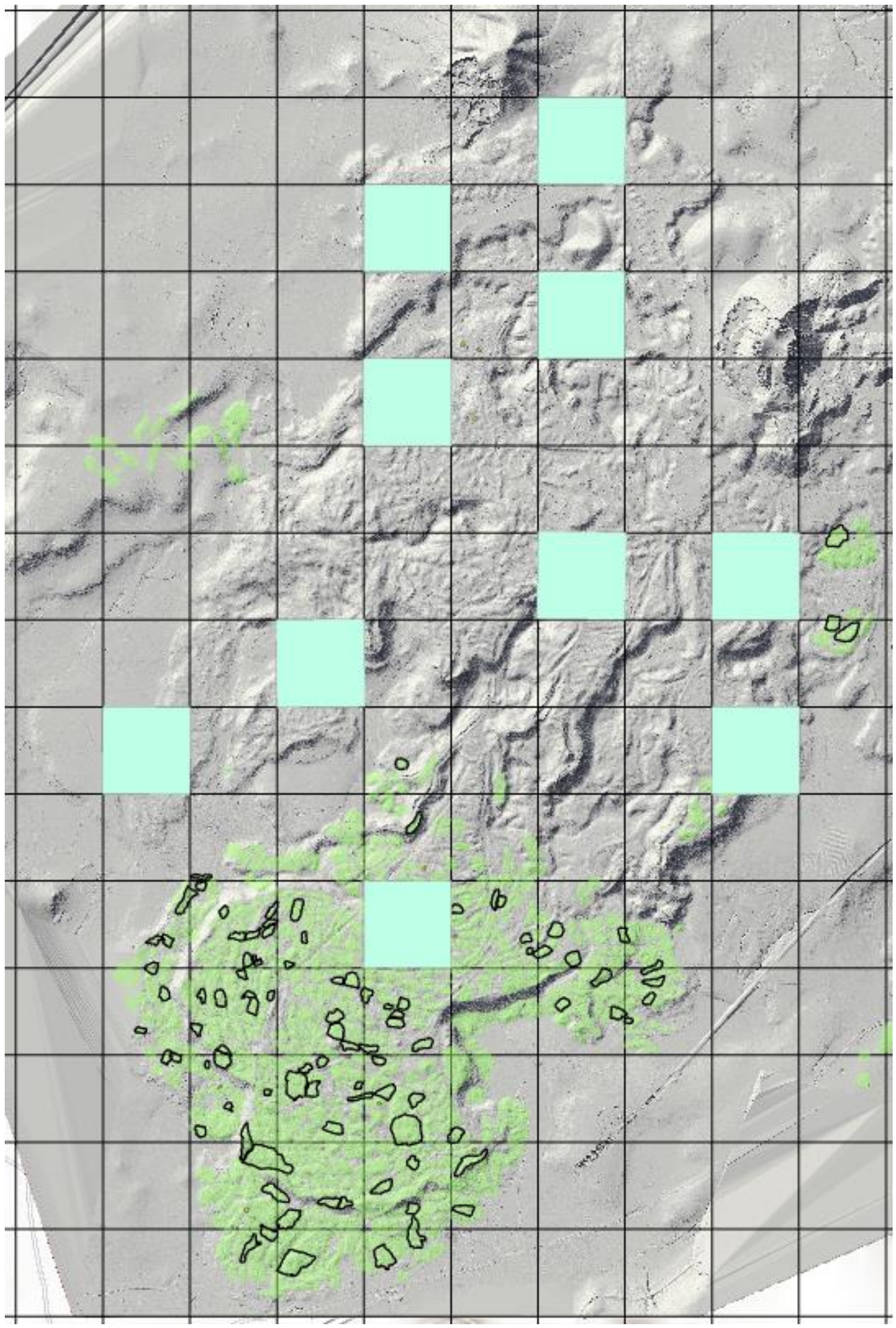

Figure 4.8: Digital test pits shown in teal squares overlain on the green Urquhart (2015) complejos and the outlined in black randomly selected polygons, shown over a hillshade++ of Angamuco

The process for investigating each test pit was to first identify if there were any complejos polygons from Urquhart (2015). If these were present, each polygon was assessed using the aforementioned checklist to determine if a walled complejos was present, then measured accordingly and annotated. After these were completed, or if there were none present, the entire tile was inspected to locate any walled complejos. If walled complejos were found, they were again annotated and analyzed using the analytical checklist. These measurements were input into a spreadsheet alongside qualitative descriptions of the walled complejo.

4.7. Fisher Complejos

In addition to the random sampling of Urquhart (2015) architecture clusters and the digital test pits of grid squares, this investigation also utilized expert-derived shapefile of known walled complejos. This shapefile was created and annotated by the project director, Dr. Chris Fisher, of walled complejos that are known from field survey and excavations at the site. This shapefile is not an exhaustive annotation of *all* known walled complejos but rather a selection of those that were easily accessible. These complejos are thus known from both formal and informal survey of the site during multiple field seasons at Angamuco.

The architecture in this sample are unique to the other two samples, as they are ground-verified walled complejos. Therefore this sample does not include the investigation into whether or not a cluster is a walled complejo, but rather is focused on the quantitative checklist described earlier in this chapter to measure these forms. The measurements will be taken in the same fashion as the two previously described samples and will similarly be recorded into a spreadsheet alongside qualitative descriptions.

4.8 Conclusions

This chapter presented the methodological approach taken in this thesis. Three separate samples will be investigated using the same parameters. These investigations will utilize LiDAR data and multiple visualization methods to best interpret the persisting above-ground built environment at Angamuco. The interpretations of architecture gleaned from these observational investigations will be measured following a checklist of eight parameters and will be input into a database for later comparative analysis; these results will be detailed in the following chapter.

CHAPTER 5: RESULTS

5.1 Introduction

This chapter will describe the findings of the investigation for this thesis. As previously mentioned, the investigation undertaken was focused on the analysis and annotation of the LiDAR data through a random sampling of the polygon shapefiles from Urquhart (2015) alongside other architectural shapefiles from Solinis-Casparius (2019) and Friedl (2019). In addition to this sample, digital test pits were conducted across ten 500m^2 grid squares to catch portions of the site that were not included in the work of Urquhart (2015). Furthermore, a small sample of known walled complejos were identified by project director, Dr. Christopher Fisher, and these polygons were analyzed alongside the other two sample groups. Results of each investigation will be presented individually and compared against each other in the final section of this chapter.

5.2 Random Sample Results

The random sample of Urquhart (2015) polygons analyzed 100 polygons. The randomly selected polygons were evaluated using the analytical checklist described in section 4.4.2 in the previous chapter. These polygons were spread across 30 500m-grid squares of the site. During analysis of the selected polygons, when a walled complejos was found it was measured and notes were taken within a spreadsheet document. This sample identified 44 walled complejos across 41 polygons; there were 59 polygons analyzed that did not contain a walled complejo (fig 5.1). From the recorded measurements, summary statistics were calculated and compiled into table 5.1, seen below.

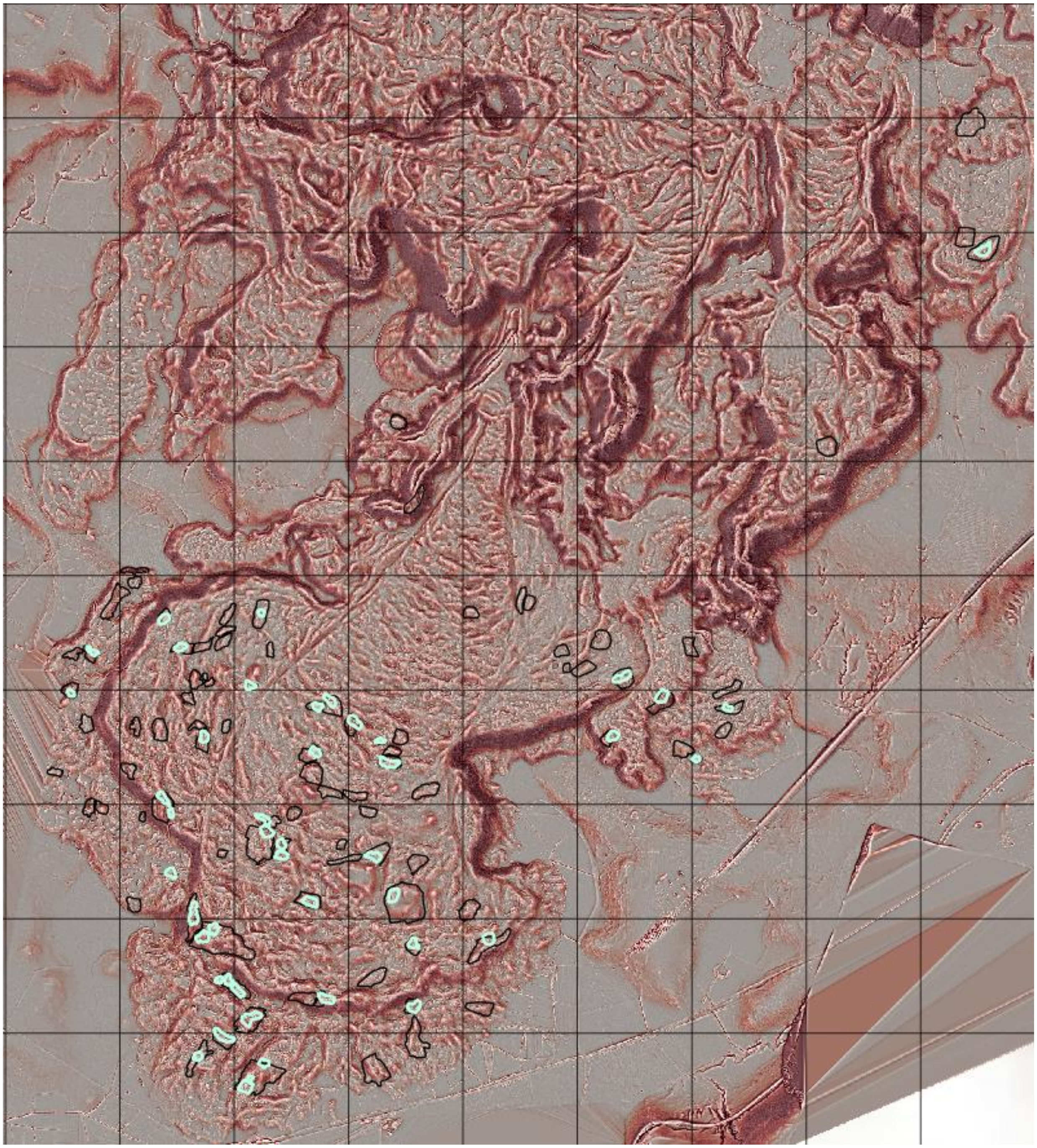

Figure 5.1: Annotated walled complejos in cyan and black outlined selected polygons displayed over pseudo-RRIM⁺ and 500m gridlines

Table 5.1: Summary statistics for random sample analysis of Urquhart (2015) architectural cluster polygons

	Minimum	Average	Maximum
Area (m2)	452.54	1493.03	2785.60
Longest Axis (m)	30.46	59.21	101.18
Wall Width (m)	1.99	3.16	5.0
Altar length (m)	2.11	3.52	6.59
Plaza Area (m2)	26.05	115.68	287.0
Rooms (#)	3	8.23	22
Distance to Mon. (m)	1.62	309.85	922.21

The average area of the walled complejos in this sample was 1493.03m^2, with the largest being 2785.6m^2 and the smallest at 452.54m^2. The average longest axis for a complejos was 59.21 m; the longest diameter for a walled complejo was 101.18 and the shortest was 30.46m. The wall width average was 3.16m, with a range from 1.99m to 5m. When available to be measured, the plaza area averaged 115.68m^2 with an average altar of 3.52m located within. Room number was similarly difficult to count, but when visible it was counted to average a room number of 8.23. The walled complejos were on average 309.85m, via Euclidean distance, from a pyramid.

5.3 Digital Test Pit Results

Within the ten 500m^2 grid squares analyzed, 15 complejos across five squares were identified (fig. 5.2). Almost half of these walled complejos were in a single grid square, AK75, which is located on the northern edge of the main malpaís of the site. The test pits included 44 of the Urquhart (2015) architectural cluster polygons, all of which were investigated to determine if they contained a walled complex. Furthermore, six pyramids from Friedl (2019) were located within the 10 test pits.

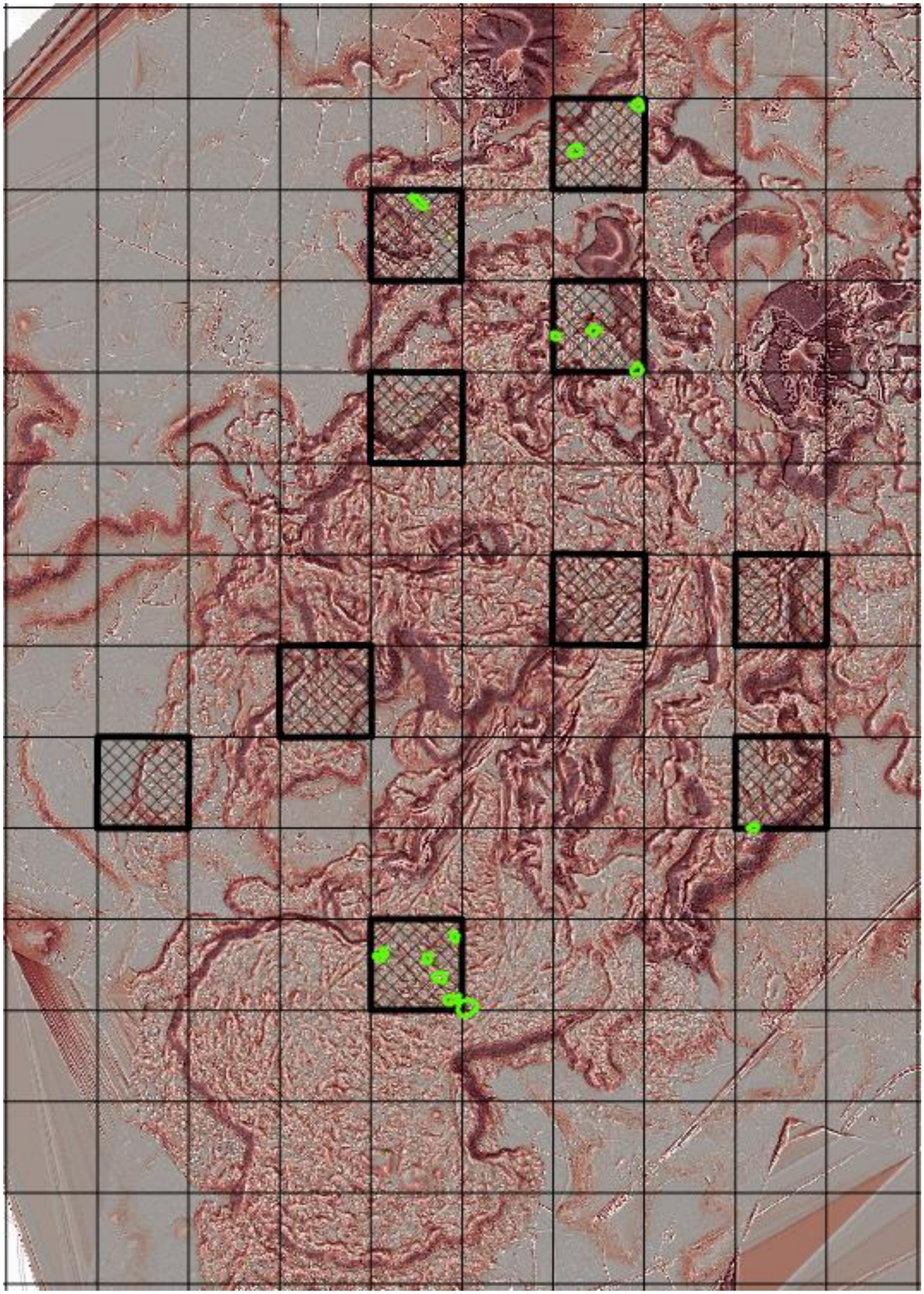

Figure 5.2: Annotated test pit walled complejos in bright green with the test pit grid square units in black cross hatching, displayed over pseudo-RRIM^{+}

The summary statistics recorded for this sample are displayed in the table below, table 5.2. The average area of the complejos identified within the test pit units was 2480.43m^2, with total areas ranging from 1150m to 6981m across the sample. The longest axis in the sample was 103.24m, with the average axis length measuring 71.04m. Wall width measurements were largely similar to those in the random sample, with the average width recorded at 3.33m.When clearly visible, plaza and altar measurements were taken; these averaged at 209.82m^2 and 3.65m, respectively. Room number averaged 10.2 rooms, with the most rooms in a single walled complejo recorded at 16. The average distance to monumental architecture, i.e. yacatas, rectilinear pyramids, and their associated plazas, was 463.70m. The furthest distance to monumental architecture from a walled complex in this sample was 1226.23m, with the nearest distance at 98.0m.

Table 5.2: Summary statistics for test pit walled complejo analysis

	Minimum	**Average**	**Maximum**
Area (m2)	1150.38	2480.43	6981.83
Longest Axis (m)	45.98	71.04	103.24
Wall Width (m)	2.27	3.33	4.92
Altar length (m)	3.24	3.65	4.05
Plaza Area (m2)	97.89	209.82	324.75
Rooms (#)	4	10.2	16
Distance to Mon. (m)	98.0	463.70	1226.23

5.4 Fisher Complejo Findings

This sample is comprised of polygons outlined by the project director of known walled complejos from formal and informal surveys of Angamuco during excavation seasons. These polygons are displayed in yellow over the RRIM in figure 5.3 below. Two of these polygons overlapped with Urquhart (2015) polygons random sample. These complejos tended to be larger and towards the south of the site, due to the observation bias of archaeological field survey staying in the lower sections of the city.

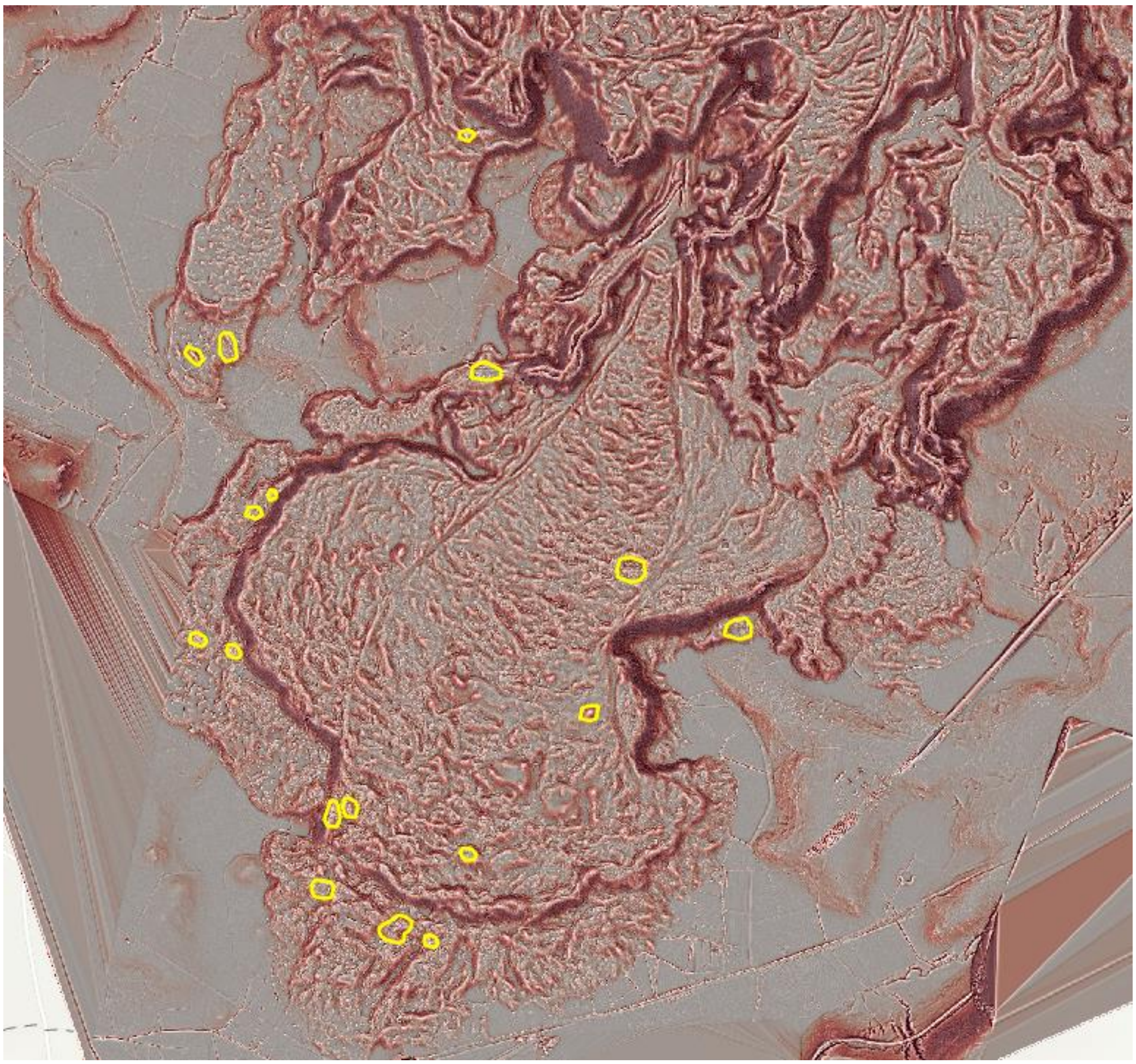

Figure 5.3: Annotated walled complejos from Fisher in yellow, over a pseudo-RRIM$^+$ of the lower malpaís

This sample was comprised of 17 polygons in the southern portion of the LiDAR data. These polygons were investigated following the analytical checklist outlined in section 4.4.1 in this thesis. The summary statistics for this sample are displayed in table 5.3 below. The average area of these walled complexes was 2720.06m^2; the range of areas for the walled complexes in this sample was 822.2m^2 to 6981.83m^2. Walls in this sample ranged from 1.95m to 3.57m wide, with the average at 2.79m. The longest axis in the sample was 111.95m long, with the average at 71.44m long. Plaza area averaged at 243.88m^2 and the average altar was 3.96m long. The range of plaza areas was large, spanning 835.57m^2 between the largest and the smallest recorded plazas in the sample. Room counts ranged from 4 to 18, with the average at 8.33 rooms. Distance to monumental architecture averaged at 327.65m of Euclidean distance; the shortest distance between a walled complejos and a pyramid in this sample was 65.61m and the longest distance was 847.41m.

Table 5.3: Summary statistics for parameter measurements of Fisher walled complejos

	Minimum	**Average**	**Maximum**
Area (m^2)	822.2	2720.06	6981.83
Longest Axis (m)	41.46	71.44	111.95
Wall Width (m)	1.95	2.79	3.57
Altar length (m)	2.82	3.96	5.48
Plaza Area (m^2)	37.37	243.88	872.94
Rooms (#)	4	8.33	18
Distance to Mon. (m)	65.61	327.65	847.41

5.5 Overall Findings

The three samples investigated architecture in 44 grid squares, or 2.2 hectares of the site. The randomly selected polygons were located in every grid square except two on the lower malpaís; the two grid squares not included were covered in the digital test pit and Fisher complejos to completely cover the lower malpaís with analysis. Figure 5.4 below displays the annotations from all three samples together: the cyan and lack outlines from the randomly selected Urquhart (2015), bright green polygons and black crosshatched grid squares for the test pits, and yellow polygons from the Fisher sample.

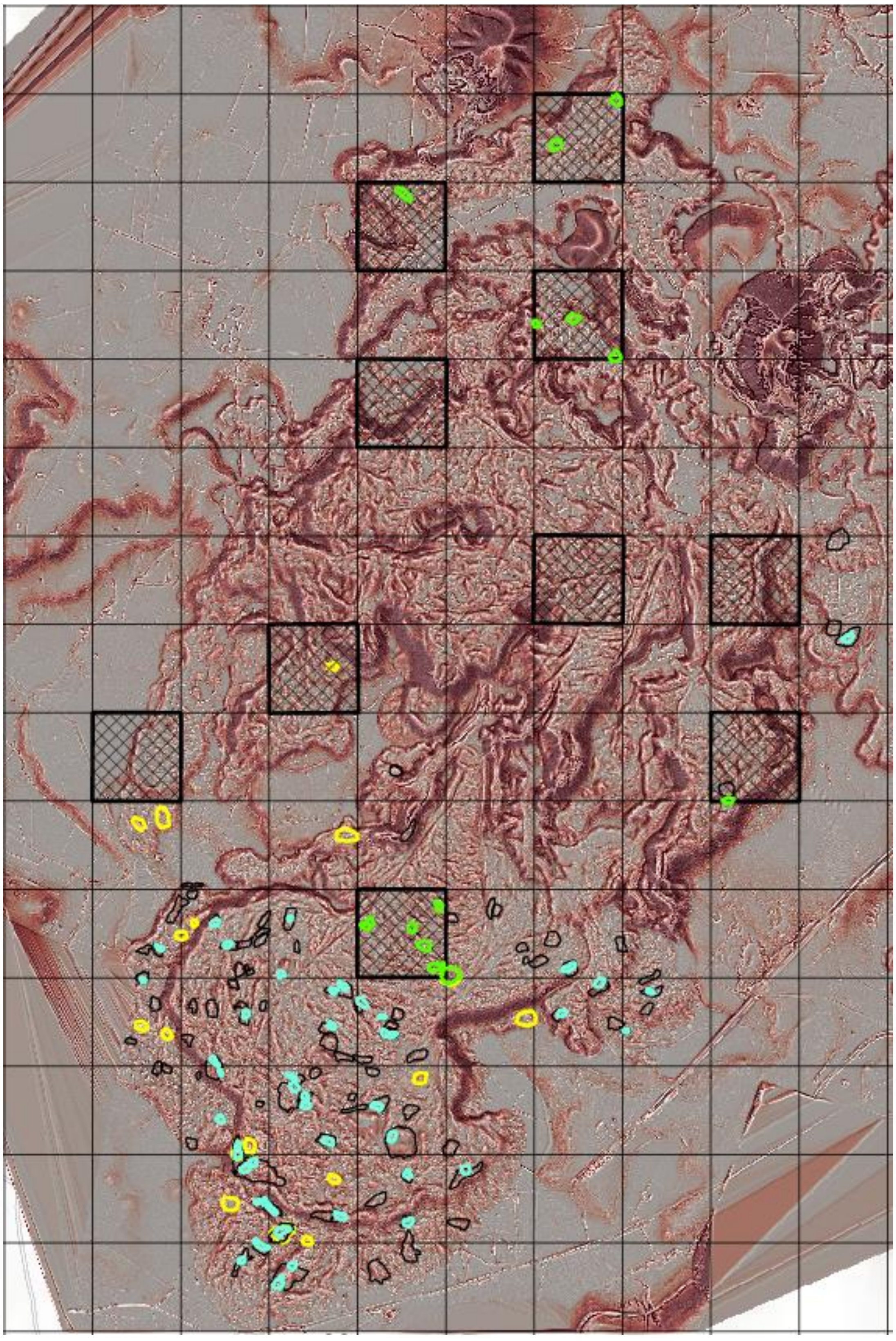

Figure 5. 4: pseudo-RRIM^{+} of Angamuco displaying all three complejo samples: random sample walled complejos in cyan, selected random polygons outlined in black,, test pit walled complejos in bright green, selected test pit grid squares hatched, and Fisher polygons in yellow

The data from each of the samples were compiled into a comprehensive spreadsheet and summary statistics were calculated. This was done from the raw data of each walled complejo rather than from the summary statistics of each sample to give each walled complejo equal weight in the calculations. Furthermore, any duplicates between the samples were removed so the polygons were only counted once in the averages. These data are displayed in table 5.4 below, alongside the averages from each of the three samples. Compiling the data brought the average area of walled complexes to 1875.24m and longest axis to 63.47m. The compiled wall width average was 3.12m. Plaza area averaged to 158.57m^2 when all samples were included, and altars averages to 3.62m. With all complejos included in the data, room number averaged to 8.32. Distance to monumental architecture averaged to 347.81m across all walled complejos measured for this investigation. Furthermore, histograms were created of each variable to visualize the spread of the data across the compiled sample set (figs 5.5-5.8).

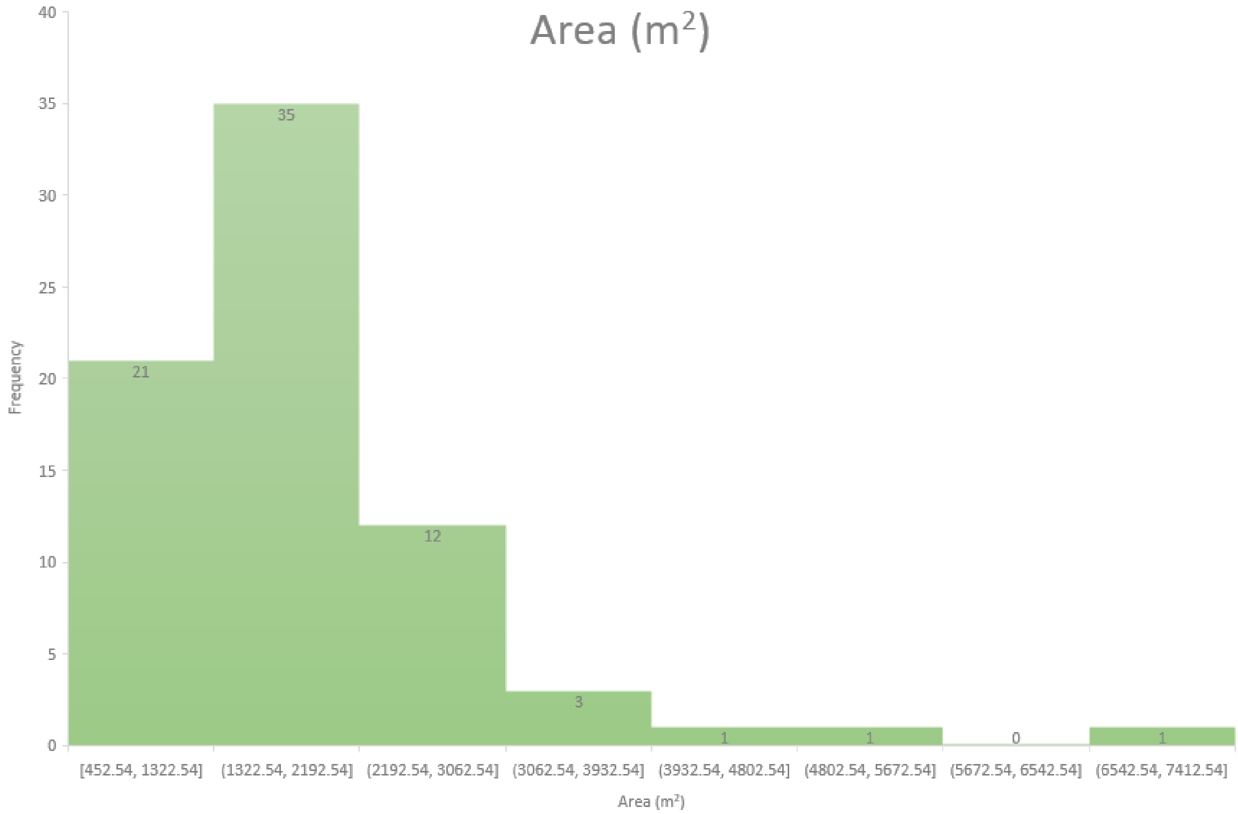

Figure 5.5: Histogram displaying the area of walled complejos (m2) for the compiled walled complejo dataset

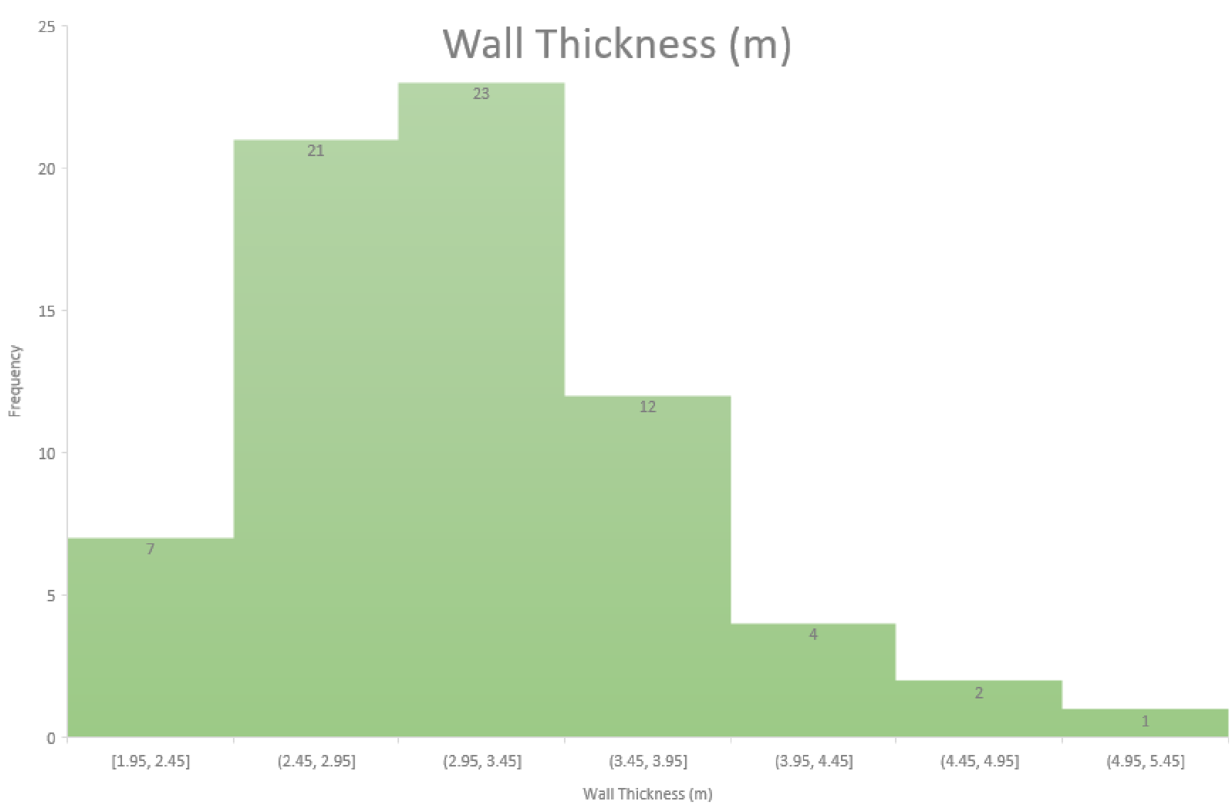

Figure 5.6: Histogram of wall thickness measurements (m) for compiled walled complejo dataset

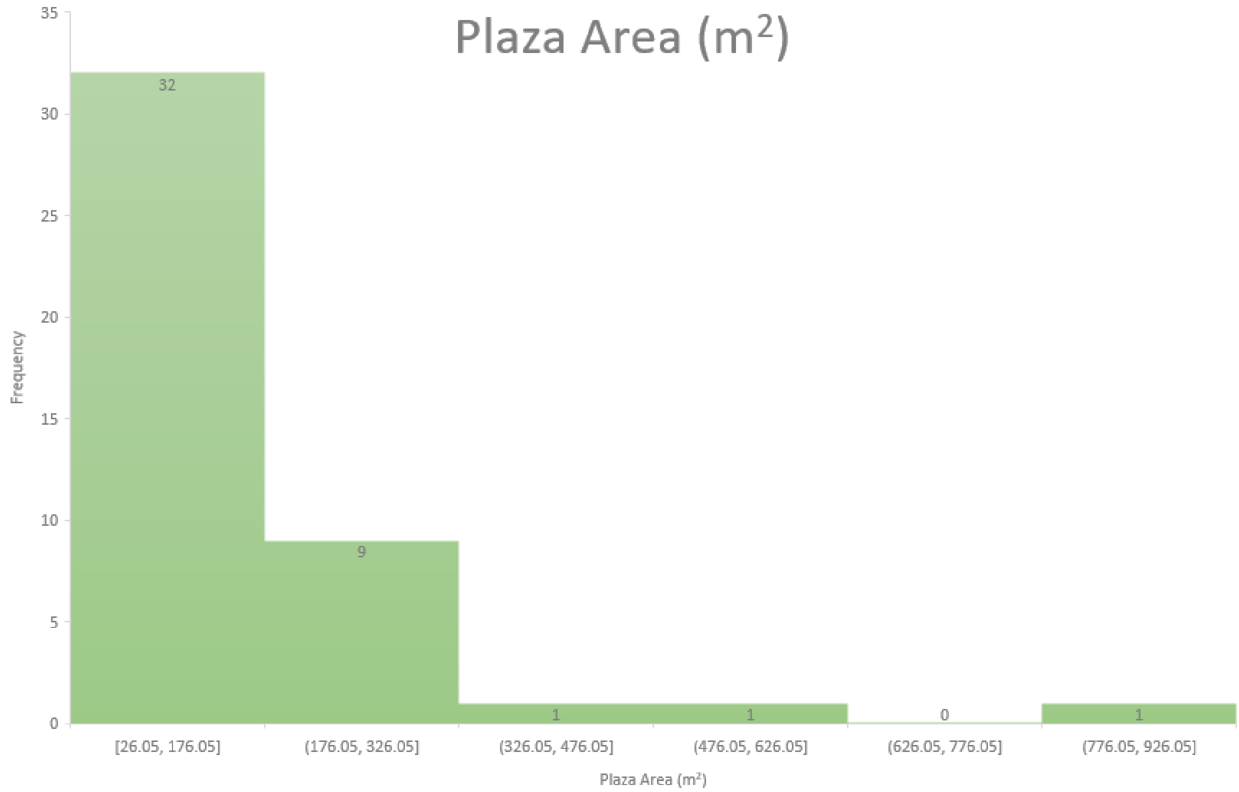

Figure 5.7: Histogram of plaza areas of compiled walled complejo dataset

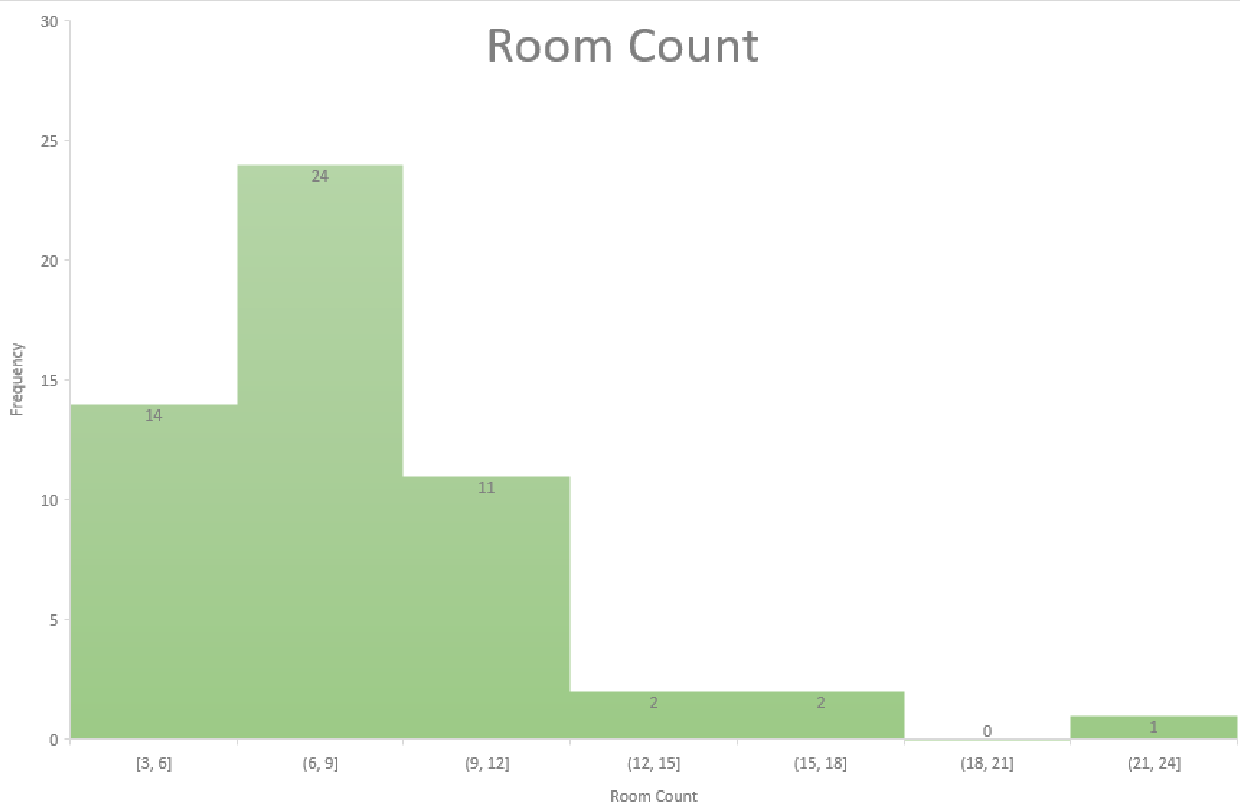

Figure 5.8: Histogram of room counts for the compiled walled complejo dataset

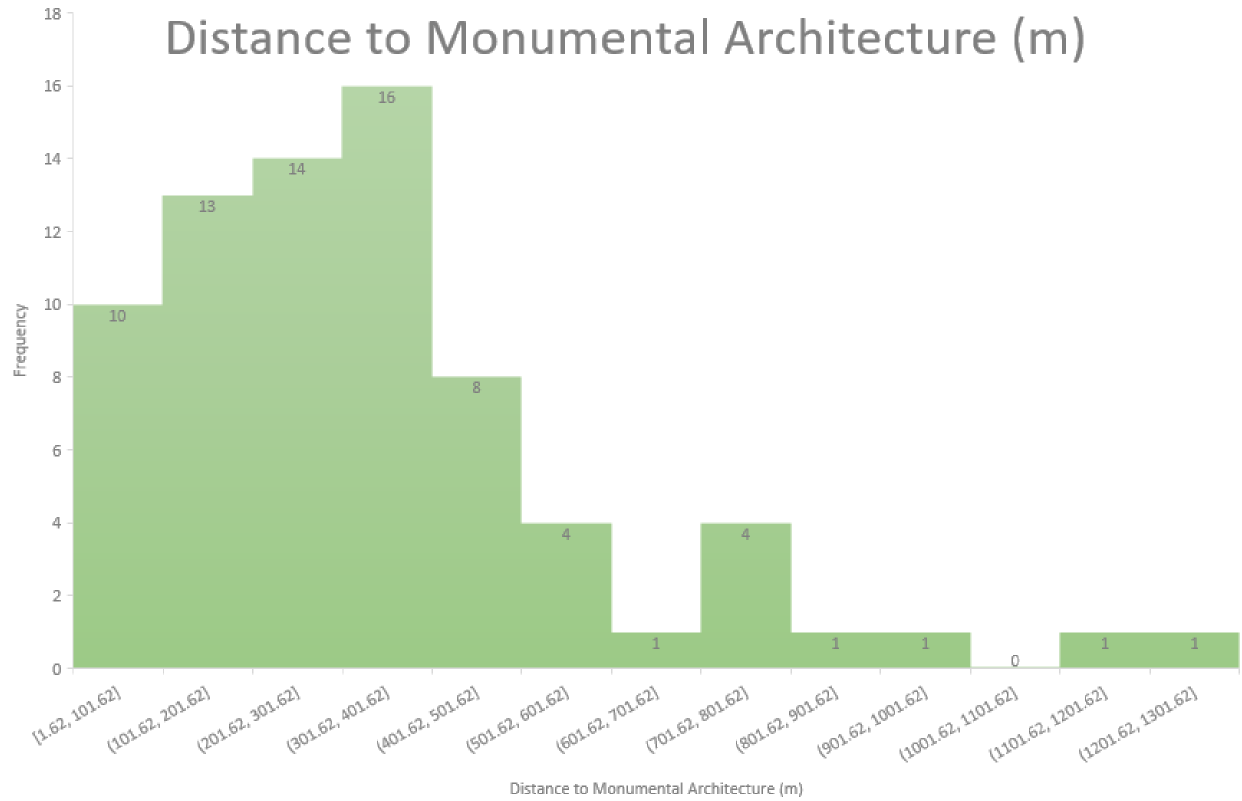

Figure 5.9: Histogram of distance to monumental architecture measurements for the compiled walled complejo dataset

Table 5.4: Parameter averages for each of the three aforementioned samples and compiled averages

	Random Sample	**Test Pits**	**Chris Complejos**	**Compiled**
n	n = 44	n = 14	n = 17	n=73
Area (m^2)	1527.15	2480.43	4300.75	1875.24
Longest Axis (m)	59.19	71.04	71.44	63.47
Wall Width (m)	3.17	3.33	2.79	3.12
Altar length (m)	3.52	3.65	3.96	3.62
Plaza Area (m^2)	121.89	209.82	243.88	158.57
Rooms (#)	8.14	10.2	8.33	8.32
Distance to Mon. (m)	297.62	463.70	327.65	347.81

5.5.2 Hot Spot Analysis

A hot spot analysis (Getis-Ord Gi*) was calculated for each parameter visualize any potential clustering of the walled complejos based on the different traits measured. Three of the hot spot analyses provided inconclusive results, where neither hot nor cold spots were identified. These parameters were: diameter, plaza area, and altar size.

Hot spot analysis for the total area of each walled complejo revealed a hot spot (red), indicating a clustering of larger polygons, on the eastern side of the lower malpaís (fig. 5.5) Furthermore, this analysis identified a cold spot, a clustering of smaller polygons shown in blue, on the western side of the malpaís. The center of the lower malpaís did not have a hot or cold spot, indicating no significant clustering based on size in this area. The hot spot analysis for room number similarly showed a hot spot on the east and a cold spot on the west, but to a less significant degree (fig. 5.6)

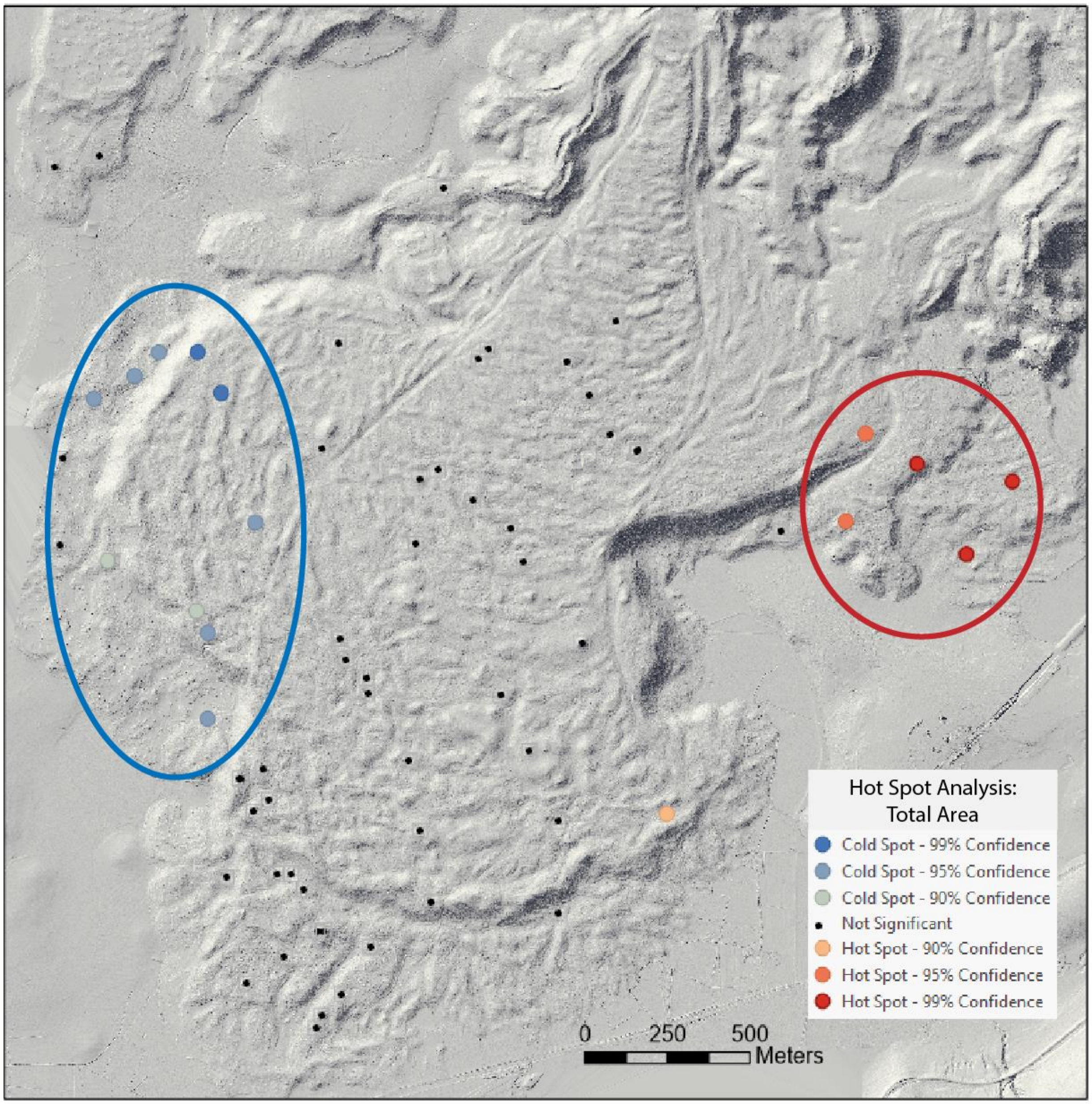

Figure 5.5: Hot spot analysis of walled complejos by total area, where red represents the significant hot spot of larger total area and blue represents significant cold spot of smaller total areas; displayed over a hillshade++

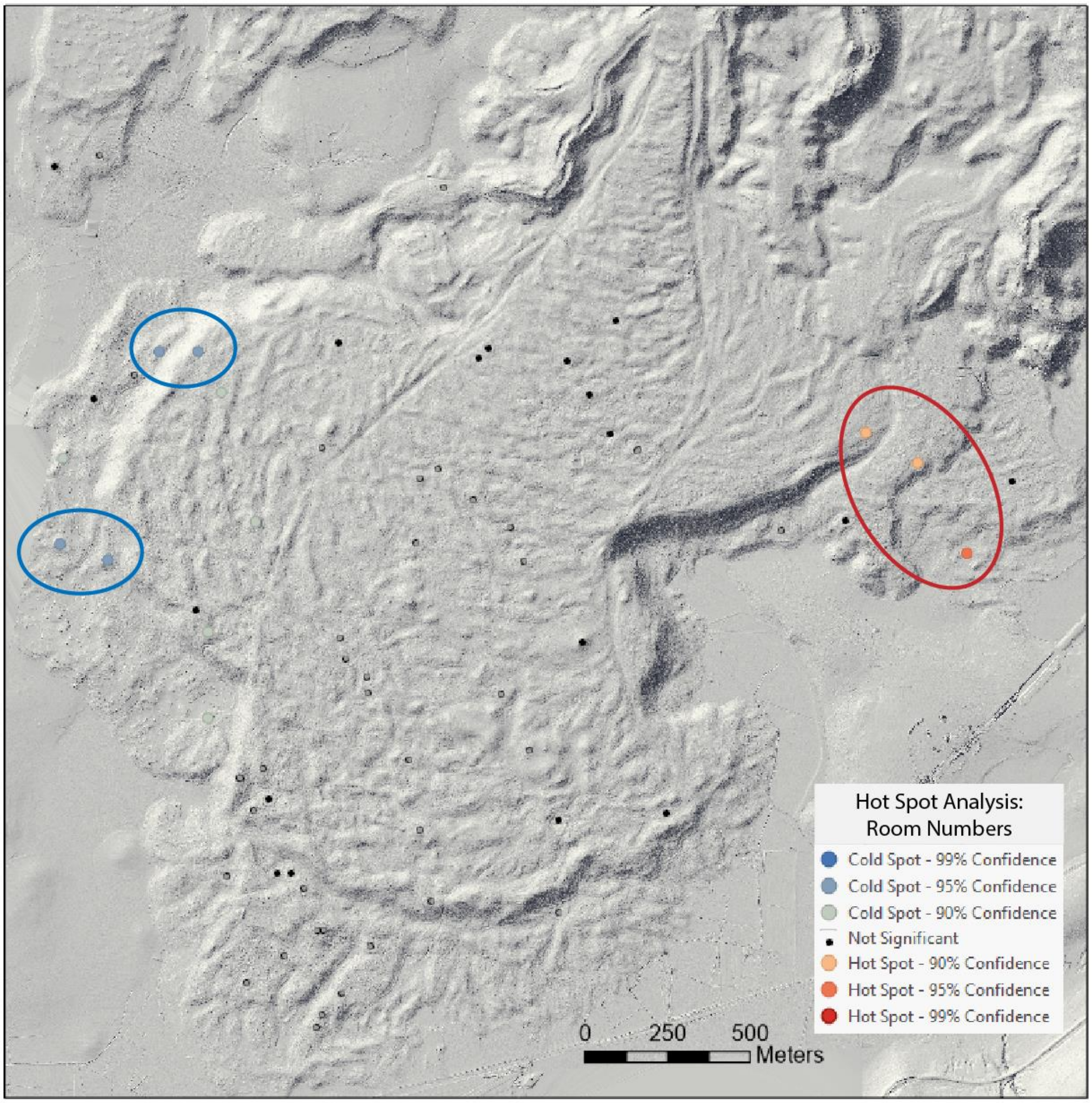

Figure 5.6: Hot spot analysis of walled complejos by room number, where red represents the significant hot spot of walled complejos with more rooms and blue represents significant cold spot of walled complejos with fewer rooms; displayed over a hillshade++

Hot spot analysis for the walled complejos by the distance to monumental architecture returned a hot spot on the lower malpaís and a cold spot on the far north of the upper malpaís. The hotspot covered a large portion of the center of the lower malpaís, with the strongest significance coming from the areas closer to the bottom of the lower malpaís (fig. 5.7). This shows that the walled complejos in this area have significantly shorter distances to pyramids than the rest of the walled complejos. While there are fewer points, the cold spot in the north is not any less significant. These walled complejos are significantly further away from pyramids than the rest of the walled complejos.

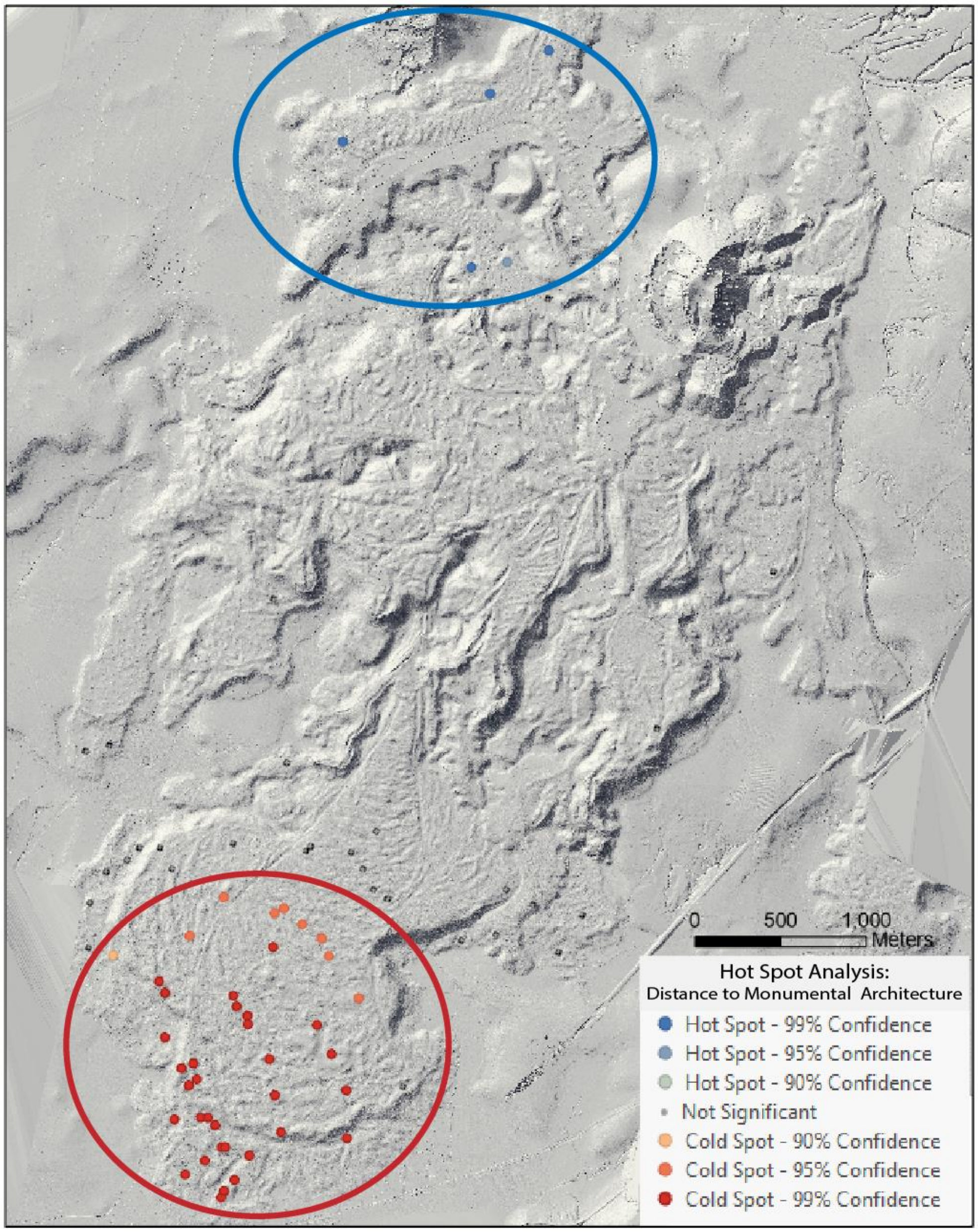

Figure 5.7: Hot spot analysis of walled complejos by distance to monumental architecture, where the red represents shorter distances to pyramids and the blue represents longer distances to pyramids; displayed over a hillshade++

The final hot spot analysis that returned results was for the wall thickness variable. The clustering of thicker walls occurred at the north end of the lower malpaís, close to where architecture tends to become more sparse (fig. 5.8). There was not a cold spot returned for this data, as there was not any significant clustering of thinner walled complejos.

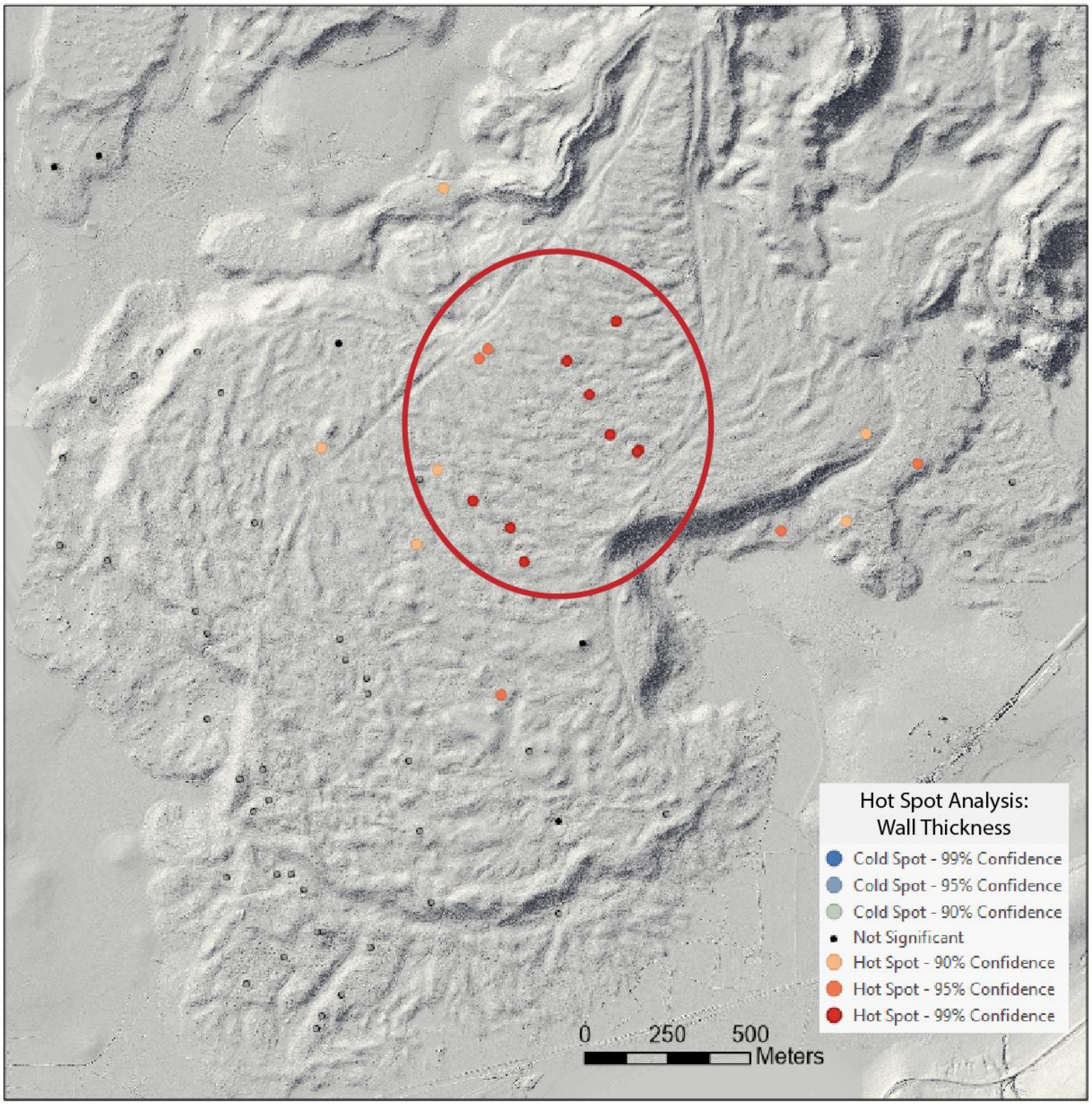

Figure 5.8: Hot spot analysis for walled complejos by wall thickness, where the red represents clustering of walled complejos with relatively thicker walls than the rest of the sample; displayed over a hills hade++

CHAPTER 6: DISCUSSION

6.1 Introduction

This chapter will build on the results presented in Chapter Five and present interpretations for that data. Discussion will be first given for the individual components of the walled complejos, based on the data gathered from all samples and the spatial analysis drawn from those data. Potential interpretations of the walled complejos as a composite structure will be presented in section 6.3 of this chapter. Finally, a discussion on how the results of this investigation impact our understanding of the urban patterning at Angamuco.

6.2 Annotation Analysis

This section will provide potential interpretations and knowledge gained from the individual portions of the walled complejos. These insights are drawn from all three sample investigations as well as the hot spot and statistical analysis.

6.2.1 Area

Area of a walled complejo could be looked at as a proxy for wealth or power of the people who lived within; the land contained within the walled complejo is under direct control of the inhabitants. There is a wide range of total area of walled complejos, the majority of the walled complejos fall within the first two columns of the histogram so the distribution is skewed by the few extremely large walled complejos (fig 5.5). If there was only one social class living within the walled complejos, we would expect relatively similar total area measurements as they would have relatively similar levels of power over land control. However, this study has found a wide range of total area measurements for the walled complejos, indicating a variety of people who are living in these complexes. Therefore, from this data we can rule out the interpretation that these walled complejos were restricted to only one section of society.

The hot spot analysis revealed that walled complejos tended to have larger total areas on the eastern side of the malpaís and smaller areas on the western side. This could be due to the relatively less dense occupation of the eastern side, leaving more room up for grabs with constructing homes. Additionally, the eastern side of the malpaís is closer to large agricultural features so potentially this is due to more wealth or power over the land than the more constricted western side.

6.2.2 Wall Thickness

Walls averaged about 3 meters in width in this investigation. This is admittedly rather thick for walls; however, it must be stated that this is likely not the original width but rather the width we can see from LiDAR data almost 1000 years after occupation. The measurements of wall thickness do need to be considered in light of their high potential for fall and thus artificial widening. Furthermore, there is no reason to believe that erosion of walls would occur at different rates across the site so wall measurements can be interpreted relative to each other safely. The distribution of wall thickness measurements can be seen in the

Hot spot analysis of the wall width displayed thicker walls in the northern section of the lower malpaís and lacked a cold spot, where walls would be thinner, entirely. There are several potential explanations and interpretations to draw from this. First, walls could be thicker due to geologic features of the malpaís; where people are building their walls into the natural ridges of the landscape and walls are seen as thicker in the LiDAR data. Next, this could be a more social reason if this is an edge of the ancient city and walls would need to be more defensive in nature. Defensive measures seem unlikely as this is the middle of a continuous occupation of the entire malpaís and there are no other features within the city that point to defensive architecture. Additionally, this could be a specific style of building, where potentially one group of people choose to build the walls on their complejos thicker than another group within the city. Finally, there is evidence at other sites in the region of continuous rebuilding of walls leading to gradually thicker walls (Feinman et. al 2016). This could be a factor in the relatively wider walls at this location of the site. In order to make a determination on any of these possibilities, field data is needed; it is impossible to definitively apply one or more of these interpretations on the LiDAR data alone.

6.2.3 Plazas and Altars

A scatter plot created shows that plaza area follows a linear pattern of relationship with total area of walled complejos, with a moderate positive correlation (r = .62). The scatterplot shows the linear relationship between the plaza area of walled complejos and the total area (fig 6.1). From this we learn that plaza areas are moderately related to the amount of space within a walled complejo overall, meaning that while 38% of the variance in plaza area can be explained by the total area of the walled complejo there are still factors impacting this variable that we cannot account for with our current data.

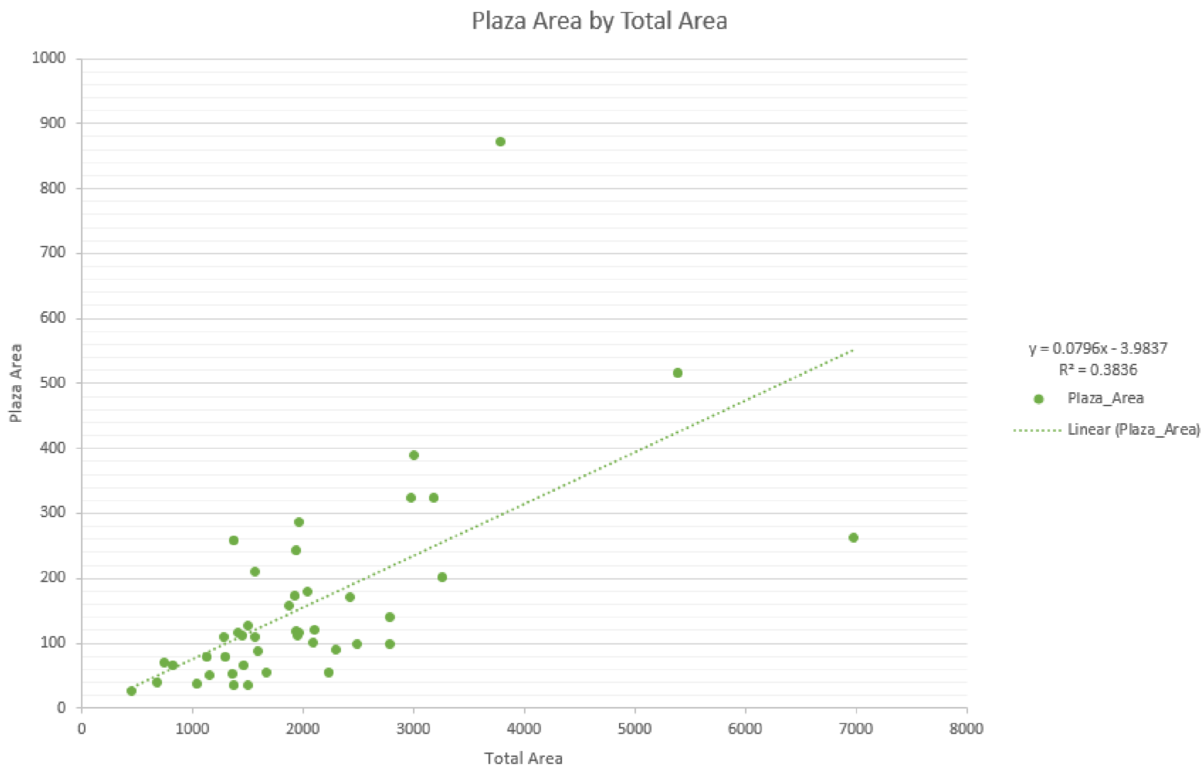

Figure 6.1: Scatterplot of plaza area measurements by total area measurements for the compiled walled complejo dataset

There was no apparent patterning in the relative location of plazas within walled complejos. They are not placed either in one location within the walled complejo standardly, but rather it appears up to the individual constructor where the plaza is in the blueprint of the domestic structure; this implies a bottom-up construction pattern. Field data, such as excavation, would be needed to understand if there is any patterning on plaza location within walled complejos by social group, ethnic group, or other subsections of society that cannot be gathered from spatial data alone.

Altar sizes tended to be relatively similar, staying close to the average of 3.6m across the samples. The histogram (fig 6.2) shows that over 80% of the altars measured for this study are within the first two bars, or less than 4.5m wide. Correlation analysis of altar size to plaza area revealed that there was a relatively weak correlation between the two (r=.55), with 30% of the variance of altar size being explained by the plaza area ($r^2 = .30$). Altars, therefore, do not necessarily get larger when plaza area increases, but it appears they have a general set size hovering around 3.5m.

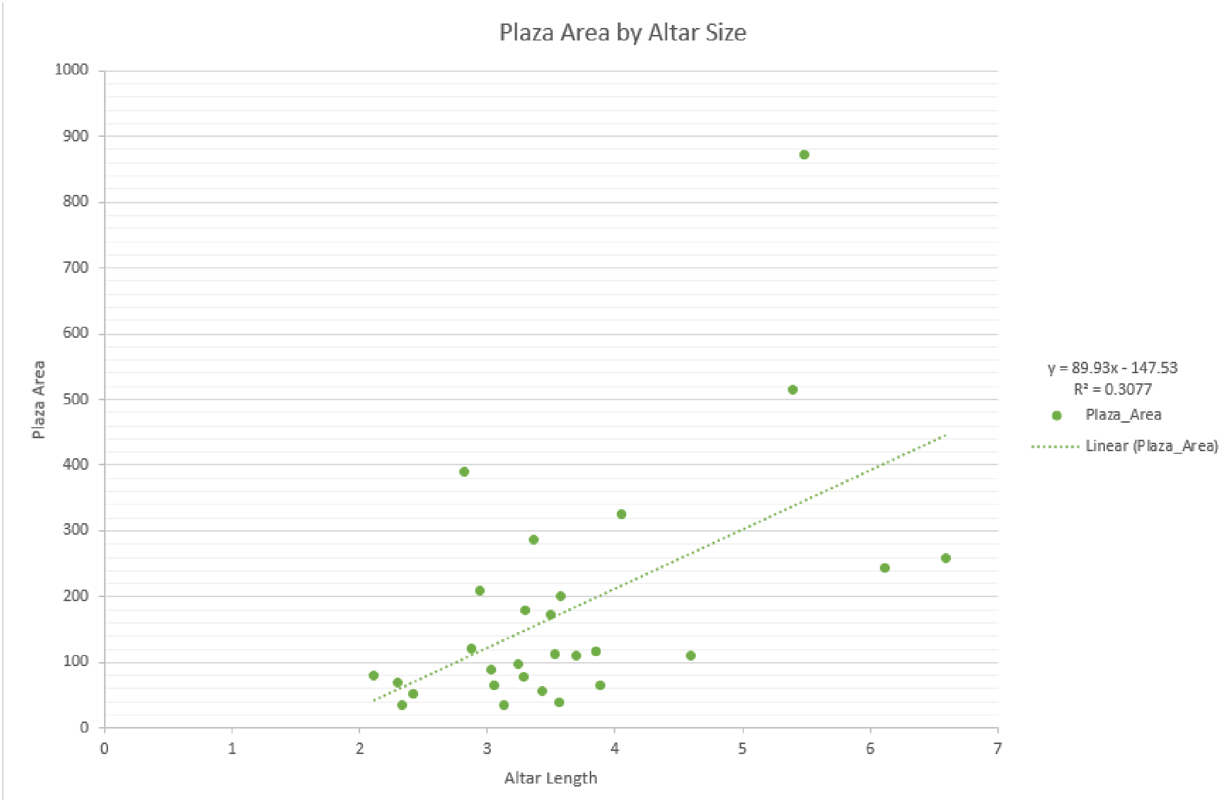

Figure 6.2: Scatter plot of plaza area measurements by altar size of the compiled walled complejo dataset

Half of the identified altars were located in the center of the plaza/patio, next large group is northwest and west, with six of 22 in that group; all other cardinal directions have only a single observation (fig 6.3). This indicates that while there is trend of center placement for altars, it is not a concrete rule that is must be built in this location within the plaza. This lack of absolute patterning could indicate further the bottom-up construction methods, where instead of there being a prescribed way to build walled complejos it was planned by the individual inhabitants.

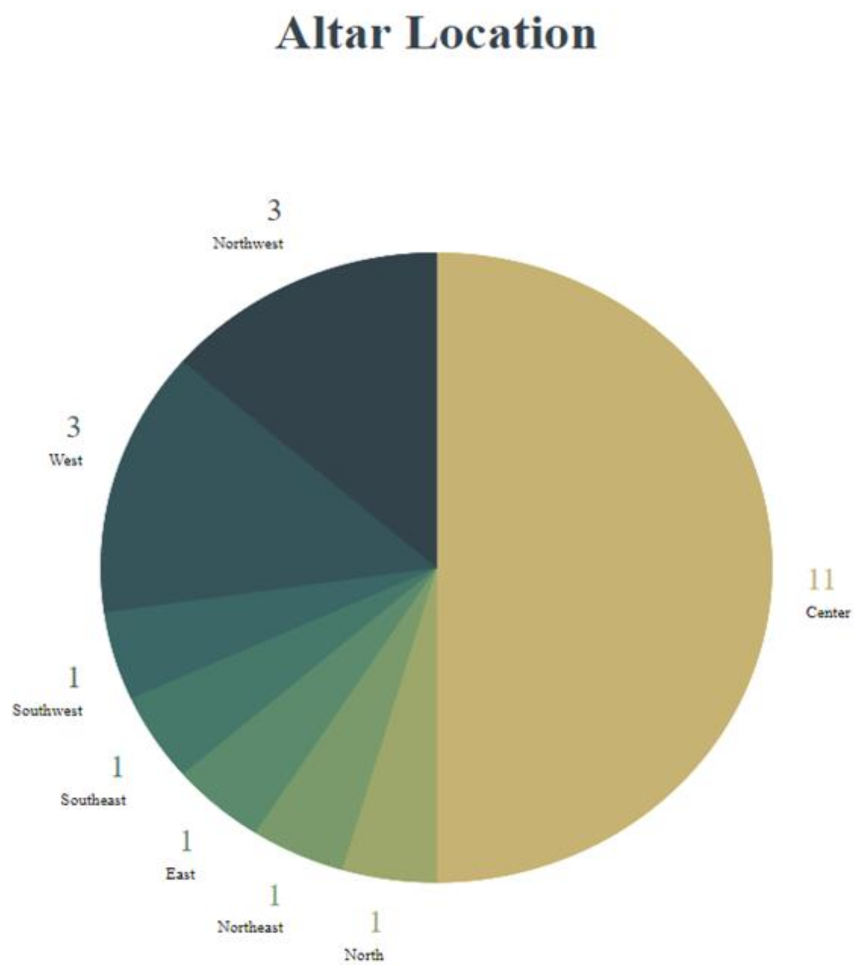

Figure 6.3: Piechart displaying relative location of altars within the internal plazas of walled complejos across the compiled dataset

6.2.4 Room Number

The average number of rooms counted for walled complejos in this study was 8, with 70% of the sample having 9 or fewer rooms. There were a few extremely large walled complejos with over 20 rooms but they did not skew the sample drastically. When understood in relation to total area of the walled complejos, there is a weak correlation ($r = .38$, $r^2 = .15$) between size of the structure and the number of rooms within (fig 6.4). Therefore, larger walled complejos do not necessarily have more rooms just because of their increased size. Hot spot analysis shows walled complejos with more rooms on the eastern side of the malpaís and those with fewer rooms on the western side. Interpretation of this analysis follows largely the interpretation of the total area hot spot analysis; potentially there is more relative power over land on the eastern side due to the association with agriculture. If this line of thinking is followed, potentially these walled complejos contain more rooms because farming requires more people than the activities that were occurring on the more densely built, western side of the malpaís.

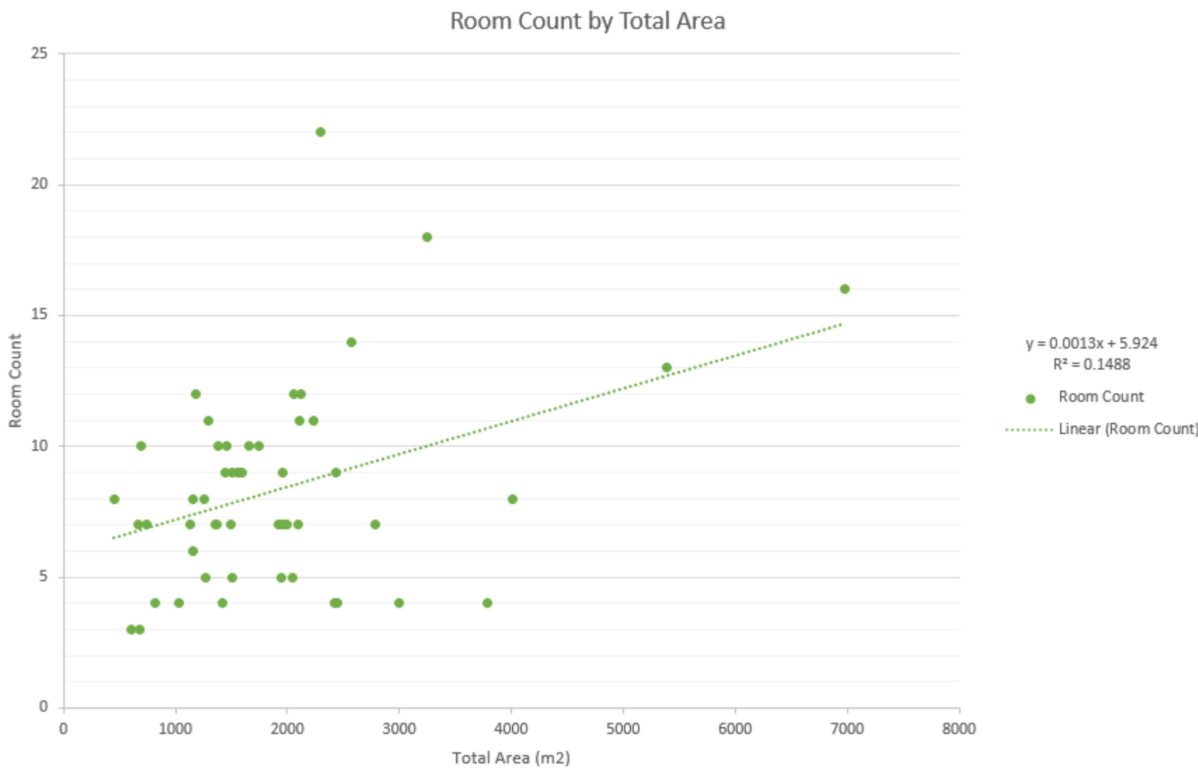

Figure 6.4: Scatterplot of room counts by total area measurements for the compiled walled complejo dataset

Unfortunately, there are many questions we cannot answer with just the LiDAR data. While we can estimate that a variety of people are living within the walled complejos based on the diversity of construction, we do not know if there are more minute differences between those living within these structures across the site as a whole without field data. It is likely that these structures were occupied by large familial groups, potentially entire lineages or multiple generations, like Maya houselots or the multi-room domestic structures seen from the Zapotec. Classical anthropological distinctions between groups, such as patrilineal or matrilineal, extended family or rather ethnic group, are beyond the scope of this investigation. Furthermore, interpretation on the function of each room, or rather individual structures within the walled complejo, is additionally impossible to determine from this investigation alone.

6.2.5 Distance to Monumental

The average distance to pyramids from the walled complejos was 297m; if we assume that the pyramids are semi-regularly spaced across the site at 500m, then the walled complejos would not be considered 'closer' to monumental architecture than any other built feature on average across the site. All but two of the walled complejos identified on the lower malpaís fell within the 500m buffers of pyramids; however, these two are both within 40m of multiple buffers so they are not far off of the norm in this sample (fig. 6.5).

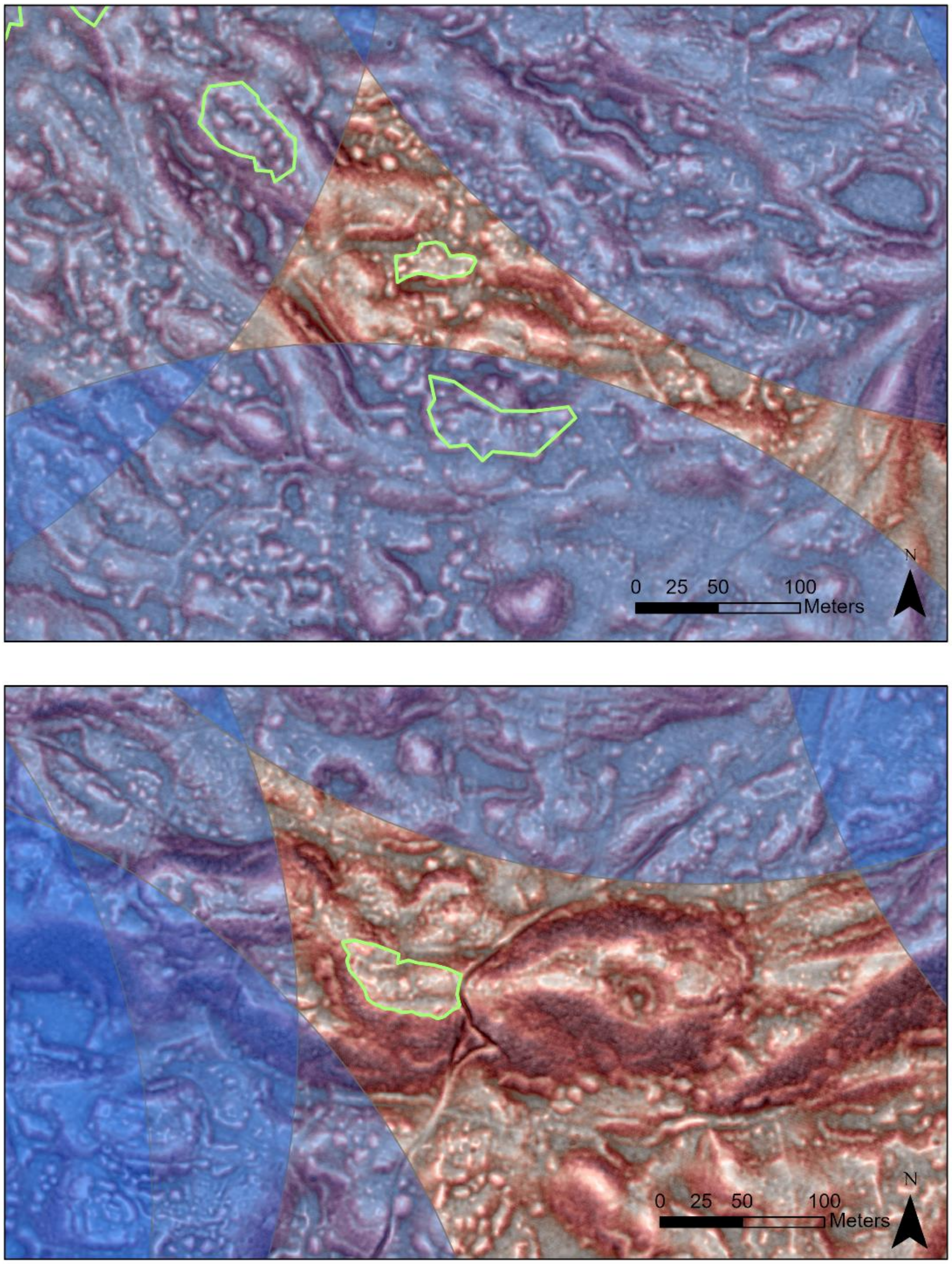

Figure 6.5: The two walled complejos within the main malpaís that did not fall within 500 m buffers (blue) of known pyramids; displayed over a pseudo-RRIM+

Hot spot analysis further revealed that walled complejos were closer to monumental architecture on the lower malpaís than they were in the upper malpaís. This is likely due to the density of monumental architecture in this section of the city, as well as the relatively high density of built features overall on the lower malpaís compared to the upper malpaís. Additionally, this cold spot could be impacted by the sampling process that caught the walled complejos on the northern section of the upper malpaís; while the lower malpaís was randomly sampled, the upper malpaís was analyzed through test pits and thus the chosen tiles may not have been as close to pyramids as the polygons in the south.

6.3 Combined Data

The high degree of variability within the metrics of the walled complejos tells us that these are not top-down constructions; built features that are constructed through top-down social frameworks tend to be more uniform in nature and have a more specific grammar than those that are built bottom-up without such a power structure. Top-down social structure means that the decisions are being made at the top of a hierarchy by some sort of powerful individual or small power-holding class and enforced upon the masses. Contrary to top-down is a bottom-up structure, where the largest portion of the social hierarchy, the bottom, influences culture and decisions themselves.

The walled complejos vary widely across the site in most variables, barring metrics like altar size and wall thickness which have relatively stable measurements. The walled complejos varied both in form and in scale, with some being very round structures with others being more kidney or oblong in shape. This inconsistency in form furthers the bottom-up construction interpretation, with individual families likely constructing the walled complejo that they will occupy and choosing to modify the shape of their compound through utilization of natural ridges or malpaís edges as walls that drastically alters/influences the shape of their home.

In the layout of the walled complejos there are differences as well, with room number varying widely as well as the architectural layout of rooms/plaza/open space within the walled compound; each walled complejo was likely built to fit the needs of the extended family that occupied it and was upgraded and renovated to meet changing needs throughout time. This deep time occupation can be seen across the archaeological record globally but also more specifically in Mesoamerica with the Zapotec (Feinman et. al 2016) and the Maya (Magnoni et al 2012), however given the potentially short lifespan of Angamuco there potentially was not occupation for more than a few generations.

Furthermore, the variability in a metric such as total area tell us that there is likely a wide range of socio-economic classes occupying these structures. Not all inhabitants of the walled complejos have the same relative power or wealth to control the same amount of land within the city. If we assume that wealth and power are based on control of land or resources, then the high variability in scale of the walled complejos would tell us that there is a wide variation of classes of occupants in these structures. Additionally, the walled complejos appear across the site, observed almost everywhere that there is architecture, so this is not an exclusive type of construction or limited to one zone of the city. If wealth or power is instead given relative distance to monumental architecture as its proxy instead of total area, then we can still see a range of classes within the inhabitants of walled complejos; while the lower malpaís can be almost entirely covered by 500m buffers of pyramids and the average walled complejo is only 297m away, there are walled complejos that exist outside of those buffers and some that are extremely far away from monumental architecture (ex. 1226m). It is thus difficult to paint a clear picture as to the specific position in society the occupants of the walled complejos held.

There is potential that some features captured in this investigation were not utilized as typical domestic structures. There are a few examples of walled complejos that are built directly into the side of a pyramid mound, i.e. one or more of the walls are shared with the edge of the pyramid mound, or that they share a plaza with a pyramid. In these specific cases, the structures are more likely to be considered a Casa de Papas, or a priest’s quarters. These are outlined in the

Relación as being locations where the priests lived and slept while they looked after the temples located within, or on top of, the pyramids (Afandor-Pujol 2015; Craine and Reindorp 1970). However, as these structures fit soundly within the analytical checklist of the walled complejos they were retained in this sample.

The spread of walled complejos across the site reveals a dispersed pattern across the lower malpaís, with only pockets of walled complejos scattered across the upper malpaís. The lower malpaís has a much higher architectural density than the rest of the malpaís, so this was expected. In the upper malpaís there was a grouping of walled complejos at the extreme north of the site which was associated with pyramids and other architectural forms. This area is distinctly different from its surroundings which are more sparsely built. The central zone of the malpaís almost entirely lacked walled complejos, except on the edges and smaller arms of the malpaís. Additionally, the sampling method that caught most of the walled complejos north of the lower malpaís was not random, and therefore it would be difficult to assess the overall spatial patterning of these features beyond the anecdotal understanding gained through hours of visual analysis undertaken for this thesis.

6.4 Multi-Nucleated Urbanism

The hypothesis proposed in Fisher (2017:132) of multi-nucleated urbanism exhibited at the site of Angamuco is upheld with this investigation. A critical principal to multi-nucleated urbanism is scalar stress; this involves cities growing and building in ways that meet the needs of an ever-expanding population. The results of this investigation are supportive of the multi-nucleated interpretation the city as far as urbanism models. Monumental architecture is spread throughout, walled complejos have high level of accessibility throughout the site due to the extensive road network. There does not appear to be clear clustering of domestic and nondomestic construction zones; rather there appears to be a dispersed pattern of walled complejos amongst the other built features across the site. Angamuco does not present any clear concentric zones or follow the strict patterns laid out by Webster and Sanders (1988) in the types of Mesoamerican cities; it is neither a regal-ritual center nor a strict administrative center.

CHAPTER 7: CONCLUSIONS

This thesis seeks to investigate the presence and patterning of multi-roomed complexes known as walled complejos. These structures have a set of defining features that are generally followed across the city: thick walls of any shape surrounding multiple smaller buildings, an altar, a plaza, and located near monumental architecture such as pyramids. Through the use of LiDAR and spatial analysis such as pseudo-RRIM and hot spot analysis, 73 unique walled complejos were identified across the urban settlement of Angamuco. These structures varied widely within the sample, in size, form, and location within the site. To conclude this thesis, the questions posed within Chapter One will be addressed here.

What are the walled complejos? Do the actual walled complejos in the data match the current ideal set of features?

The walled complejos at Angamuco are composite structures made of a suite of archaeological features to create a multi-roomed, organized, and walled complex. The proposed 'ideal' walled complejo is round in nature with several rooms, a clear plaza with a clear altar, and very close to monumental architecture (<100m). This investigation revealed that while some walled complejos on the site do exhibit these features in the exact ideal manner, a vast majority of the walled complejos do not perfectly match our ideal definition. The form of walled complejos varies from a near circle to more kidney or oblong shaped walls. The range of rooms varied from only a few to over 20 in the extreme cases. Plazas and altars were not always clearly visible from the LiDAR data, but this does not mean they did not exist or do not currently exist in the archaeological record. Distance to monumental architecture was less than 300m on average, which is relatively close, but is more likely a function of the urban organization of Angamuco than the preferential placement of walled complejos near pyramids.

Are there spatial patterns within the walled complejos? Is there any clustering present? Are there trends in form?

Hot spot analysis revealed several spatial patterns within the walled complejos identified for this investigation. On the eastern portion of the lower malpaís, walled complejos tended to be larger in total area and in room number; a cold spot on the western side of the lower malpaís of smaller area walled complejos with fewer room was also present. Additionally, walled complejos on the lower malpaís tended to be closer to pyramids than those on the northern extents of the upper malpaís. The final spatial pattern identified through hot spot analysis were the thicker walls on the northern edge of the lower malpaís. Beyond the hot spot analysis, walled complejos appeared to be fairly dispersed throughout the entire 26km^2 archaeological site. There was a gap in the center of the upper malpaís, but as addressed previously this could be due to the nature of sampling rather than a true absence of these structures. There were no clear trends in form as far as shape or organization of the features within the walled complejos.

Do the walled complejos align with expectations for domestic structures? If so, can we infer who is living within the walled complejos at Angamuco?

The walled complejos align with our expectations of multi-roomed domestic structures. The walled complejos present similarities to the Maya houselots and the Zapotec domestic structures. Furthermore, walled complejos are present across the entirety of the site and their variability in scale would indicate that these are homes for many people beyond just the extreme elite or a specific group within the city; the lack of consistency within their form implies that multiple groups or classes are utilizing the same architectural grammar to build themselves and their family's homes. I do agree with the original assumption that these complexes were likely both elite and non-elite homes. However, our understanding of walled complejos cannot be complete without field verification. Excavation and survey data is critical to complete the context of walled complejos, especially in answering our questions about who specifically is living in these structures, for how long, and when in the timeline of Angamuco were these houses built and occupied.

How does this information change or uphold our current understanding of the ancient city of Angamuco?

The dispersion of walled complejos across the city upholds our understanding of Angamuco being a multi-nucleated city. There were no clear zones of domestic architecture or zones free of domestic architecture. Moreover, the distance to monumental architecture of walled complejos identified that these features were likely spread at relatively even intervals across the site further supporting the multi-nucleated interpretation of Angamuco. The data collection and geographic layers of spatial data created in this investigation add to our ever-growing geodatabase of architectural knowledge at Angamuco. Prior to this thesis, there has been no investigation of walled complejos. While this investigation did not identify all walled complejos at Angamuco, it has created a dataset large enough to begin to parse out their spatial patterning and variability. Ideally this data can help build a more comprehensive digital landscape of Angamuco, which will get the LORE-LPB project closer to understanding the city.

7.1 Future work

As stated many times in this thesis, field work, whether it be survey or excavation, is critical to deeper anthropological interpretations of the walled complejos at Angamuco. Remotely sensed data and spatial analysis can inform us greatly about the archaeological record above ground at the site, however our current data does not include architecture underneath the surface or small artifacts that are not picked up with LiDAR. While we can gain an understanding about the form and layout of walled complejos from remotely sensed data, we cannot answer the deeper anthropological questions about these structures without artifacts found within them.

The agricultural infrastructure at Angamuco was not included in this analysis. There are large, potentially irrigated terraces along the edges of the malpaís and smaller terraces within the dense urban landscape (Westberry 2021). The potential interplay between agriculture and walled complejos could elucidate connections between power over land management or accessibility to resources that are beyond the scope of this thesis. Likewise, other datasets composed of built landscape features could contribute to questions of resource access.

Finally, this thesis did not address potential domestic structures at Angamuco that are not walled complejos. There were instances in the annotation phase of the methodology where clusters of architecture were found but without a wall, they could not be classified as walled complejos. Previous research has classified clusters of architecture, with or without walls, as simply complejos (Urquhart 2015, Bush 2012). If these are also domestic clusters, then what is the reason some are walled and some are not? Potentially this is a question of relative power or wealth, but it could be based on ethnic group or something else entirely. Further research into the domestic structures at Angamuco should be done to parse these questions out.

This thesis sought to investigate the walled complejos at Angamuco, and their form and patterning. Through this study, 73 unique walled complejos were identified and their spatial associations within the dataset were assessed. From this data we can reject the hypothesis that these were exclusive elite homes, as there was not enough consistency nor restriction. The walled complejos were present throughout the city and did not form any identifiable domestic or walled complejo-only zones. Further excavation and survey work is needed to answer questions about who is occupying these homes and why the walled complejos differ so greatly.

BIBLIOGRAPHY

Afandor-Pujol, Angelica Jimena
2015 *The Relacion de Michoacan (1539-141) & The Politics of Representation in Colonial Mexico*. First. University of Texas Press.

Bush, Jason W
2012 Architectural Patterning in the Purepecha Heartland: An Intrasite Settlement Study at the Urban Center of Sacapu Angamuco, Michoacan, Mexico. Unpublished Master of Arts, Colorado State University, Fort Collins, CO.

Canuto, Marcello A., Francisco Estrada-Belli, Thomas G. Garrison, Stephen D. Houston, Mary Jane Acuña, Milan Kováč, Damien Marken, Philippe Nondédéo, Luke Auld-Thomas, Cyril Castanet, David Chatelain, Carlos R. Chiriboga, Tomáš Drápela, Tibor Lieskovský, Alexandre Tokovinine, Antolín Velasquez, Juan C. Fernández-Díaz, and Ramesh Shrestha
2018 Ancient lowland Maya complexity as revealed by airborne laser scanning of northern Guatemala. *Science* 361(6409):eaau0137. DOI:10.1126/science.aau0137.

Chase, A. F., D. Z. Chase, C. T. Fisher, S. J. Leisz, and J. F. Weishampel
2012 Geospatial revolution and remote sensing LiDAR in Mesoamerican archaeology. *Proceedings of the National Academy of Sciences* 109(32):12916–12921. DOI:10.1073/pnas.1205198109.

Chase, Adrian S.Z., and John Weishampel
2016 Using Lidar and GIS to Investigate Water and Soil Management in the Agricultural Terracing at Caracol, Belize. *Advances in Archaeological Practice* 4(03):357–370. DOI:10.7183/2326-3768.4.3.357.

Chase, Arlen F., and Diane Z. Chase
2017 Detection of Maya Ruins by LiDAR: Applications, Case Study, and Issues. In *Sensing the Past*, edited by Nicola Masini and Francesco Soldovieri, 16:pp. 455–468. Springer International Publishing, Cham.

Chase, Arlen F., Diane Z. Chase, John F. Weishampel, Jason B. Drake, Ramesh L. Shrestha, K. Clint Slatton, Jaime J. Awe, and William E. Carter
2011 Airborne LiDAR, archaeology, and the ancient Maya landscape at Caracol, Belize. *Journal of Archaeological Science* 38(2):387–398. DOI:10.1016/j.jas.2010.09.018.

Chiba, Tatsuro, Shin-ichi Kaneta, and Yusuke Suzuki

2008 RED RELIEF IMAGE MAP: NEW VISUALIZATION METHOD FOR THREE DIMENSIONAL DATA:6.

Cohen, Anna S., Michael L. Galaty, and Christopher T. Fisher
2018 Petrographic analysis of ceramics and clay from Angamuco, Michoacán. *Journal of Archaeological Science: Reports* 19:155–165. DOI:10.1016/j.jasrep.2018.02.035.

Cohen, Anna S., Daniel E. Pierce, and Christopher T. Fisher
2019 Geochemical analysis and spatial trends of ceramics and clay from Angamuco, Michoacán. *Journal of Archaeological Science: Reports* 23:216–230. DOI:10.1016/j.jasrep.2018.10.025.

Cohen, Anna Stephanie
2016 Creating an Empire: Local Political Change at Angamuco, Michoacan, Mexico. Unpublished Thesis.

Cordell, Linda S, Carla R. Van West, Jeffery S. Dean, and DEBORAH A. Muenchrath
2007 Mesa Verde Settlement History and Relocation. *KIVA* 72(4):379–405. DOI:10.1179/kiv.2007.72.4.001.

Craine, Eugene R, and Reginald C Reindorp (editors)
1970 *The Chronicles of Michoacan*. First edition. University of Oklahoma Press, Norman, Oklahoma, USA.

Crawford, O. G. S.
1912 The Distribution of Early Bronze Age Settlements in Britain. *The Geographical Journal* 40(2):184. DOI:10.2307/1778466.

Crow Canyon Archaeological Center
2014 The Pueblo I Period: A.D. 750 - 900 - Housing. *Peoples of the Mesa Verde Region*. https://www.crowcanyon.org/EducationProducts/peoples_mesa_verde/pueblo_I_housing.asp.

Feinman, Gary M., and Linda M. Nicholas
2013 Settlement Patterns of the Ejutla Valley, Oaxaca, Mexico: A Diachronic Macroscale Perspective. *Fieldiana Anthropology* 2013(43):1–330. DOI:10.3158/0071-4739-43.00.1.

Feinman, Gary M., Linda M. Nicholas, and Helen R. Haines

2002 Houses on a Hill: Classic Period Life at El Palmillo, Oaxaca, Mexico. *Latin American Antiquity* 13(3):251–277. DOI:10.2307/972111.

2007 Classic Period Agricultural Intensification and Domestic Life at el Palmillo, Valley of Oaxaca, Mexico. In *Seeking a Richer Harvest*, edited by Tina L. Thurston and Christopher T. Fisher, 3:pp. 23–61. Springer US, Boston, MA.

Ferguson, Charles
2011 Select Random Features Toolbox. USDA.

Fisher, Christopher T
2009 RESPONSIBLE FOR ACADEMICS:64.

2010 *Proyecto Arqueológico Legados De La Resilencia: La Cuenca Del Lago De Patzcuaro. Informe Tecnico Parcial, Temporada 2010*. Proyecto Arqueológico Legados De La Resilencia: La Cuenca Del Lago De Patzcuaro. Instituto Nacional de Antropologia e Historia, Michoacan, Mexico.

2011 *Legados De La Resiliencia: La Cuenca del Lago de Patzcuaro Proyetco Arcquelogico (Proyecto LORE LPB) - Informe Tecnico Parcial, Temporada 2011*. Instituto Nacional de Antropologia e Historia, Michoacan, Mexico.

2018 Legacies of Resilience: The Lake Patzcuaro Archaeological Project Wiki. *Legacies of Resilience: The Lake Patzcuaro Archaeological Project Open Science Framework*. Project Management, osf.io/yn2p9/wiki/home, accessed March 8, 2021.

Fisher, Christopher T., Anna S. Cohen, Juan Carlos Fernández-Diaz, and Stephen J. Leisz
2017 The application of airborne mapping LiDAR for the documentation of ancient cities and regions in tropical regions. *Quaternary International* 448:129–138. DOI:10.1016/j.quaint.2016.08.050.

Fisher, Christopher T., Anna S. Cohen, Rodrigo Solinis-Casparius, Florencia L. Pezzutti, Jason Bush, Marion Forest, and Andrea Torvinen
2019 A Typology of Ancient Purépecha (Tarascan) Architecture from Angamuco, Michoacán, Mexico. *Latin American Antiquity* 30(03):510–528. DOI:10.1017/laq.2019.50.

Fisher, Christopher T., Juan Carlos Fernández-Diaz, Anna S. Cohen, Oscar Neil Cruz, Alicia M. Gonzáles, Stephen J. Leisz, Florencia Pezzutti, Ramesh Shrestha, and William Carter
2016 Identifying Ancient Settlement Patterns through LiDAR in the Mosquitia Region of Honduras. Edited by Michael D. Petraglia. *PLOS ONE* 11(8):e0159890. DOI:10.1371/journal.pone.0159890.

Fisher, Christopher T, and Stephen J. Leisz
2013 New Perspectives on Purepecha Urbanism Through the Use of LiDAR at the Site of Angamuco, Mexico. In *Mapping archaeological landscapes from space*, edited by Douglas C. Comer and Michael J. Harrower. SpringerBriefs in archaeology. Springer, New York.

Folan, William J., Armando Anaya Hernandez, Ellen R. Kintz, Laraine A. Fletcher, Raymundo Gonzalez Heredia, Jacinto May Hau, and Nicolas Caamal Canche
2009 COBA, QUINTANA ROO, MEXICO: A RECENT ANALYSIS OF THE SOCIAL, ECONOMIC AND POLITICAL ORGANIZATION OF A MAJOR MAYA URBAN CENTER. *Ancient Mesoamerica* 20(01):59. DOI:10.1017/S0956536109000054.

Friedl, Alexandra
2019 The Pyramids and Temples of Angamuco: Decoding Meaning Through Spatial Analysis of Form, Scale, and Directional Orientation. Unpublished Master of Arts, Colorado State University, Fort Collins, CO.

Hare, Timothy, Marilyn Masson, and Bradley Russell
2014 High-Density LiDAR Mapping of the Ancient City of Mayapán. *Remote Sensing* 6(9):9064–9085. DOI:10.3390/rs6099064.

Harris, Chauncy D, and Edward L Ullman
1945 The Nature of Cities. *The Annals of the American Academy of Political and Social Science* 242. Building the Future City:12.

Harris, Edwin
2019 Viewed from above: Extracting the Built Environment from the Ancient Purepecha site of Angamuco through Development of a New Methodology. Unpublished Master of Arts, Colorado State University, Fort Collins, CO.

Hutson, Scott R.
2015 Adapting LiDAR data for regional variation in the tropics: A case study from the Northern Maya Lowlands. *Journal of Archaeological Science: Reports* 4:252–263. DOI:10.1016/j.jasrep.2015.09.012.

Hutson, Scott R., Aline Magnoni, Daniel E. Mazeau, and Travis W. Stanton
2006 The archaeology of urban houselots at Chunchumil, Yucatan. In *Lifeways in the Northern Maya Lowlands: New Approaches to Archaeology in the Yucatan Peninusla*. University of Arizona Press.

Inomata, Takeshi, Daniela Triadan, Flory Pinzón, Melissa Burham, José Luis Ranchos, Kazuo Aoyama, and Tsuyoshi Haraguchi
2018 Archaeological application of airborne LiDAR to examine social changes in the Ceibal region of the Maya lowlands. Edited by John P. Hart. *PLOS ONE* 13(2):e0191619. DOI:10.1371/journal.pone.0191619.

Inomata, Takeshi, Daniela Triadan, Erick Ponciano, Estela Pinto, Richard E. Terry, and Markus Eberl
2002 Domestic and Political Lives of Classic Maya Elites: The Excavation of Rapidly Abandoned Structures at Aguateca, Guatemala. *Latin American Antiquity* 13(3):305–330. DOI:10.2307/972113.

Judd, Neil M
1964 *The Architecture of Pueblo Bonito*. Vol. 47. 1 vols. Smithsonian Miscellaneous Collections. Smithsonian Institution.

Kowalewski, Stephen A., Stefan P. Brannan, Marisol Yadira Cortés Vilchis, Laura Diego Luna, Gabriela García Ayala, José Leonardo López Zárate, Fernando Méndez Sobel, Laura R. Stiver Walsh, Ellen B. Turck, John A. Turck, and Sergei Vepretskiy
2017 REGIONAL ARCHAEOLOGY AND LOCAL INTERESTS IN COIXTLAHUACA, OAXACA. *Latin American Antiquity* 28(3):353–372. DOI:10.1017/laq.2017.19.

Leisz, Stephen J.
2013 An Overview of the Application of Remote Sensing to Archaeology During the Twentieth Century. In *Mapping Archaeological Landscapes from Space*, edited by Douglas C. Comer and Michael J. Harrower. Springer.

Licon, Ernesto Gonzalez
2003 Social Inequality at Monte Alban Oaxaca: Household Analysis from Terminal Formative to Early Classic:307.

Magnoni, Aline, Scott R. Hutson, and Bruce H. Dahlin
2012 LIVING IN THE CITY: SETTLEMENT PATTERNS AND THE URBAN EXPERIENCE AT CLASSIC PERIOD CHUNCHUCMIL, YUCATAN, MEXICO. *Ancient Mesoamerica* 23(02):313–343. DOI:10.1017/S0956536112000223.

Malmstrom, Vincent H.

1995 Geographical Origins of the Tarascans. *Geographical Review* 85(1):31–40. DOI:10.2307/215553.

Millon, R.
1970 Teotihuacan: Completion of Map of Giant Ancient City in the Valley of Mexico. *Science* 170(3962):1077–1082. DOI:10.1126/science.170.3962.1077.

Pezzutti, Florencia Lorena
2010 THE STEPS OF KINGS: TERRACED LANDSCAPES IN THE LAKE PÁTZCUARO BASIN, MICHOACÁN, MÉXICO:191.

Pollard, Helen Perlstein
1977 An Analysis of Urban Zoning and Planning at Prehispanic Tzintzuntzan. *Proceedings of the American Philosophical Society* 121(1):46–69.

1980 Central Places and Cities: A Consideration of the Protohistoric Tarascan State. *American Antiquity* 45(04):677–696. DOI:10.2307/280141.

1993 *Tariacuri's Legacy: The Prehispanic Tarascan State*. University of Oklahoma Press, Norman, Oklahoma, USA and London, England, UK.

2004 Tarascan Urbanism: Central places and cities in the Lake Patzcuaro Basin. Michigan State University.

2018 Tula of the Toltecs annd Tzintzuntzan of the Tarascans. In , edited by Ronald K Faulseit, Nezahualcoyotl Xiuhtecutli, and Haley Molt Mehta, City, Craft, and Residence in Mesoamerica: Research Papers Presented in Honor of Dan M. Healan:pp. 259. Tulane University, New Orleans.

Ricketson, Oliver, and A. V. Kidder
1930 An Archeological Reconnaissance by Air in Central America. *Geographical Review* 20(2):177. DOI:10.2307/208878.

Rodríguez, Verónica Pérez
2006 States and Households: The Social Organization of Terrace Agriculture in Postclassic Mixteca Alta, Oaxaca, Mexico. *Latin American Antiquity* 17(01):3–22. DOI:10.2307/25063034.

Sanders, William T., and David Webster
1988 The Mesoamerican Urban Tradition. *American Anthropologist, New Series* 90(3):521–546.

Santley, Robert S, and Kenneth G Hirth (editors)
1993 *Prehispanic DomesticUnits in Western Mesoamerica: Studies of the Household, Compound, and Residence*. CRC Press, Inc., Boca Raton, Florida, USA.

Sheehy, James J.
1991 STRUCTURE AND CHANGE IN A LATE CLASSIC MAYA DOMESTIC GROUP AT COPAN, HONDURAS. *Ancient Mesoamerica* 2(1):1–19.

Simpson, Nick
2019 Testing the waters: A Spatial Analysis of an Engineered Water Management System at Angamuco, Michoacan, Mexicco. Unpublished Master of Arts, Colorado State University, Fort Collins, CO.

Smith, Michael E.
1989 Cities, Towns, and Urbanism: Comment on Sanders and Webster. *American Anthropologist, New Series* 91(2):454–460.

2007 Form and Meaning in the Earliest Cities: A New Approach to Ancient Urban Planning. *Journal of Planning History* 6(1):3–47. DOI:10.1177/1538513206293713.

2011 Empirical Urban Theory for Archaeologists. *Journal of Archaeological Method and Theory* 18(3):167–192. DOI:10.1007/s10816-010-9097-5.

2014 Housing in Premodern Cities: Patterns of Social and Spatial Variation. *International Journal of Architectural Research: ArchNet-IJAR* 8(3):207. DOI:10.26687/archnet-ijar.v8i3.448.

2017 The Teotihuacan Anomaly: The Historical Trajectory of Urban Design in Ancient Central Mexico. *Open Archaeology* 3(1). DOI:10.1515/opar-2017-0010, accessed October 9, 2018.

Solinis-Casparius, Rodrigo
2019 The Role of Road Networks in Social Definition and Integration of Angamuco, MIchoacan (250-1350 CE). Unpublished Doctor of Philosophy, University of Washington.

Steele, Louise M, and Celena Westberry
2020 Integrating Remote Sensing Techniques to Reconstruct Cultural Landscapes in Postclassic Patzcuaro Basin. In *Annual Meeting 2020*. Denver, CO.

T., H. G., and O. G. S. Crawford
1926 Air Survey and Archæology. *Journal of the County Louth Archaeological Society* 6(2):106. DOI:10.2307/27728230.

Urquhart, Kyle R
2015 The Ireta: A Model of Political and Spatial Organization of P'urepecha Cities. Unpublished Master of Arts, Colorado State University, Fort Collins, CO.

Westberry, Celena
2021 Terraces at Angamuco: Analysis of Urban Agricultural Landscapes Through LiDAR and GIS. Unpublished Master of Arts, Colorado State University, Fort Collins, CO.

Williams, Eduardo
2020 *Ancient West Mexico in the Mesoamerican Ecumene*. Archaeopress Publishing Ltd.

Zakšek, Klemen, Kristof Oštir, and Žiga Kokalj
2011 Sky-View Factor as a Relief Visualization Technique. *Remote Sensing* 3(2):398–415. DOI:10.3390/rs3020398.

APPENDIX A

* Lidar Metadata:

The first LiDAR flight for Angamuco was not projected using WGS-84. This means that the first and second flights (Merrick vs NCALM) have z-values that differ by roughly five meters. Juan Carlos Fernandez-Diaz (University of Houston/NCALM) re-projected the original Merrick data in late 2016 and merged the two point cloud datasets so the z-values match. This was not a minor effort on Juan's part.

Projection Standards
Version 1.0 04/09/17
Projection - UTM Zone 14 North
Units - Meters
Horizontal - WGS-84
Vertical Datum – WGS ellipsoidal heights

Data Collection and Processing Summary for the 2015 Mapping Project of Corrales, Michoacan

PI: Christopher Fisher

Data Collection Summary:

Collection dates, # of flights: 1 flight on March 29, 2015
Airplane and Equipment: Piper Navajo PA-31-350, N154WW, Optech Titan s/n 14SEN340
Equipment Specs: http://www.teledyneoptech.com/index.php/products/airbornesurvey/
Flight Plan Parameters: Flying height 900 m AGL (2 PIA), swath1000 m, 50% Overlap, line spacing 500 m.
Equipment Parameters: PRF: 250 kHz x 3 main, 30° x 20 Hz
GPS Reference Stations: Morelia Airport: 19.84606792 W, 1830.098 m Ellip
Requested / Collected Area:16.595 km² / 50.571 km²

Data Processing Summary:

Horizontal / Vertical Datum: WGS-84 / WGS-84 ellipsoidal heights
Projection / Units: UTM Zone 14 North / Meters
Point Cloud Tiles: 500 m x 500m tiles, 233 total in the LAS 1.2 format classified as ground and not-ground returns.
First Surface Elevation Model: ArcGIS FLT @ 2 meter resolution. Anga2_GEF20.flt
First Surface Hillshade: ArcGIS ADF @ 2 meter resolution. Anga2_HEF20
Bare-earth Elevation Model: ArcGIS FLT @ 2 meter resolution: Anga2_GEG20.flt
Bare-earth Hillshade: ArcGIS ADF @ 2 meter resolution. Anga2_HEG20

Conventions Followed:

Flight Line Numbering:
The flight number assigned to each of the returns contained on the .LAS tiles has been encoded with four digits #### (i.e. 1012). Where the first digit corresponds to the Titan Channel (1: 1550, 2: 1064, 3: 532 nm) and the next three digits correspond to the sequential order of each flight strip ranging from 037 to 049.
PC Tile Naming:
The 500 m tiles follow a naming convention using the lower left coordinate (minimum X, Y) as the seed for the file name as follows: XXXXXX_YYYYYYY. For example if the tile bounds coordinate values from easting equals 556000 through 556500, and northing equals 3769000 through 3769500 then the tile filename incorporates 556000_3769000.

ArcGIS
Products Naming: Due to the limited number of characters that can be used for ArcGIS data products the following format was followed: NNNNN-TWR##. Where "NNNNN" correspond to the 5 letter identifier for the project area; the seventh character "T" represent the type of raster and it can be an "G" for a grid or "H" for a hillshade; the eight character "W" represent what kind of data was used to create the raster and it can be an "E" for elevation or an "I" for intensity; the ninth character "R" represents the type of return that was used for creating the raster and could be a "F" for First return or "G" for ground return, the last two characters "##" represent the raster resolution in decimeters.

** Digital Elevation Model:

Layer created using LiDAR base files (see * above) processed from the .las files and projected into UTM Zone 14N using Global Mapper by Blue Marble. The .las point cloud data was cleaned to include only last returns/ground returns. A triangulated irregular network with a .25m grid was built from these returns and then exported as a float/grid file to be used as the DEM in other geospatial software.

*** Lake Patzcuaro Basin Digital Elevation Model Creation:

ALOS PRISM data, with pixel size of 2.5 meters, was used to develop a high resolution digital elevation model for the Lake Patzcuaro lake basin using photogrammetric methods. The scenes used were ALPSMB20431(frame 3255, 3260, and 3265), collected on November 24, 2009. The scenes are oriented in the fore, aft, and nadir look position, so that maximal overlap of the scenes was achieved. 60 well distributed ground control points were collected using Differential GPS (horizontal accuracy +/- ½ m, vertical accuracy +/- 1m) units. 11 were used as ground control points in the digital elevation model (DEM) development process and 49 were held back and used to assess the accuracy of the DEM. Leica Photogrammetry System (within ERDAS Imagine) was used to generate the DEM. The DEM was generated to a pixel size of 2.5 m by 2.5 m, the pixel size of the original ALOS PRISM data. At the suggestion of the Space Archaeology Program Manager we requested that the Alaska Satellite Facility (ASF) create a DEM for the same area using similar ALOS PRISM data. ASF uses state of the art software and creates DEMs for production purposes and for use by other scientists and organizations. We then compared our results to the ASF produced DEM. The average vertical error of our DEM is +/- 2.4 m, the ground truth point with the least error has an error of +0.06 m and the largest error is -

12 m. The ASF DEM’s average error is 11.31 m, the ground truth point with the least error has an error of 0 m and the largest error is 16.83 m. Overall the DEM that we were able to produce appears to be more accurate and have less vertical error than the ASF produced DEM. The DEM is registered to the WGS 84 Datum."

+Pseudo-Red Relief Image Map created using LiDAR base files (see * above) and methodology developed in Harris (2019)

++Hillshade raster created using the LiDAR base files (see * above) and 3D Analyst toolbox in ArcGIS Pro from ESRI