

EVALUATING CAVE USE THROUGH SPATIAL ANALYSIS OF ANIMAL REMAINS
FROM MAYA CAVES IN GUATEMALA AND BELIZE

By

EROL GEORGE KAVOUNTZIS

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

UNIVERSITY OF FLORIDA

2009

© 2009 Erol George Kavountzis

To my family and Jessica, without all of your support and help I could not have done this

ACKNOWLEDGMENTS

This thesis was only possible with the help and assistance of my advisor Dr. Kitty F. Emery, who helped to explore and understand the Maya and their use of caves. I would also like to thank Dr. Susan deFrance for her support and input for my research and Dr. Christian Russell who's GIS knowledge made most of this research and mapping possible. Without the work and help of all of those in the Zooarchaeology lab in the Florida Museum of Natural History (FLMNH), I not sure I could have done this. Big thanks to Elyse Anderson, Erin Thornton, Michael Kay, Melissa Ayvaz, and all the Ethnobotanical interns for making my analysis fun and productive at the same time. Also thanks to the zooarchaeology interns, Erin Ives and Jen Boekenoogen, for their work with organizing my faunal assemblages.

This work was partially funded by a Tinker Field Research Grant provided by the Center for Latin American Studies at the University of Florida. This funding allowed me to export my large collection of animal bones from Belize during the summer of 2007. I would like to thank the researchers who shared their faunal assemblages for this study including Dr. Jaime Awe, Dr. James Brady, Dr. Gabriel Wrobel, and graduate student Cameron Griffith.

I thank my great neighbors and friends the Reuter family, including Mason, Georgia, Ellie, and Wilson. I thank all of my wonderful Housing coworkers, GHDs and RAs, for making my experience at UF fun and enjoyable. I would also like to thank my family for all their support both mentally and financially. A big hug and thanks go to my great friends and support at UF, Elyse, Mary, and Jon, you are the three that made my experience wonderful. Finally, to my BFF Jess, thanks for helping me get through this long, and sometime painful, journey, without your support I don't think I could have done it.

TABLE OF CONTENTS

	<u>page</u>
ACKNOWLEDGMENTS	4
LIST OF TABLES	10
LIST OF FIGURES	12
ABSTRACT.....	13
CHAPTERS	
1 INTRODUCTION	15
Cognitive Archaeology	18
Maya Cave Archaeology:	19
Maya Cave Zooarchaeology:.....	20
Geographic Information Systems and Maya Caves.....	22
Maya Spatial Patterns, Zooarchaeology, and GIS	22
Summary.....	24
2 THEORETICAL FRAMEWORK: CAVES, LANDSCAPE, COGNITIVE ARCHAEOLOGY, AND THE USE OF SPACE BY THE ANCIENT MAYA	26
Overview.....	26
Maya Cognitive and Landscape Archaeology	27
The Cognized Universe and Caves.....	29
Separation of Space and the Use of Space by the Ancient Maya.....	33
Cardinal Directions and Quadripartite:	33
Left and Right Sides	34
Light and Dark.....	36
Open and Restricted Access	37
Summary.....	38
3 PRIOR RESEARCH IN MAYA CAVE ARCHAEOLOGY, ZOOARCHAEOLOGY, AND GIS	40
Maya Cave Research: History and Progress over the Decades	40
Brief History of Maya Zooarchaeology.....	42
Ritual Use of Animals from the Maya Region	43
Previous Maya Cave Zooarchaeological Research.....	47
GIS in Cave Research Projects and the Maya Region.....	49
Current Research Goals	51
4 RESEARCH SETTING: FIVE CAVES FROM THE MAYA REGION UNDER ANALYSIS.....	52

Introduction.....	52
Primary Research Sites in Belize.....	53
Caves Branch Rockshelter, Belize	53
Stela Cave, Belize.....	55
Primary Research Sites in Guatemala.....	56
Cueva de Sangre, Guatemala.....	56
Cueva de El Duende, Guatemala.....	57
Published Source from Guatemala: Naj Tunich, Guatemala.....	58
Summary.....	59
5 ZOOARCHAEOLOGY, GIS, AND VISUAL ANALYSIS METHODS.....	67
Introduction.....	67
Zooarchaeological Methods.....	68
Geographic Information Systems (GIS)	71
Separation of Space within the caves	74
Summary.....	76
6 RESULTS	88
Introduction.....	88
Caves Branch Rockshelter	90
Crustaceans	91
Actinopterygii.....	92
Amphibia	93
Testudines.....	94
Sauria	94
Serpentes.....	95
Aves	96
Didelphidae.....	96
Dasypus novemcintus.....	97
Chiroptera	98
Canidae	98
Procyonidae	99
Artiodactyla	99
Tayassuidae	100
Cervidae.....	101
Rodentia.....	101
Agoutidae and Dasyproctidae.....	102
Sylvilagus sp.....	103
Stela Cave	103
Crustaceans.....	104
Actinopterygii.....	104
Amphibia	105
Testudines.....	105
Sauria	105
Serpentes.....	105

Aves	106
Didelphidae.....	106
Dasypus novemcinctus	106
Chiroptera	107
Canidae	108
Procyonidae	108
Artiodactyla	108
Tayassuidae	109
Cervidae.....	109
Rodentia.....	110
Scuiridae	110
Agoutidae and Dasyproctidae.....	110
Sylvilagus sp.....	111
Cueva de El Duende	111
Crustacean	112
Actinopterygii.....	112
Amphibia	113
Testudines.....	114
Sauria	114
Serpentes.....	114
Aves	115
Didelphidae.....	115
Dasypus novemcinctus	115
Chiroptera	116
Canidae	116
Felidae	117
Artiodactyla	117
Cervidae.....	117
Rodentia.....	118
Agoutidae and Dasyproctidae.....	118
Cueva de Sangre	119
Crustaceans	119
Actinopterygii.....	120
Testudines.....	120
Serpentes.....	121
Aves	121
Didelphidae.....	121
Dasypus novemcinctus	122
Chiroptera	122
Canidae	123
Artiodactyla	123
Tayassuidae	124
Cervidae.....	124
Rodentia.....	125
Agoutidae and Dasyproctidae.....	126
Naj Tunich	126

Crustacean	128
Testudines	128
Aves	128
Didelphidae	129
Dasypus novemcinctus	130
Chiroptera	130
Primates	131
Canidae	131
Felidae	131
Procyonidae	132
Tapirus bairdii	132
Artiodactyla	133
Tayassuidae	133
Cervidae	134
Rodentia	135
Agoutidae/Dasyproctidae	135
Sylvilagus sp	136
Summary	136
7 INTERPRETATIONS	155
Introduction	155
Limitations to Spatial Pattern Analysis	156
Taxonomic Trends	159
Crustaceans	160
Ray-Finned Fishes	162
Amphibians	163
Turtles	164
Lizards	166
Snakes	167
Birds	167
Opossums	168
Armadillos	169
Bats	170
Primates	171
Canids	171
Felids	172
Raccoons	173
Tapirs	174
Artiodactyls	174
Peccaries	174
Deer	175
Rodents	176
Squirrels	177
Agoutis and pacas	178
Cottontail rabbit	178
Summary	178

8	CONCLUSIONS	200
	Trends	200
	Limitations	202
	Recommendations.....	206
	Summary	206
	LIST OF REFERENCES	208
	BIOGRAPHICAL SKETCH	219

LIST OF TABLES

<u>Table</u>	<u>page</u>
4-1 Five Cave Site Information Including Proximity to Sites, Time Periods, and Excavation Methods.....	66
5-1 Gentax Numbers for Taxonomic Classification of Faunal Remains	77
5-2 Element Numbers for Element Types.....	86
5-3 Body Portion Numbers for Body Portions.....	87
5-4 Sidedness Numbers for Element Sidedness	87
5-5 Age Class Numbers for Age Classes	87
5-6 Burning and Charring Numbers for Burning and Charring Descriptions.....	87
6-1 Relative Frequency Values for Five Cave Sites.	150
6-2 Separation of Space for Caves Branch Rockshelter, Belize	151
6-3 Separation of Space for Stela Cave, Belize	151
6-4 Separation of Space for Cueva de El Duende, Guatemala.....	152
6-5 Separation of Space for Cueva de Sangre, Guatemala	153
6-6 Separation of Space for Naj Tunich, Guatemala	154
7-1 Separation of Space Summaries for Left versus Right Sides and North versus South Directions at Caves Branch Rockshelter, Belize.	180
7-2 Separation of Space Summaries for Light versus Dark and Open versus Restricted Regions at Caves Branch Rockshelter, Belize.....	181
7-3 Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Caves Branch Rockshelter, Belize.....	182
7-4 Separation of Space Summaries for Left versus Right Sides, North versus South, East versus West Directions, Light versus Dark, and Open versus Restricted Regions at Stela Cave, Belize.	183
7-5 Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Stela Cave, Belize.....	184
7-6 Separation of Space Summaries for North versus South Directions at Cueva de El Duende, Guatemala.....	185

7-7	Separation of Space Summaries for East versus West Directions, Light versus Dark, and Open versus Restricted Regions at Cueva de El Duende, Guatemala.	186
7-8	Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Cueva de El Duende, Guatemala.	187
7-9	Separation of Space Summaries for Left versus Right Sides at Cueva de Sangre, Guatemala.	189
7-10	Separation of Space Summaries for North versus South Directions at Cueva de Sangre, Guatemala.	190
7-11	Separation of Space Summaries for East versus West Directions at Cueva de Sangre, Guatemala.	191
7-12	Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Cueva de Sangre, Guatemala.	192
7-13	Separation of Space Summaries for Left versus Right Sides at Naj Tunich, Guatemala.	194
7-14	Separation of Space Summaries for North versus South Directions at Naj Tunich, Guatemala.	195
7-15	Separation of Space Summaries for East versus West Directions at Naj Tunich, Guatemala.	196
7-16	Separation of Space Summaries for Light versus Dark Regions at Naj Tunich, Guatemala.	197
7-17	Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Naj Tunich, Guatemala.	198

LIST OF FIGURES

<u>Figure</u>	<u>page</u>
4-1 General Location of Caves Sites in Belize and Guatemala.	60
4-2 Location of Operations and Units for Caves Branch Rockshelter, Belize.....	61
4-3 Location of Units for Stela Caves, Belize.....	62
4-4 Location of Surface Collections for Cueva de Sangre, Guatemala	63
4-5 Location of Excavation Units for Cueva de El Duende, Guatemala	64
4-6 Location of Lots for Operation IV, Naj Tunich, Guatemala.....	65
6-1 Separation of Space at Caves Branch Rockshelter, Belize	137
6-2 Separation of Space at Stela Cave, Belize	138
6-3 Separation of Space at Cueva de El Duende, Guatemala	139
6-4 Separation of Space at Cueva de Sangre, Guatemala	140
6-5 Separation of Space at Naj Tunich, Guatemala	141
6-6 Caves Branch Rockshelter, Crustacean Remains Ordinary Cokriging Light versus Dark Regions	142
6-7 Caves Branch Rockshelter, Testudines Remains Ordinary Cokriging Light versus Dark Regions	143
6-8 Caves Branch Rockshelter, Serpentes Remains Ordinary Cokriging Light versus Dark Regions	144
6-9 Cueva de Sangre, Testudines Remains Ordinary Cokriging Left versus Right Sides	145
6-10 Cueva de Sangre, Cervidae Remains Ordinary Cokriging North versus South Regions	146
6-11 Cueva de Sangre, Rodentia Remains Ordinary Cokriging Light versus Dark Regions ..	147
6-12 Naj Tunich, Aves Remains Ordinary Cokriging Light versus Dark Regions.....	148

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Master of Arts

EVALUATING CAVE USE THROUGH SPATIAL ANALYSIS OF ANIMAL REMAINS
FROM MAYA CAVES IN GUATEMALA AND BELIZE

By

Erol George Kavountzis

December 2009

Chair: Kitty F. Emery
Major: Anthropology

Scholars suggest caves in the Maya region were used for ritual activities and represented a connection to the underworld (Brady 1989; Stone 1995). Recent studies (Moyes 2001, 2002, 2004) use spatial and GIS analysis of artifact distributions to understand the role of spatial cognition in Maya ritual cave use based on directionality. Other studies suggest a variety of cave ritual functions and several cognized spatial divisions within caves such as north-south, east-west, right-left, light-dark, and restricted-open spaces. This zooarchaeological study uses Geographic Information Systems (GIS) to test the spatial distribution of animal remains within multiple cave sites in Belize and Guatemala. These cave sites include Caves Branch Rockshelter and Stela Cave in Belize and Cueva de El Duende, Cueva de Sangre, and Naj Tunich in Guatemala. Patterning is addressed using both spatial analysis tools from ArcGIS and a visual analysis of animal remains by taxonomic groups.

While spatial patterning is present for key taxonomic groups of animal remains, overall patterning of skeletal remains is rare due to small sample sizes, limited distribution of remains, taphonomic processes, the use and placement of animal offerings, the shape of the caves, and the possible differential use of caves within the Maya region. If used properly, GIS coupled with

with zooarchaeological analysis can provide a new method for investigating the use of animal remains in cave contexts.

CHAPTER 1 INTRODUCTION

To the ancient and modern Maya, caves represent entrances into the underworld or Xibalba, and are places where various ritual events are carried out. Recent cave archaeology (Awe 1998; Brady 1989; Stone 1995) attests to the ritual nature of caves in the Maya world and demonstrates that these locations did not primarily serve as dwelling places, refuges, or middens. Therefore, these features represent a known ritual context and the archaeological materials found within them can be assumed to represent, at least in large part, the activities associated with ancient ritual events.

I use the zooarchaeological remains from five cave sites in Guatemala and Belize to improve our understanding of ancient Maya rituals. We know from ethnographic, ethnohistoric, and iconographic records that one of the components of ritual activities was the use of animals as sacrifices and offerings (e.g., Brown 2005; Brown and Emery 2008; Pohl 1983; Tozzer 1941). The Maya codices present ritual events with offerings of animal bread, or tamales, and animal parts (Bricker 1991; Taube 1988; Thompson 1972). Many of these events are associated with caves (Bricker 1991; Stone 1995). Recent ethnographic and ethnoarchaeological studies show a close association between caves/rockshelters and hunting rituals conducted by contemporary Maya hunters living around Lake Atitlan in Guatemala which highlights the continued importance of animals and caves in Maya rituals (Anderson 2009; Brown 2005; Brown and Emery 2008). The writings of Friar Diego de Landa dated to 1566 contain accounts of seasonal and annual rituals which included the sacrificial offerings of animals associated with various landscape features including the cardinal directions and possibly caves (Tozzer 1941). Iconographic and epigraphic research has identified depictions and writing of caves and animal offerings in the codices and carvings of the ancient Maya. Some authors have suggested that

these too can be linked to modern day events (Brady 1989; Pohl 1981, 1983; Taube 1988; Vail 1997).

I have chosen to evaluate the possible connection between the spatial distribution of animal remains within Maya caves and the ancient Maya worldview or cognized landscape.

Ethnographic and ethnohistoric documents show that the contemporary Maya worldview is defined on the basis of various spatial patterns including the layering of the universe, cardinal directions, and sidedness (Brown 2004; Garcia-Zambrano 1994; Mathews and Garber 2004; Moyes 2001, 2002, 2004; Palka 2002; Pohl 1983). Importantly, Maya ritual activities and behaviors are also based on these spatial divisions, so the remains of these activities should be patterned in ways that duplicate the Maya worldview. Many researchers have argued that this same worldview was held by the ancient Maya as well and that analysis of archaeological spatial patterning, particularly in caves, can reveal ritual behaviors associated with the cognized spatial landscape of the ancient Maya (Brady 1989; Moyes 2001, 2002, 2005).

In this thesis, I analyze the caves as ritual contexts and study the distribution of animal remains using GIS and visual analysis to identify spatial patterns related to the Maya worldview. I examine several dichotomized relationships that have been shown by archaeologists to be replicated in artifact distributions in both cave and aboveground sites (Moyes 2001, 2002, 2004). These include sidedness or the left versus right sides of a space, cardinal directionality or the separation of space into northern versus southern and eastern versus western spaces, light versus dark spaces, and open versus restricted spaces. By analyzing the frequency of different taxonomic groups and skeletal proportions in these specific spaces within the cave, I reveal some preliminary patterns in animal use that reflect the ancient Maya worldview and use of ritual space in caves.

This research project was conducted in a total of five cave sites, two located in Belize and three located in Guatemala. In 1997, Dr. Jaime Awe (1998) started the Western Belize Regional Cave Project (WBRCP) which investigated multiple cave sites around the modern town of San Ignacio. Two of these sites, Caves Branch Rockshelter and Stela Cave, are included in this study. Caves Branch Rockshelter (CBR) is located in the Cayo District of western Belize along the Caves Branch River Valley and the faunal assemblage is from the excavation of the site during the summers of 2005 and 2006 by Dr. Gabriel Wrobel (Wrobel and Tyler 2006; Wrobel 2008). CBR is a known cemetery site that dates to the Late Preclassic to Early Classic periods (Glassman and Bonor Villarejo 2005; Wrobel and Tyler 2006; Wrobel 2008). Stela Cave (STC) is also located within the Cayo District along the Macal River Valley of western Belize and the faunal assemblage was from the 2004 season which was excavated by Ph.D. student Cameron Griffith (Ishihara and Griffith 2004). STC dates from the Preclassic to Late Classic periods and contains a large architectural feature in a back chamber that may have served as an altar or platform (Ishihara and Griffith 2004).

Within Guatemala, two of the sites, Cueva de Sangre and Cueva de El Duende, were located at the site of Dos Pilas and were excavated as part of the Petexbatun Regional Cave Survey by Dr. James Brady in the mid-to late-1990's under the supervision of the project director Dr. Arthur Demarest (Brady et al. 1997; Minjares 2003; Scott 1995). Cueva de Sangre is a long (over 3.5 km), multiple tunnel system that is located under a hill about 3 km south of the El Duende Pyramid Complex. It dates to the Late Preclassic to the Late Classic periods (Minjares 2003). Cueva de El Duende is a collapsed cave with a single long tunnel system located just southwest of the El Duende Pyramid Complex and it dates to the Late Preclassic to Early Classic

periods (Brady and Rodas 1992). Preliminary zooarchaeological research was conducted by Kitty Emery in 1998. Emery's identifications are included in this study.

There is one published source used for this analysis, the site of Naj Tunich excavated by James E. Brady (1989) during the early to mid-1980s. Naj Tunich is the largest known cave site in the Maya region and may have served as a pilgrimage site. The ceramics date the site from the Late Preclassic to the Late Classic period (Brady 1989). The faunal remains from Naj Tunich were identified by Susan Colby at UCLA in 1984 and these identifications were included in this analysis. The description and placement of excavation units and types of analysis for these sites is presented in further detail in Chapter 4, Research Setting: Five Caves from the Maya Region under Analysis.

Cognitive Archaeology

The idea that spatial patterning in archaeological remains may reflect ancient behaviors informed by a cognized landscape is a basic tenet of cognitive archaeology and, in many ways, landscape archaeology. Landscape archaeology, simply identified as the study of the social and natural influences of a people's landscape, has allowed researchers to move beyond economic studies of land use and into studies of the social and sacred influences of both the natural and built environment (Knapp and Ashmore 1999; Brady and Ashmore 1999). Cognitive archaeology is another field of archaeology that provides an important theoretical overlay to these landscape studies. Cognitive archaeology can be defined as a basis for reconstructing the "ancient mind" by using the material cultural to understand the behaviors that resulted in the placement of these remains (Flannery and Marcus 1993, 1996, 1998; Renfrew 1994; Renfrew and Zubrow 1994).

Technological advances in spatial archaeology, such as the use of Geographic Information System mapping (GIS), has also aided in the development of these studies of the ancient Maya landscape and mind. Maya landscape archaeologists have spent much time trying to understand

the Maya ritual use of underground sites, caves, and cenotes, or water-filled sink holes, because these geological features are and were such an important element of the sacred Maya landscape (Ashmore 1989, 1991; Brady 1997; Brady and Ashmore 1999). Maya cave archaeology, a more recent addition to archaeology in this region, has helped to solidify our understanding of the ancient Maya ritual use of these openings to the underworld. These theoretical underpinnings are further discussed in Chapter 2, Theoretical Framework: Caves, Landscape, Cognitive Archaeology, and the Use of Space by the Ancient Maya.

Maya Cave Archaeology:

Maya cave archaeology is a new field with a long history. Dating back to the 1840s archaeologists have recorded and documented cave sites within the Maya region (Brady 1989). However, it was not until recently that the importance and ritual significance of these sites became apparent to Maya archaeologists. The Maya region is located within a limestone karstic environment that includes many geological features that are cut into the landscape through water degradation. In the Yucatán region or the northern Maya lowlands, the relatively flat dry environment contains open water-holes throughout the landscape; these water-holes are the cenotes of the ancient Maya. Cenotes served as both water sources and sacred entrances into the underworld. The southern Maya lowlands and highlands include areas of mountainous and flat tropical forest with a plethora of caves and other rock openings throughout the landscape. The ancient Maya viewed any entrance into the landscape as a sacred opening into the earth and as a connection to the underworld (Anderson 2009; Stone 1995). The Maya worldview is based on layering, directionality, and sidedness, and are found to occur in many ritual contexts at above ground sites in large scale events (Brown 2004; Mathews and Garber 2004; Palka 2002). Caves have been shown to represent smaller versions, or microcosms, of the larger Maya worldviews (Moyes 2001, 2002, 2004. For example, the quadripartite placement of artifacts at Actun Tunich

Muknal's Main Chamber (Moyes 2001, 2002, 2005) may be a representation of the large scale foundation rituals for setting territorial borders (Garcia-Zambrano 1994).

Current research in Maya cave archaeology has moved from site-level analyses of cave use to a more regional approach to understanding how and why the Maya accessed and used these landscape features (Awe 1998). Some cave sites are hypothesized to have been ritual pilgrimage sites (e.g., Naj Tunich, Brady 1989), while others were likely elite controlled caves directly linked to a surface site or polity (e.g., the Dos Pilas caves including Cueva de Sangre and Cueva de El Duende) (Brady 1997; Brady et al. 1997). Finally, recent studies have begun to look at multiple cave systems (such as Caves Branch Rockshelter and Stela Cave) to see who was accessing and using these smaller cave groups and for what purposes (Awe 1998; Peterson 2006).

All of these studies have helped to form a new perspective on our understanding of ancient Maya rituals because ritual activities which are often difficult to define at surface sites and within non-elite or commoner spaces are more readily defined in a cave context. There are some known difficulties in working within cave sites, including the taphonomic movement of artifacts, both natural, including animal and water movements within the cave, and cultural, in the form of looting. In addition, stratigraphy and chronology are often problematic because most cave archaeology projects concentrate on mapping and collecting surface artifacts rather than excavation. This is due to the lack of clear stratigraphy in caves. Maya cave archaeology is further discussed in Chapter 3, Prior Research in Maya Cave Archaeology, Zooarchaeology, and GIS.

Maya Cave Zooarchaeology:

Zooarchaeological research has also had an evolving role in Maya archaeology. As described by Emery (2004a), faunal remains from the excavations in the 1940s to 1980s were

collected and analyzed by zoologists to produce a laundry list of animals from archaeological sites. This practice of simply listing animals limited the role of information that could be collected from zooarchaeological materials to questions of subsistence and the types of animals used. Animals were therefore assigned the role of foodstuff in archaeological research during this period. However, there was a push for change during the post-processual movement to revise our understanding of animals in societies (Emery 2004a; Pohl 1983). Zooarchaeology went from being defined as the use of animals for subsistence to the study of the interactions between humans and animals (Emery 2004a). This included the role of animals in ritual and also as sacred beings in many societies (e.g. Pohl 1983).

Maya cave zooarchaeology has also gone through the same evolution. Early cave studies included a short laundry list of animal species within the cave with little to no reference to the role of these animals in ritual or their placement within the caves (e.g. Pendergast 1969, 1971). However, after Mary Pohl's (1983) ground breaking work on the ritual use of animals in the Maya region, specifically in caves and cenotes, researchers began to look into zooarchaeological materials within these settings. James Brady's (1989) dissertation on Naj Tunich, was one of the first Maya cave archaeology projects to address both the role of caves in the ritual patterns of the Maya and the role of animal remains within this specific setting. Recent cave work included faunal analysis and interpretations in their research (Brady et al. 1991; Ishihara 2007; Peterson 2006). Few studies, however, have specifically evaluated the ritual use of animals at cave sites and examined the patterning and meaning of their distribution (for an exception see Emery 2004c). This has left open the opportunity to study faunal remains in cave archaeological contexts in order to test ideas and patterns for the ritual use of animals within caves. The role of

animals within ancient Maya culture and the changes in the study of faunal remains are discussed in detail in Chapter 3 Prior Research in Maya Cave Archaeology, Zooarchaeology, and GIS.

Geographic Information Systems and Maya Caves

Geographic Information Systems (GIS) has become a very important tool in Maya archaeology and Maya cave archaeology in particular where artifact spatial distributions over cave surfaces are of great interest. GIS allows researchers to map at multiple scales, from the site to the region, and allows them to look for patterning within and between excavation units at these sites. Spatial distinctions have always been an important part of archaeological research, but with the addition of GIS, archaeologists are now able to store more information into georeferenced databases and test for statistically-significant patterning.

One of the most important GIS papers in the Maya region identified spatial patterning in artifact distributions (ceramics, lithics, groundstones, faunal remains, broken speleothems, and slate) that mirrored the Maya worldview. Holley Moyes (2001, 2002, 2005) was able to show a quadripartite distribution of artifacts within the Main Chamber at Actun Tunich Muknal in Belize. A more recent GIS-based cave study at El Miron Cave in Spain included faunal remains and helped to answer questions about the seasonal use of caves (Marín Arroyo 2009). Although Marín Arroyo's (2009) study took place outside of the Maya region, it shows the importance of analyzing the spatial distribution of animal remains within a cave site. The use of GIS in archaeology and cave archaeology is explored in full detail Chapter 3 Prior Research in Maya Cave Archaeology, Zooarchaeology, and GIS.

Maya Spatial Patterns, Zooarchaeology, and GIS

Zooarchaeological analysis included the identification of taxonomic groups, elements, sides of elements, age characteristics, and both cultural and natural effects on the faunal materials. For this study, the Number of Identifiable specimens (NISP) was used for the

quantitative analysis of remains. The GIS analysis included using two spatial statistical methods, spatial autocorrelation and cokriging, to identify patterns for the faunal remains by taxonomic groups. Due to the small sample sizes and limited distribution of some taxonomic groups, a visual analysis was also performed. This visual analysis helped to identify some patterns that were not seen using GIS. In Chapter 5, Zooarchaeology, GIS, and Visual Analysis Methods, includes a further discussion in how these cave sites were analyzed and their findings incorporated into this study.

The results from the zooarchaeological, GIS, and visual analysis are presented for each individual cave by taxonomic groupings. The ability to present the data in this form allows the visualization of patterning for the placement of species, elements, and element siding to become apparent for some taxonomic groups. A further and more in-depth presentation of these findings can be found in Chapter 6. There were some limitations identified during the analysis of faunal remains and their distributions within the sites. These limitations include small sample sizes, limited distributions, differential collection methodologies, natural and cultural taphonomic, differential cave shapes, and differential uses of these caves. The limitations are described in greater detail in Chapter 7, Interpretations.

The evaluation of zooarchaeological spatial distributions using GIS revealed that there is some patterning of crustacean, turtle, squirrel, peccary, and deer remains. There is a lack of specific patterning for ray-finned fishes, amphibians, snakes, birds, opossums, armadillos, primates, tapir, raccoons, rodents, agoutis and pacas, and cottontail rabbits. Finally, there is also a lack of patterning for some taxonomic groups that were expected to have close affiliations with either caves or who played a major role in ritual offerings including lizards or iguanas, bats, canids, and felids remains. Although there were no definitive patterns identified throughout all of

the caves, the finding of some patterns indicates that there were possibly some close connections between the placement of faunal remains within the caves and the Maya worldview and delineation of space.

This study provides a baseline for the analysis of spatial distributions of faunal remains in both cave and surface sites in the Maya region. The use of GIS along with the expansion of collection areas and consistent collection methods will produce detailed data pertaining to the spatial distribution of faunal remains within cave contexts. There is also a need for researchers to continue the excavation of many different cave sites within a multitude of contexts. The more information and the storage of this information into geographically referenced databases may allow for a more ideal analysis of patterning of faunal remains with Maya cave sites. The collection and analysis will also allow for larger collections of materials within caves that can be better analyzed using statistical tools available in GIS programs. Chapter 8, Conclusions, provides a more through explanation of the patterns and future uses of GIS and zooarchaeology within Maya cave archaeology.

Summary

In this research project I analyze the faunal assemblages from five Maya cave sites in Belize and Guatemala and reconstruct their spatial distribution using GIS and visual assessment to answer questions about the connection between the ancient Maya worldview, sacred landscape, ritual activities, and the use of animals in caves. In this study faunal remains add another element to the recent analyses of spatial patterns in the material record of caves. Animals are closely associated with how the Maya viewed the world and these associations add another element to the understanding of cave use by the ancient Maya. I suggest that using GIS to map, analyze, and identify the pattern of animal remains adds another method by which zooarchaeologists and archaeologists can conceptualize and identify ritual and secular practices

among an ancient people. Caves represent an important part of Maya archaeology and the use of them for rituals and animal offerings needs to be continually explored.

CHAPTER 2
THEORETICAL FRAMEWORK: CAVES, LANDSCAPE, COGNITIVE ARCHAEOLOGY,
AND THE USE OF SPACE BY THE ANCIENT MAYA

Overview

This research project relies on the theoretical framework of cognitive archaeology. Cognitive archaeology is defined as the study of material cultural and its placement within a site as a vector to understanding ancient behaviors of humans in an attempt to reconstruct the “ancient mind” (Flannery and Marcus 1993, 1996, 1998; Renfrew 1994; Renfrew and Zubrow 1994). I also draw on elements of landscape archaeology theory in understanding the relationship between cognized worldviews and the use of space across a landscape. Landscape archaeology is defined as the study of the social and natural influences of humans on the landscape and it has allowed researchers to move beyond the economics of land use to include the social and sacred influences of the natural and built environment (Knapp and Ashmore 1999; Brady and Ashmore 1999). In this study, I compare spatial patterns in archaeological animal remains across ritual landscapes (caves) with the ethnographically and ethnohistorically understood Maya “worldview” or cognitive map. In this chapter, I review the approaches of cognitive and landscape archaeology and discuss the evidence for an ancient Maya cognized landscape.

Over the last few decades there has been a shift in how archaeologists interpret artifacts and archaeological remains. After the 1960s, the focus of archaeology was on science and the use of the scientific method in answering questions involving economic, subsistence, and other measurable aspects of society (Binford 1962; Trigger 2006). During this time, “New Archaeology” identified three forms of material culture: the “technomic” or economic and subsistence technology, the “socio-technic” or social aspects including kinship and status, and the “ideo-technic” which included religion and ideology (Binford 1962:217). The ideo-technic was identified as the unanswerable parts of religion, ideology, symbology, and cosmology which

were considered unavailable to archaeologists using the material culture we analyze (Binford 1962; Moyes 2001). The human mind was considered inaccessible in the archaeological record. More recently, archaeologists have begun to approach these “unanswerable” issues. Using the theoretical frameworks of cognitive and landscape archaeology, researchers have attempted to link archaeological spatial patterning to ancient religion, ideology, cosmology, and symbology. In Maya archaeology, links between the cognized landscape and cosmology are an important part of our understanding of the use of space in architectural placement across communities (Ashmore 1989, 1991), within natural landscapes (Brady 1997; Mathews and Garber 2004) and even in representations of human interactions (Palka 2002).

In the sections of this chapter, I define and review cognitive and landscape archaeology and discuss their roles in understanding links between the cognized space of the ancient Maya, their spatial use of landscapes, and their ancient religious beliefs, ideology, and cosmology. I then define the Maya worldview and the specific spaces demarcated by the Maya in architecture, daily life, and the Maya codices. This chapter will form the basis for understanding the possible use of cognized space and its reflection in the distribution of animal remains from Maya cave sites.

Maya Cognitive and Landscape Archaeology

Cognitive archaeology was redefined by multiple authors over the last two decades (Flannery and Marcus 1996, 1998; Preucel 2006; Renfrew 1994). Flannery and Marcus (1996:351, 1998:36) define it as “the study of all those aspects of ancient culture that are the products of the human mind” which they separated into groups that include cosmology, religion, ideology, iconography, and other symbolic behaviors. Renfrew (1994:3) defines cognitive archaeology as the “the study of past ways of thought as inferred from the material remains.” All agree, however, that the main focus is the “ancient mind” and the links between symbolism and

material artifacts, placing emphasis on the intentionality of artifact placement and its reflection of an ancient worldview (Flannery and Marcus 1993, 1996, 1998; Renfrew 1994; Renfrew and Zubrow 1994).

Rituals are more easily identifiable in the archaeological record than concepts of religion or ideology because they leave material signatures within the archaeological record (Fogelin 2007). Cognitive archaeology allows for researchers to move beyond the habitual patterns formed by ritual events to understand the specific religious and ideological reasons for behaviors. The Maya, in particular, use space and modify space in ways that reflect their worldview and, therefore, their religion and ideology. As people use and modify space, they leave marks and remains that we can interpret as archaeologists. Therefore, the material remains found in the archaeological record can be used to approach the ancient mind. The Maya were very intentional in their placement of artifacts within caves and this can be seen in the placement of large ceramics, both whole and broken, on both high and low inaccessible parts of the caves (Stone 2005). The ability to understand the Maya worldview has allowed for a cognitive archaeological reconstruction of the ancient Maya mind.

An important approach to cognitive studies is through landscape archaeology, or the study of the human landscape. Landscapes have always been a part of what archaeologists study (Anschuetz et al. 2001; Knapp and Ashmore 1999); however, our perspectives on how landscapes are formed, used, and identified by ancient people have changed. The concept of landscape as “neutral and passive” (Bender 2002:323) has been rejected as archaeologists began to think of landscapes as active agents in ancient worldviews (Brady and Ashmore 1999). Humans cultivate, build, and change their landscape over time and these changes do not always reflect simply the requirements of basic human subsistence and shelter. Instead their use and

modification can reflect such epiphenomenal concepts as religion and sacredness, ethnicity, ownership, and even connections to the past and ancestry. Landscape archaeology is a movement away from a simplistic understanding of the ancient human-land relationship in terms of land-use, subsistence, economics, and politics. Instead landscape archaeology considers the more complex and dynamic relationship between people and landscapes by also including the social, symbolic, and sacred values of landscapes (Knapp and Ashmore 1999).

The Maya are known to have perceived cosmological links between their natural and built landscapes that were “manifest in domestic, civic, and wider spatial scales” (Brady and Ashmore 1999:126). Wendy Ashmore (1989, 1991, 2002) is one of the main proponents of the close connection between Maya land-use and worldview. She has shown that the directionality and layering of ancient Maya built landscapes reflect a pan-Mesoamerican cosmology. For example, temple-pyramid complexes are considered to represent the duality of cave and mountain (Brady 1997; Stone 1995; Vogt and Stuart 2005), while the quadripartite plaza group represent the four quarters of the universe (Ashmore 1989, 1991; Ashmore and Sabloff 2002; Coggins 1980; Stone 2005). Similarly, on a smaller scale, offerings in Maya households to the four corners and center represent the division of the world into four cardinal quarters plus the center or axis mundi (Brady 1991, 1997; Brady et al. 1997; Garcia-Zambrano 1994; Pugh 2005).

The Cognized Universe and Caves

In Maya cosmology, caves represent a particularly important landscape feature that defines them as intrinsically ritual, powerful, and symbolically potent. Here I discuss some aspects of the Maya worldview that relate directly to caves and associated landscape features in both the ethnographic and archaeological record. Directionality and layering are considered the two most important frameworks within the worldview, of the ancient Maya. An emphasis was placed on the separation of space within the horizontal and vertical planes, respectively (Coggins 1980;

Kunen et al. 2002; Mathews and Garber 2004; Stone 2005). The Maya universe is partitioned into three main layers, including the upper-world that is made up of thirteen layers, the earth, and the underworld consisting of nine layers (Mathews and Garber 2004). The directional division of the Maya worldview is defined as a quadripartite separation of space related to the cardinal directions. All of the directions meet at a center point, termed the axis mundi, which is associated with both caves and the ceiba tree (Brady 1991, 1997; Coggins 1980; Mathews and Garber 2004; Pugh 2005). The ceiba tree is believed to be the connection between the three world layers, by holding up the sky, or upper-world, and having its roots reach deep into the ground, or underworld. Caves are identified as another connection point between both the horizontal and vertical planes of the Maya worldview.

Highlighting the work of Eliade, Brady (1991:6) defines the axis mundi as “the universe... the most sacred of places, a place of prestige, a place of inexhaustible abundance... the spot where three levels of the universe meet... the creation of man took place.” This idea of center is incorporated in the patterning of the settlements and within the landscape of the ancient Maya (Brady and Ashmore 1999). Caves are described as the center of the universe because they are located at the intersection of the three layers of the world (Brady 1991). Caves are located within the mountains which are associated with the upper-world. The mouth of the cave is the middle layer or the earth. It represents the conduit between the earth and the underworld (or *Xibalba*). Besides representing the center of the Maya universe, caves are also associated with the underworld (Stone 1989), water (Prufer and Kindon 2005), the home of clouds and rain (Ishihara 2008; Vogt and Stuart 2005), human and agricultural fertility (Stone 1995), ancestry and place of origin (Pugh 2001; Vogt and Stuart 2005), political and social power (Halperin 2005), and as places for ritual events (Brady and Prufer 2005b; Prufer and Brady 2005b).

Ethnographic research can also help in solidifying our understanding of the role of caves and cenotes as centers in the Maya worldview. In early Colonial records, natural features including mountains with caves and water-holes play a large role in the foundation rituals for setting territorial borders (Garcia-Zambrano 1994). To fulfill the spatial requirements, settlements were placed in relation to five mountains, one for each cardinal direction and a center point (Garcia-Zambrano 1994). Ethnographic research on modern Maya communities found similar associations between caves and settlement locations. Tzeltal Maya communities are situated in relation to “sacred caves” from which they derive their community name (Brady 1991:1, 1997; Vogt and Stuart 2005). Integrating the sacred landscape into identification of place and person, the “Tzotzil Maya communities are located around waterholes, along with caves,” and individual’s take their surnames from these water hole or cave features (Brady 1991:2, 1997). Ethnographic studies in the highlands of Guatemala also found that caves and rockshelters are still used as hunting shrines and places of communication between the Maya and the “Guardian of the Animals” (Brown 2005:137-138; Emery and Brown 2008).

In recent years, archaeologists have begun to research caves within the Maya region and many studies found that the caves and cenotes play an important role in the placement of sites (Pugh 2005; Brady 1997; Brady et al. 1997). The cave and cenote as the axis mundi of the archaeological site can be found in both the southern and northern lowlands. Within the northern lowlands of the Yucatan peninsula, many archaeological sites were associated with and connected to a cenote (Pugh 2005) including Mayapan (Brown 2005) and Chichen Itza (Brady 1997). In the southern lowlands, at the site of Dos Pilas large public architecture was constructed on top of an extensive cave system (Brady 1997; Brady et al. 1997). Archaeologists argue that the placement

of elite architecture in relation to cave features is directly related to the ideological foundations of elite sociopolitical rule and control.

Outside and within the Maya region associations are found between large architectural monuments and man-made caves. In the Aztec region, under the Pyramid of the Sun at Teotihuacan, Heyden (1975:131) identified a man-made cave that was found to be associated “with the mythical Chicomoztoc, Seven Caves, [or] place of creation in ancient Mexican mythology.” Other man-made caves have been identified at other sites (Brady 1991) within both the Mexican and the Maya regions. This Pan-Mesoamerican occurrence makes the use of caves as important in the association of civic and elite architecture (Brady 1991). Nevertheless, not all caves in the Maya region are found in relation to archaeological site and site construction. These unassociated caves may have represented pilgrimage sites, for example Brady (1989, 1991) suggests that Naj Tunich and Cueva de las Pinturas were used by the ancient Maya but do not have settlements associated with them.

Caves in the Maya region have also been associated with calendrical rites, specifically the New Year and Ueyab (Wayeb) ceremonies, and also as places for the katun ending celebrations (Pugh 2001; Stone 1989, 1995, 2005). These calendrical associations may be due to the fact that caves are viewed as “the place of primordial emergence of ancestors and places of origin” (Pugh 2001). The ethnographic record also finds that within some modern Tzotzil and Tzeltal Maya groups in the highlands of Chiapas annual ceremonies are still performed at caves within the region (Vogt and Stuart 2005). These rituals have been influenced by Christian ideals and images, but they do show a historical connection between the ancient and modern-day Maya cave rituals (Vogt and Stuart 2005).

Separation of Space and the Use of Space by the Ancient Maya

The use of space, particularly ritual space, is directly linked to worldview. In his early work at Naj Tunich, Brady (1989) acknowledged the fact that caves were not physically uniform and that these differences in cave formations were important to the ancient Maya. The ancient Maya undoubtedly considered each cave a separate landscape within which the worldview could also be symbolically expressed. Here I review the spatial separations that are of particular interest in this study of the cave landscape.

Cardinal Directions and Quadripartite:

Along with other Mesoamerican groups, the Maya associate the world, or their community, or themselves with the center of the cognized universe and from this center extend points in all four cardinal directions, creating the quadripartite divisions of the world (Garcia-Zambrano 1994; Kunen et al. 2002; Mathews and Garber 2004). The Maya directions begin in the east and move counterclockwise to the north, west, and south. The glyphical interpretations and representations of the directions have been debated by epigraphers. Some have connected them with the movement of the sun during the day, suggesting that east and west are associated with the rising and setting of the sun, while the use of north and south are more variable including the zenith and nadir of the sun (Bricker 1988), up and down (Coggins 1988), or that the horizon represented north (Closs 1988).

Each cardinal direction has a series of symbolic meanings and connotations. The east, with the rising of the sun, was considered positive and it represented fertility and the birth of the sun (Coggins 1980) The west or the setting sun, on the other hand, was closely associated with death and the underworld (Coggins 1980). North and south are not very well defined or understood and may in fact represent both up and down respectively (Bricker 1988; Closs 1988; Coggins 1988). Other associations for the quadripartite separation of the ancient Maya cosmos have been closely

identified with the order and chaos associated with the creation of the Maya world (Pugh 2001). The center of this square or intersection of lines can be used to define both ritual use of space (Hanks 1990; Moyes 2001) and the “Rituals of Foundations” (Garcia-Zambrano 1994) used by the Maya to define the borders and placement of communities which usually contain a center defined by a mountain with a cave or water hole. Archaeologists have identified the five directional associations within the formation of architecture (Coggins 1980; Pugh 2001), in the codices and other inscriptions (Bricker 1983, 1988; Closs 1988; Coggins 1980), the placement of communities (Garcia-Zambrano 1994), and also in the placement of artifacts (Griffith and Helmke 2000; Ishihara and Griffith 2004; Moyes 2001, 2002, 2005; Moyes and Awe 1998).

Epigraphic accounts from the Maya codices show an association between directionality and artifactual offerings. The accounts in the Maya codices include animal offerings and sacrifices which work well for this research project. For example, in the Dresden Codex animal offerings are linked to Chac in relation to the four world directions in the almanac on pages 29b-30b. The directional offerings identified in this section include to the east an offering of a tortoise, to the north a fish, to the west an iguana, and to the south an offering of a wild turkey is made at 13 day intervals in this 4 event cycle. The almanac on pages 29b-30b has been described as a summer rain-making ceremony by Victoria Bricker (1991). This is a known epigraphic example of directional offerings of specific taxonomic animal groups and it also may have some connections with caves and rain.

Left and Right Sides

The human body, in both the ethnographic and archaeological record, has been shown to be “the most fundamental spatial domain of the Maya” (Brown 2004:42). William F. Hanks (1984) uses the body as a source of reference when he identifies “three paired oppositions: front/back, left/right, and up/down” (Brown 2004:42). The most significant of these dichotomies

to the ancient Maya is the relationship between the left and right sides, which is identified in “ the left and right sides of the human body, left/right spatial orientation, and handedness have had important and symbolic meanings” (Palka 2002:419). In the ethnographic and iconographic record, the sacredness of sidedness is an important part of the ancient Maya worldview that is also linked to the cardinal directions.

The right side is identified with the east direction, the rising sun, and birth (Coggins 1980), and also with men, power and purity (Palka 2002). While on the opposite side, or hand, the left is a representation of the west, the setting sun, death, and the underworld (Coggins 1980), and is considered the domain of women and the weak. The primacy for the right side can be identified in the pictorial representation of Maya kings on stela, as rulers are usually depicted facing the right. While their subordinates are pictured facing the left, or in an inferior position. In relation to architectural and archaeological evidence, little research has been conducted on the right and left dichotomy. In the zooarchaeological record, Mary Pohl (1983) showed that in zooarchaeological assemblages from ritual contexts there is an association with the ritually charged use of left skeletal elements over right skeletal elements. Other researchers working with ritual contexts, specifically in caves, also attempted to look for this type of right over left sided element patterning , but none of these studies have been able to confirm this occurrence (i.e., Anderson 2009; Brady 1989; Emery 2004c).

Sidedness is an intrinsic feature of ritual space to the Maya. The Maya households are used as representations and also for specific ritual events. Stone (1995) makes reference to the identification of cave as being considered a manifestation of the house. Therefore, caves could also be used in the analysis and understanding of the left and right sidedness of the home and rituals that may have occurred within them. Caves, houses, and other such features are considered

active agents with a personal perspective as though seated looking out through the entrance (Brown 2004). Several authors have suggested that sidedness is an intrinsic feature of ritual space (Palka 2002). Research at the site of Aguateca (Palka 2002) has shown that the left side of the house was used for food and textile production (ethnographically associated with women), while the east side was associated with fine crafting and scribing (associated with men). Therefore it is possible that cave landscapes were also used with attention to their left and right sides.

Light and Dark

Brady's (1989:402) research found a relationship between the types of artifacts associated with the tunnels of the interior (or dark regions) and those associated with the entrances to the exterior (or light regions) of caves. The symbolic association of light and dark (upper-world and underworld) is fairly intuitive in this separation (Brady 1989). It is likely that the Maya considered the darker regions more closely related to the underworld, and therefore more sacred and elite. While the light parts of the caves usually include lit or dimly lit regions of the cave were used for public rituals that could be attended by all class groups. Brady (1989) used artifact differences to suggest that the ceremonies held in light regions were public rituals while those held in dark regions were private ritual events. He also noted that the size of these enclosures played a role in the size of the groups attending these ceremonies (Brady 1989; Stone 2005).

Caves and some architectural features have both a light, including well lit and twilight areas, and dark regions within them. The temple on top of a pyramid has been identified as human-made representations of the cave-mountain relationship (Vogt and Stuart 2005). To the Maya the opening of the temple can be seen by all those in the plazas below; however, the indoor recesses or darker regions of these temples were not accessible or seen by those in the plaza. This access and inaccessibility to rituals may have been a part of the way elite distinguished their

rituals from the commoners in the plaza below. This separation of space intensified the divide between the elites and non-elites in the Maya worldview.

Open and Restricted Access

The construction of archaeological sites is not haphazardly planned. There is intentionality in the placement and construction of architecture based on the Maya worldview. Cosmologically speaking, the placement of large monuments and structures has strong connection ancestor veneration. The most prominent or longest lived areas of the site are usually the parts inhabited by the elite. The commoners are usually found outside of the ceremonial centers and the areas lived in by the elites. The accesses to the elite residences are also restricted with only single openings into their large courtyards. The most apparent aspect of Maya elite center construction is the division between areas of restriction, elite areas, and the open areas, accessible to all status groups (Ashmore and Sabloff 2002).

The use of space within a cave is an important part of understanding the idea of access to these naturally sacred places within the Maya worldview. Accessibility to elite structures is an important part of understanding elite versus non-elite access to many of the Maya ceremonial centers. It has been shown to define how some caves were utilized by who had or had not had access to them. At the site of Dos Pilas, large monumental buildings have been found to have been built on top of caves (Brady 1997; Brady et al. 1997). The access to these caves was restricted to only the elite residents.

Many of these caves also had architectural construction mainly in the form of walls to restrict or close off different areas of the cave. These walls could be used to block off multiple entrances to certain chambers, thus restricting what once might have been a more open area. At multiple cave sites within western Belize, there are examples of stela erections within caves with restricted access (Awe et al. 2005; Healy 2007). The restriction and open access is also part of

the elite and non-elite access to parts of the site and they are related to both private and public rituals, respectively.

Monolithic erection and the restricted access to these areas within caves has been identified as an important part of the ritual behavior of the ancient Maya (Stone 1995). With relation to the restricted and open access within caves, Dr. Andrea Stone (2005) identified the prevalence of whole ceramics that were hidden in high (almost inaccessible) ledges in caves and also in low crevices. This suggested that these less accessible areas may have defined more sacred and important ritual sites or events for the Maya because of their accessibility.

Stone (2005) defined a different model that she called the “High-Low System” of ritual offerings, which is similar to the hot-cold system from present-day Mesoamerican people (Ishihara and Griffith 2004). The high within high-low system is related to the sun, or the hot, while the low is related to the dark, or the cold, both of which show the close association between these two systems. Stone (2005) found that more whole ceramics are found to be hidden in these high (almost inaccessible) ledges in caves and also in low crevices, and suggested that these less accessible areas may have defined more sacred and important ritual sites or events for the Maya. North and south have also been associated with high and low, respectively. These associations may have played a role in the utilization of these inaccessible areas within caves.

Summary

Cognitive archaeology and landscape archaeology provided the theoretical framework for this research study. Caves are a sacred and ritually significant part of the Maya world and the use of these naturally and culturally influenced landscapes are vital to Maya cosmology. Cognitive archaeology includes both the intentional placement of these remains and the repetitive ritual distribution that have also occurred in certain parts of the caves. Using these theoretical frameworks, I attempted to reconstruct the ancient Maya mind in relation to faunal offerings

from cave. The five uses of space, directionality, sidedness, dark and light, and open and restricted access each play a role in the modern and ancient Maya cognition of their landscape. By studying these five spaces, I was able to better understand and analyze how the ancient Maya used caves as microcosms for their universes.

CHAPTER 3
PRIOR RESEARCH IN MAYA CAVE ARCHAEOLOGY, ZOOARCHAEOLOGY, AND GIS

Maya Cave Research: History and Progress over the Decades

Only over the last few decades, have archaeologists begun to look at the importance of caves to the ancient Maya (Brady 1989; Brady and Prufer 2005b). Using the European concepts of caves as habitation sites, early archaeologists did not recognize other possible uses of caves in the Maya region (Brady 1989:3). James Brady (1989) was one of the first archaeologists to demonstrate that caves in the Maya region were used in Prehispanic times, as some are still used today, for ceremonial or ritual events (Brown 2005; Brown and Emery 2008). The concept of the cave and its importance to the Maya is seen in both the use of caves around archaeological sites and in the architecture and artwork of the ancient Maya. For example, archaeologists theorize that the temple-pyramid complex imitates the cave-mountain relationship because the single opening of these windowless shrines mimicked the deep, darkness of caves (Vogt and Stuart 2005). Many archaeologists have given in depth historical accounts of the investigation of caves in the Maya region (Brady 1989; Brady and Prufer 2005; Ishihara 2007; Peterson 2006). I draw on these works to create a brief history of Maya cave archaeology below.

Brady (1989:10) splits the history of Maya cave archaeology “into three periods: the Early Period (1840-1918), the Middle Period (1914-1950), and the Recent Period (1950-present).” The early period included research by some of the forefathers of Maya archaeology and their findings within multiple cave sites in the Maya region sparked some interest into cave studies. Few of the sites, however, were excavated and archaeologists were only interested in the findings of treasures and exotic artifacts. The drawings of John Lloyd Stephens and Frederick Catherwood, the findings from the dredging of the Cenote of Sacrifice by Edward H. Thompson, and the

excavations for early human occupation in the Yucatan by Henry C. Mercer, provide some of the important backdrops to the great discoveries from this time period

During the Middle period (1914-1950), there was a hiatus in major archaeological research throughout the world. Due to multiple world wars and economic downspins, archaeology was little studied or done. Despite the rarity of archaeological work at the time, Thomas Gann conducted research within the Maya region and specifically within caves. Gann's work identified all caves in the Maya region as habitation sites even though the artifactual remains suggested otherwise (Brady 1989).

In the recent period, Brady (1989) identifies all of the research that had been completed up until his dissertation. But, this period has been extended another 20 years since its publication (Brady and Prufer 2005b). The first research paper to include the analysis of caves as places for rituals and habitation was written by J. Eric Thompson in 1959. In Thompson's (1959) *The Role of Cave in Maya Culture*, building upon ethnographic and historical sources, caves are identified as places of ritual instead of places of habitation. Thompson lists eight possible uses for caves including as sources of drinking water, sources of sacred water, places of ritual rites, for burials or cremations, as art galleries, ceremonial deposition of artifacts or remains, areas for refuse, and other non-specific uses (Brady 1989: 32). Most of these uses revolve around water, rituals, human burials, offerings of goods both artifacts and ecofacts, and as art galleries. This list of ceremonial uses for caves in the Maya region is still an important part of how researchers identify and explore the use of caves in this culture area.

Archaeologists and iconographers alike are now studying the Maya cave systems as an intrinsic feature of the ancient Maya ritual landscape and ceremonial universe (Brady 1989; Healey 2007). The material remains are ritually linked and should form a spatial pattern of

distribution when they are analyzed. Recent ethnographic and ethnoarchaeological studies have shown a close association between rockshelters and hunting rituals in within the modern day Maya located around Lake Atitlan in Guatemala which show relative importance of caves in Maya rituals (Brown 2005; Brown and Emery 2008). Iconographic and epigraphic research has found depictions and writing of caves in codices and carvings of the ancient Maya. These depictions of the caves have been associated with the cave in many different ways including its depiction as a house, a hole, a place of fertility, and the link to the underworld (Stone 1995). Zooarchaeology has been included in some recent studies; however it has not yet been fully integrated into these studies (Ishihara 2007; Peterson 2006; Spenard 2006).

Brief History of Maya Zooarchaeology

In the past, Maya archaeologists viewed animal remains and their associations within archaeological contexts as evidence of past subsistence practices or as a means to reconstruct ancient environments (Emery 2004a, 2004b). However, to the ancient Maya, animals also served an important function in ritual behavior (Emery 2003, 2004a, 2004b, 2004c; Pohl 1983). Pohl (1983) provided the first review of the ritual importance of animal remains in caves, cenotes, burials, and caches. Some of Pohl's (1983) ideas became a framework for the analysis of ritual faunal deposits, most notably her theory on the ritually charged use of left elements over right elements (Beaubien 2004; Moholy-Nagy 2004; Teeter 2004).

Early zooarchaeological studies attempted to identify the possible ritual associations of animal bones from caves by looking for the patterning and associations presented by Pohl (1983) (e.g., Brady 1989). There are only a few zooarchaeological studies that analyze cave fauna sufficiently (Brady 1989; Emery 2004; Pendergast 1969, 1971) and only a few have looked at multiple cave sites within a region. Usually only small faunal assemblages or parts of an assemblage are identified (Ishihara 2007; Peterson 2006).

Beyond even the simple analysis of animal assemblages recovered from cave sites, the archaeological and ethnographic evidence for patterned associations between artifacts related to specific ritual beliefs or behaviors suggests that zooarchaeological remains can provide important additional data. Animals are vital actors in most Maya rituals today and in the past (Pohl 1981), therefore their remains are also likely to have been discarded or intentionally placed in patterned spatial distributions and/or in patterned associations with other artifacts. These remains are vital to a full understanding of the archaeological patterning being revealed through other archaeological studies of ancient cave-related rituals.

Ritual Use of Animals from the Maya Region

In Mary Pohl's 1983 book chapter *Maya Ritual Faunas: Vertebrate Remains from Burials, Caches, Caves, and Cenotes in the Maya Lowlands*, she describes in detail each of the major vertebrate animal species and families that are represented and most commonly used in rituals from the archaeology, ethnography, and ethnohistoric records. This list includes deer, monkey, peccary, dog, felines, fish, snakes, opossums, armadillos, crocodiles, turtles, turkeys, birds, and small mammals (i.e., rats, bats, etc.). This list is a direct reflection of the types of animals most commonly depicted in the Maya codices and those most commonly found in the archaeological record. Some of the major animal groups are highlighted and reviewed from this paper and newly identified associations are also discussed.

The most commonly identified faunal remain at most archaeological sites and in the epigraphies in the Maya region is the deer. The white-tailed deer (*Odocoileus virginianus*) is identified more often but the brocket deer (*Mazama* sp.) is also an important deer species. The deer is associated with the sun and the renewal rites of the Maya New Year ceremonies known as the *cuch* rites which have been identified as being related to the modern day cargo rites (Pohl 1981, 1983). Within the Maya codices the deer, specifically the white-tailed deer (von Nagy

1997) is an important part of hunting and trapping scenes (Taack 1973; Vail 1997; von Nagy 1997), and as ritual offerings (Bricker 1991). Peccaries (Tayassuidae) are within the same order, Artiodactyla, as the deer, and they are also commonly identified at archaeological sites. There are no identified associations but peccary skulls are often found in the archaeological record and may have been intentionally treated differently from other parts of the body (Pohl 1983).

There are two major groups of monkeys located in the Maya region, the howler monkeys (*Alouatta palliata* and *Alouatta pigra*) and the spider monkey (*Ateles geoffroyi*). Monkeys are rarely identified in the archaeological record, but they are associated with the arts and creation myths of the ancient Maya (Baker 1992). Scribes are often depicted as monkeys and their body parts are sometime incorporated in the depictions of deer which may be a link between these two animals (Pohl 1983). There have been a few monkey remains found within caves in the Maya region.

Dogs, or the family Canidae, are also an important part of the archaeological record, the domestic dog (*Canis familiaris*) represents one of the very few domesticated species in the Maya world. Dogs were at time both an important food source, but also an important part of rituals, including the New Year ceremonies. Mythological literatures (Pohl 1983) identified dogs as being associated with assisting those across the river of the underworld and were commonly offered in burials for this purpose. The felines or cats, the family Felidae, are usually associated with the largest representative species in the Maya region, the jaguar (*Panthera onca*). Jaguars are closely associated with lineage, rulership and power, and also as an underworld deity (Pohl 1983). Jaguar paws and pelts are found in the epigraphic and archaeological record and may have played a role in the accession of rulers (Pohl 1983).

Fish have been associated with some rituals like the *cuch* rite and marine fish, in particular, can be found in burials and elite residences. Marine fish are considered the most representative species in the trade between coastal sites and inland sites, and these marine goods represent status differentiation at inland sites. Fish remains have been identified as part of the “cult of the sea” which shares some associations with renewal ritual events (Pohl 1983). Marine shells are also important symbols to the ancient Maya, they have been found to be associated with death and birth, and also with fertility, rain, and water (Pohl 1983). Fish and shells are both found to be associated with water and may also have a close association with caves since these land formations are also associated with being places of pure water and fertility.

There are some important reptilian families identified as being ritually significant to the Maya, including snakes (Serpentes), crocodiles (*Crocodylus* sp.), turtles (Testudines), and lizards (Sauria) represented mainly by Iguanas (Iguanidae). Snakes are found in depictions of ritual bloodletting and may be associated with this act of sacrifice to the gods. Crocodiles are associated with the earth and the ancient Maya depict and describe the world as the back of a crocodile (Pohl 1983). Turtles are associated with water and may have also been used as drums. These turtle drums may have provided the music during ritual events, especially those that occurred within caves (Zender 2006). The association of water and turtles may be an important connection between the depositions of their remains within caves that are also associated with watery worlds. The iguana is an important part of the offerings by the ancient Maya to the gods. Iguana offerings in the form of “iguana breads” (Thompson 1972) or “iguana tamales” (Taube 1988:238) are found throughout the Maya codices and they have been also identified to offerings in to the western direction (Bricker 1991).

There are numerous species of birds located within the Maya region. The most notable and only other domesticated animal, besides dogs, bees, and possibly the Muscovy duck, from the Maya region is the turkey (*Meleagris gallopavo*). The turkey was identified as an important part of ritual offerings during the Postclassic and is found depicted multiple times in the codices (Bill et al. 2000; Bricker 1991, 1997; Pohl 1983; Taube 1988; Thompson 1972) and the ethnographic accounts of Diego de Landa (Tozzer 1941). Other birds have specifically important functions including the quetzal whose bright green feathers are shown in the ornamentation of kings, the macaw which was traded long distances and is connected with the sun because of its bright red wings, and finally, the owl, which is identified with omens (Pohl 1983).

Both medium-sized mammals, including the opossums (Didelphidae) and the armadillos (*Dasypus novemcinctus*), and small mammals, including rodents (Rodentia), and bats (Chiroptera), are identified as being significant animals to the Maya. Opossums are depicted in the Maya codices as “Bacabs” and may be part of the New Year and Uayeb rites (Thompson 1972; Love 1986; Taube 1988). The armadillo is rarely represented pictorially, but within Mesoamerica it has been associated with fertility (Pohl 1983). Bats have symbolic links to the underworld and caves, and they may be an important symbolic representation of the underworld (Brady 1989; Pohl 1983). Rodents are also found within caves and they too may have some associations with the underworld.

Pohl (1983), besides individually identifying important animal species to the Maya, also discusses some of the symbolic representations and use of animal body elements, element sides, and animal age classes. Deer haunches are offered throughout the Maya codices and are theorized to have a close connection with the offering of animals by elites (Bricker 1991, 1997; Thompson 1972). The haunches are considered a prime cut of meat to the ancient Maya. In

Pohl's (1983) work at Seibal and Copan and the Maya codices depictions, she found that the left haunches were the most important part of the deer offered in rituals and consumed by the Maya elite. Pohl (1983) identifies directional symbolism in the ritual deposition or offering of faunal remains, most notably her theory on the ritually charged use of left elements over right elements (Beaubien 2004; Moholy-Nagy 2004; Teeter 2004). The age of animals is also considered an important part of how and when animals are offered for specific sacrifices. When the age classes of animals are identified in ritual contexts and the epigraphic literature, there are examples of younger animals as being necessary in the sacrificial offerings of animals for certain rites. For example, immature deer are needed for some rituals to the rain god and fertility goddesses and young dogs have been identified in the New Year rituals (Pohl 1983). The offering of animal remains may also have a close association with the three main elements of the Maya including air, earth, and water (Kunen et al. 2002; Mathews and Garber 2004). At the site of Caracol, Diane Z. Chase and Arlen F. Chase (1998) identified a cache as having three layers that contain a top layer of bird remains symbolizing air a middle layer of mammalian remains symbolizing land or earth, and a lower level containing fish remains that symbolizes the watery underworld.

Previous Maya Cave Zooarchaeological Research

Zooarchaeology offers an interesting tool of analysis for understanding ritual. During the excavation of surface sites it is difficult to distinguish between the animal remains from consumption or ceremonial practices. At surface sites most midden, occupation, and fill contexts contain the remains of animals used for both food and domestic and public ritual. Caves, however, do present a known ritually utilized archaeological context, which zooarchaeologists can use for our advantage. There are a few research studies that have attempted to incorporate the faunal materials into the overall analysis of artifacts from these sites. These sites are located in both Guatemala, including Naj Tunich (Brady 1989), Cueva de los Quetzales (Emery 2002),

the Grieta Principle at Aguateca (Ishihara 2007), cave sites surrounding Cancuen (Spenard 2006), and also in Belize, including the caves sites Eduardo Quiroz Cave (Pendergast 1971), Actun Balam (Pendergast 1969), Actun Polbilche (Pendergast 1974), and the Sibun Valley Caves (Peterson 2006).

In the early to mid-1970s, Pendergast (1969, 1971, 1974) incorporated faunal analyses into the study of Actun Balam, Eduardo Quiroz Cave and Actun Polbilche. These analyses provide information about the types of animal remains from the site; however, they are not fully incorporated into the overall analysis of the site and this keeps the zooarchaeological and other artifactual remain analyses separated. At the site of Naj Tunich, Brady (1989) identified possible uses for the cave in elite ritual events and accession ceremonies, and he also incorporated the analysis of faunal material conducted by another researcher into the overall analysis of the site. This analysis helped in solidifying and identifying some of the patterns that were hypothesized by Pohl (1983).

Recent studies, the Sibun Valley Caves (Peterson 2006) and the Grieta Principle at Aguateca (Ishihara 2007), have also incorporated the analysis of faunal remains into the overall identification of patterns within the site. In 2002, Emery analyzed a sample of the faunal remains from the site of Cueva de los Quetzales and was the first paper to specifically identify and discuss in detail the overall patterning of the remains from this elite-controlled faunal assemblage. Over time, the analysis of faunal remains in Maya cave archaeology has increased and these remains are being incorporated and identified as important vital parts for the overall analysis at these cave sites. However, there are some recent studies at the cave site of the Cancuen area that lack the necessary laboratory identifications necessary in using zooarchaeological materials in the analysis of faunal remains (Spenard 2006). Animal remains

were identified very sparsely from photographs, and although they were incorporated into discussion of these sites, I feel they were a step back in the analysis of faunal remains from archaeological contexts.

In a recent study from this year, Elyse Anderson (2009) examined the faunal remains from multiple cave sites in Belize and Guatemala to identify possible ancient hunting caches. The ethnographic record has shown that multiple rockshelters around the Lake Atitlán in Highland Guatemala contain large number of animal remains being cached and offered as part of pre- and post-hunt ceremonies (Brown and Emery 2008). Anderson (2009) identifies whether or not the ancient Maya also cached or interred the remains of animals within caves during hunting rituals as proposed by Emery and Brown (2008). These studies were able to identify the possible relationships between the modern and ancient use of rockshelters and caves for hunting caches. The specific placement of animal remains more accurately accessed using spatial computer analysis programs to identify the patterns that may be lost during visual analysis.

GIS in Cave Research Projects and the Maya Region

Geographic Information Systems (GIS) has become a prominent part of archaeological research because it offers archaeologists a tool to better understand site-level and artifact-level spatial distributions. It also provides a database management system to organize archaeological data. To some archaeologists GIS provides a tool for analysis, but it also can be seen as a methodological and possibly theoretical addition to study of archaeological sites. Initially used to look at the regional level of sites, GIS can also serve as a great mode of analysis at the site- and even within the site-level (Ebert 2004; Kvamme 1999). Therefore, the scale of GIS can be an important addition to understanding ancient cultures. GIS is a relative new science to the field of archaeology and anthropology. It has only recently become an important addition to most archaeological research project. From a zooarchaeological perspective, GIS can serve as a tool to

identify the spatial distribution of faunal remains at an archaeological site (Marín Arroyo 2009; Nardini and Salvadori 2003). Within Maya cave research, GIS has also been shown to be a great tool in the identification of patterns associated with the ancient Maya worldview (Moyes 2001, 2002, 2005).

GIS was initially used to study large-scale regional studies in archaeology (e.g., Belli 1999). But more and more studies have begun to use it to look at the distribution of artifacts within a single archaeological site (e.g., Arata 2008). As a zooarchaeologist, I am interested in using GIS as a tool for understanding the spatial distribution of faunal remains within a site to answer questions of subsistence, social classes, trade, and many other aspects of the human and animal relationship. On a site level, the mapping of the distribution of faunal remains can help to answer questions of site usage and seasonality. In a recent study by Marín Arroyo (2009), the spatial distribution of faunal remains at El Miron Cave, Spain were analyzed to find if there were patterns in both the types of animal remains identified in the cave and their overall placement within the cave. Marín Arroyo (2009) showed that the remains identified indicated that the site was temporarily occupied during the summer and that differential butchering techniques were used for the main two species identified at the site. The red deer, a large-sized mammal from the region, were butchered at the kill site while medium-sized mammals, Ibex, were brought back to the cave whole. The research at El Miron cave presents an interesting model for future zooarchaeological studies, including my thesis, because it shows that the patterning of faunal remains can be used in understanding past human behaviors.

Within the Maya region, GIS has also helped in the analysis of patterning within cave sites. Archaeologists working in the Western Belize Regional Cave Project incorporated GIS analysis into their cave research (Moyes 2001, 2002, 2005; Moyes and Awe 1998; Griffith and Helmke

2000). These studies produced a spatial understanding of the patterns of remains within these cave sites. They also produced a large scale database that includes all of the necessary and important artifactual information in relation to artifact placement both vertically and horizontally. GIS offers researchers the opportunity to give later researchers the chance to reconstruct and reanalyze the remains from an archaeological site. For this thesis, the use of old maps and the addition of databases about the faunal assemblages from these sites has helped to build a basis for the study of zooarchaeological remains from these sites.

Current Research Goals

Maya cave zooarchaeology is a new and budding field in Maya archaeology. Until recently, Maya zooarchaeological research provided archaeologists primarily with a laundry list of species, with little to no interpretation of the animal remains being identified within these projects. New research is looking at the ritual significance of animal remains in these known ritual contexts of caves. The Maya have a strong connection with rituals and the use of animals within these rituals. My research project is pushing it further by adding a spatial component of using GIS to understand the distribution and intentional placement of these remains within the caves by the ancient Maya. The next chapter describes in full detail the cave sites that were analyzed in this study. Each site represents an example of how caves were used by the ancient Maya for ritual events and the influence of animals during these rituals.

CHAPTER 4
RESEARCH SETTING: FIVE CAVES FROM THE MAYA REGION UNDER ANALYSIS

Introduction

The Maya region is located in Mesoamerica and includes the Yucatan Peninsula in Mexico, Guatemala, Belize, and parts of Honduras and El Salvador. This region lies on a karstic limestone foundation that is characterized by sinkholes, cenotes, caves, rockshelters, and other such natural formations. My research concentrates on faunal assemblages from two cave sites from Belize and three from Guatemala. One of these faunal assemblages was previously identified in 1984 by Susan Colby and published in James Brady's dissertation on Naj Tunich. The remaining four cave faunal assemblages from Caves Branch Rockshelter, Stela Cave, Cueva de Sangre and Cueva de El Duende were identified by me for the purpose of this thesis. Here I present the site and excavation information for each assemblage. The location, use patterns, and excavation methods, including placement of units or surface collections and cave formations, for each site are highlighted and used to explain the selection of these sites for my analysis.

In 1997, Jaime Awe (1998) began a research project called the Western Belize Regional Cave Project (WBRCP) that was interested in understanding the use of multiple cave sites around the modern town of San Ignacio. Their main goals were to identify patterns and difference for the use of caves within the region, over time, and by different social classes. WBRCP started off by mapping and excavating known cave sites around San Ignacio, but the project also continued to examine and look for new cave sites within the region that were later excavated. The overall theme of the WCRCP research questions were to understand how and by whom were these cave were being used through the mapping and excavation of multiple cave sites in this region (Awe 1998). Awe (1998) describes each cave as being a different and unique natural feature, since no two caves are ever the same. Some sites are simple rockshelter

overhangs, like Caves Branch Rockshelter; however, others are more complex and include multiple chambers that show a large amount of human construction and movement of objects into these chambers, such as the large limestone monument located in the back chamber of Stela Cave. The idea that all caves are morphologically unique is hypothesized to have played a role in the type of rituals that may have been performed at these sites (Awe 1998). Stela Cave and Caves Branch Rockshelter were both part of the WBRCP and their mapping and excavations were done under supervision of Dr. Jaime Awe (1998).

Primary Research Sites in Belize

Caves Branch Rockshelter, Belize

Caves Branch Rockshelter (CBR) is located in the Cayo District of Western Belize along the Caves Branch River Valley, approximately 20 kilometers southeast of the modern capital of Belize, Belmopan (Figures 4-1, 4-2) (Wrobel 2008). A rockshelter is a cave formed by a ledge of overhanging stone, the most important part of the rockshelter is the dripline which is a line on the ground in front of a cave formed from the dripping of water down from the overhanging rocks above. CBR is 35 meters long north to south, 15.2 meters high, and the dripline goes to a maximum depth of 10 meters (Glassman and Bonor Villarejo 2005). The Caves Branch River runs to the south of the site and may have been an important source for procuring animals whose remains were possible deposited within the site. CBR was excavated in 1994 and 1995 by Juan Luis Bonor Villarejo (Bonor 1998, 2003; Glassman and Bonor Villarejo 2005) and recently from 2005 to 2007 by Gabriel Wrobel (Wrobel 2008; Wrobel and Tyler 2006). The archaeological site of CBR is well known for containing a large number of human burials

The ceramics assemblages cover a long time span and include “numerous ceramics dating to the Floral Park / Hermitage / Spanish Lookout and New Town Complexes” or the Late Preclassic to the Early Classic (Wrobel 2008:3). Accelerator Mass Spectrometry (AMS) of the

human remains from the site include a range of 800 years that work within this time frame (Table 4-1). There were 15 to 20 mounds located in front of the rockshelter which appears to represent the local population who utilized CBR as a cemetery (Bonor 1998, 2003). The use of the rockshelter as a cemetery and its lack of grave goods appear to give the site a more domestic rather than ritual function for the local population (Bonor 1998, 2003). Wrobel (2008) used Peterson's (2006:13) hypothesis for the Sibun River Valley cave site. That is that the elites controlled larger and more impressive caves for their rituals, while leaving the smaller and less impressive caves to be used by commoners. Thus, CBR and other smaller cave sites may represent differences in the use of caves between elite and commoners and not the separation of different ritual events (Healy 2007; Wrobel 2008).

The CBR faunal material for this analysis comes from the recent excavations by Dr. Wrobel in 2005 to 2007. I analyzed the remains from the 2005 and 2006 seasons which included excavations of the northern (Operation 1A), central (Operation 1B and 1D), and southern (Operation 1C) portions of the rockshelter. These excavations were interested in looking at the overall distribution of human remains at the site (Figure 4-2) (Wrobel and Tyler 2006; Wrobel 2008). During the 2006 season, excavations were continued in Operations 1A and 1B, with a new operation, Operation 1D, being excavated within the small cave located in the eastern-most section of CBR. During the first field season in 2005, an attempt was made to define stratigraphic layers; however, distinct layers were not present. Therefore, all levels were excavated in 20 cm arbitrary levels (Wrobel and Tyler 2006; Wrobel 2008). The soil is typically a gray silty limestone soil that is homogeneously mixed chronologically and is defined as grave fill (Wrobel and Tyler 2006). Ceramic sherds dating from the Late Preclassic to the Early Classic

period were found within the same level. Multiple disarticulated burials were found within the site caused by the excavation of graves during different time periods.

The excavation units of CBR were made on a grid system of 1 meter by 1 meter units which aided my analysis of the spatial distribution of faunal materials (Figure 4-2). For the GIS analysis of this site, the units were used as the specific areas of analysis. This site provided some interesting information because it is a rockshelter with known human interments on a large scale. The soils are not stratified and represent grave fill which might show some different patterning than the other caves in this study that do not have multiple burials associated with them. There is also the possibility for high natural disturbances because of both run-off of water and also animal intrusions into the soils within the rockshelter (Wrobel and Tyler 2006).

Stela Cave, Belize

Stela Cave is located in the Macal River Valley of western Belize and was also a part of the Western Belize Regional Cave Project (Figures 4-1, 4-3) (Ishihara and Griffith 2004). This small cave is easily accessible and was looted by modern people. The ceramics within the cave date from the Preclassic to the Late Classic periods (Table 4-1). The cave was mapped and excavated in 2003 (Ishihara and Griffith 2004). The excavation and mapping of the cave was done “to examine the extent and nature of the various architectural features and their role in the use of space in Stela Cave” (Ishihara and Griffith 2004:57). The cave consists of multiple chambers which contain architecture modifications (Figure 4-3). These modifications may have served multiple functions; the most notable is the large square stone slab in Chamber 3 that is theorized to have been used as a platform for performances or as an altar (Ishihara and Griffith 2004). No site has been identified near Stela Cave.

In Chamber 1, six units were excavated. Units 1 to 5 were 1 meter (east/west) by 4 meters (north/south) and unit 7 was a 1.5 meter extension north off of unit 2 (Figure 4-3). In the back

chamber, Chamber 3, there were four excavation units (Units 8 to 11). North of the large limestone platform or altar there was a 2 meter by 2 meter excavation unit. Along the western wall of the chamber, there was a very small and shallow surface (Unit 10) collection taken along the wall. Unit 9 was a 1 meter by one meter unit excavated within a small alcove in the northern part of Chamber 3. Finally, next to a large stone formation, unit 11 was excavated; it followed the contour of the rocks with an outline of a unit that was about 2 meter by 2 meters in size. Faunal materials were identified for most of the units, except for units 9 and 10.

Primary Research Sites in Guatemala

The next two caves, Cueva de Sangre and Cueva de El Duende, are located at the site of Dos Pilas in the Petexbatun region, in the Pasion River Valley and were part of the Petexbatun Regional Caves Survey (Figures 4-1, 4-4, 4-5). There have been about 30 caves identified in the Dos Pilas region and seven of these caves have been mapped and excavated and/or surface collected.

Cueva de Sangre, Guatemala

Cueva de Sangre, Guatemala is located above a settlement at the site of Dos Pilas about 3 kilometers southeast of the El Duende Pyramid which is located 1 km west of the site core (Figures 4-1, 4-4) (Brady 1997; Brady et al. 1997; Brady and Scott 1997; Minjares 2003). Cueva de Sangre is a long cave measuring 3,314 meters in total length that runs underneath a small hill with 4 entrances (Brady 1997). The main area of excavation included a 400 meter long section of the cave that had a detailed map of each artifact's location. Cueva de Sangre was incorporated into the architecture and mounds on top of this site and to limit the access to this tunnel system many of these openings being deliberately blocked by stones (Minjares 2003). The artifacts from the site were both from surface collections and excavations. Cueva de Sangre is an interesting site because of its waterlogged, clay-rich environment. Special collection techniques were

incorporated including the use of deflocculant and water screening in order to excavate through clay-rich soils (Brady and Scott 1997).

Being the most complex cave system at Dos Pilas, there are multiple cave operations at the site. A total of eleven operations were either excavated or surface collected (Figure 4-4). Most of the surface collections came from Operation 1 within the main entrance of this complex tunnel system. Operation 1 contained three architectural constructions including a wall built at the entrance of this cave and a 6 meter long limestone pavement area (Minjares 2003). This part of the cave floods during the rainy season and had a large amount of clay and muddy build up. Faunal materials were also located in the other operations located in the cave, however, there are few descriptions of the other parts of the caves available (Minjares 2003). Ceramics from this cave date from the Late Preclassic to the Late Classic with most of the materials dating to the Early and Late Classic periods (Table 4-1).

Cueva de El Duende, Guatemala

Cueva de El Duende, Guatemala is a cave site that was located just southwest of the El Duende pyramid at the site of Dos Pilas (Figures 4-1, 4-5) (Brady 1997; Brady et al. 1997). The site was identified from the collapse around the entrance of the cave and the site includes a chamber that then opens up to a long tunnel, which runs for about 300 meters (Minjares 2003). The cave has a circular opening that is about seven meters in diameter. The main chamber is 17 meters long and about 7 meters wide and the height varies from 4 to 5 meters (Brady and Rodas 1992). The cave was split into three operations that was mapped and excavated (Figure 4-5).

Operation 1 is located at the cave entrance and runs into the first main chamber of the cave (Minjares 2003). This area contained the remains of stone constructions that may have been used to block the entrance of the cave during ancient times. Operation 2, west of operation 1, has an entrance to the south that consists of a large, dry room and contains the largest artifact scatter in

the cave. Operations 1 and 2 are both located within regions of the cave that are light by natural light (Minjares 2003). Operation 3 “consists of two large tunnels with low ceilings” and has a floor that maybe flooded during the rainy season because of the high amount of clay and mud in this part of the cave (Minjares 2003:42). Operation 3 has no natural lighting and is the dark-zone of the cave. The ceramics from Cueva de El Duende date to the Late Preclassic to Early Classic periods (Table 4-1) (Brady and Rodas 1992). There is a preliminary study of the faunal remains completed for Cueva de El Duende by Dr. Kitty Emery which were incorporated into my analysis from the site (Brady et al. 1991: 726-730).

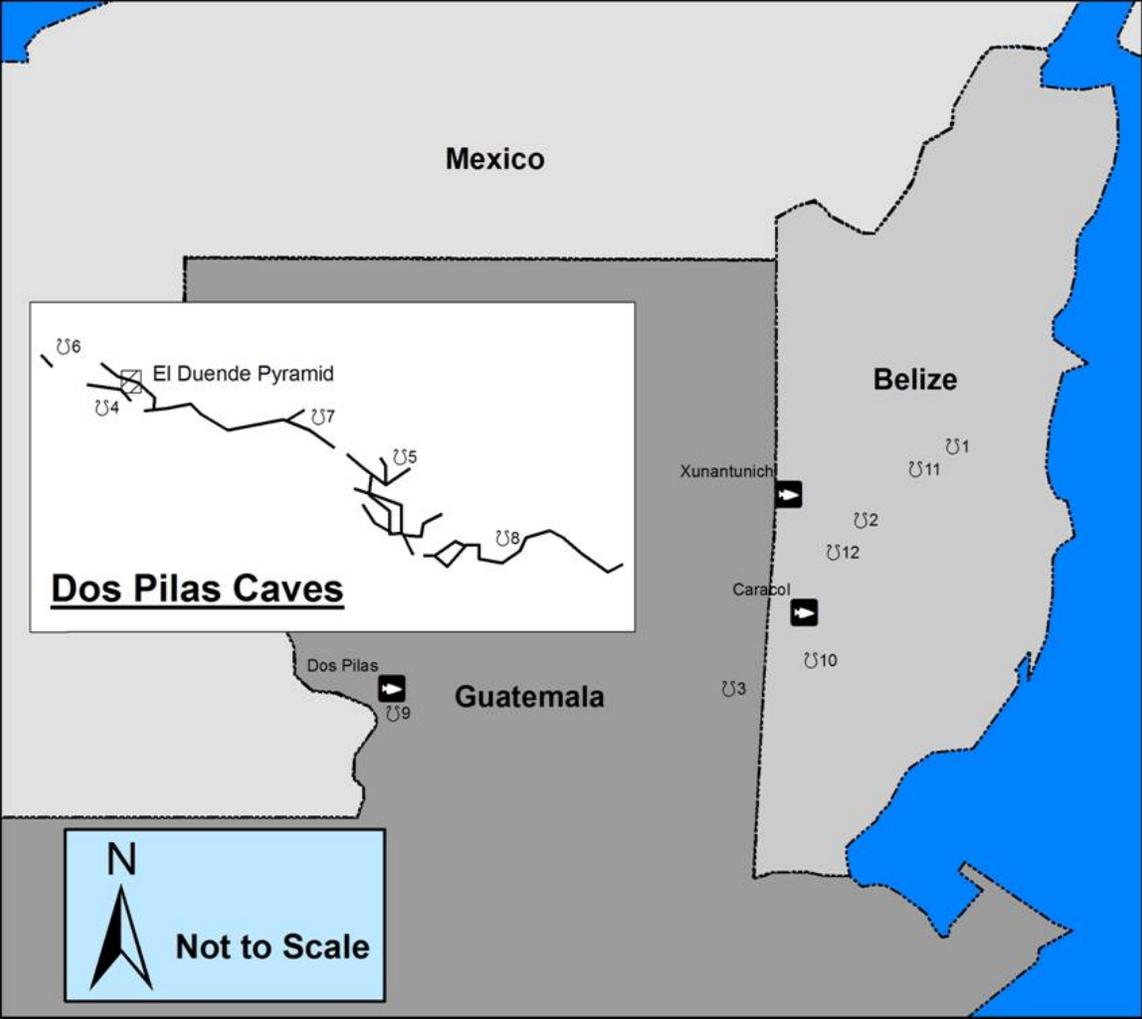
Published Source from Guatemala: Naj Tunich, Guatemala

Naj Tunich is one of the largest known caves in the Maya region (Figure 4-1). It is located in the Maya Mountain of Guatemala close to the Belizean border (Brady 1989). The cave was discovered in 1980's and multiple field seasons took place at the site during the early to mid-1980s. The site is most notably known for having a large number of cave drawings with glyphs that are important for understanding the ritual use of caves by the Maya elite during accession ceremonies. A total of 9 operations were excavated in the cave, but the faunal remains analyzed in this thesis are from Operation IV. Operation IV was used for this study because it has a map that depicts all of the surface collection locations (Figure 4-6). The faunal remains from the surface collections and some excavations in Naj Tunich were analyzed by Susan Colby at UCLA in 1984. Faunal material was analyzed and the identifications include the taxonomic information, NISP, element, side, age, and presence/absence of burning. The ceramics in the cave date from the Late Preclassic to the Late Classic periods (Brady 1989). There are no sites located near Naj Tunich and the site is considered a pilgrimage site for the Maya, with the elite accessing the inside portions of the cave for private rituals and the commoners having access to and utilized the entrance of the cave for large public rituals (Brady 1989).

Summary

The five caves identified in this research project present a varied representation of the types of caves found within the Maya region. The variation in cave types, placement in or adjacent to sites, time periods, and the possible ritual events which occurred in these caves are important aspects to consider during this analysis (Awe 1998). Caves Branch Rockshelter is a known ancient Maya cemetery with a possible settlement site located adjacent to it. Stela Cave contains a large altar or stela that was intentionally placed in the cave and may have served as a place for ritual events. Cueva de Sangre and Cueva de El Duende are associated with elite architecture at Dos Pilas and may have been only utilized by elites. Finally, the largest known cave site, Naj Tunich, may have served as an ancient pilgrimage site for the Maya. Each of these sites provides different conditions (or settings) for investigating the use of animal remains during ritual events.

Selected Caves Sites from the Maya Region, Including the Five Sites Under Study



	Cave_Sites
	Arch_Sites
	Dos Pilas Caves
	El Duende Pyramid
	Dos Pilas
	Belize
	Mexico
	Guatemala
	Rivers

- Caves Sites:**
- | | |
|-----------------------------|-----------------------------|
| 1. Caves Branch Rockshelter | 7. Cueva de Rio Murcielagos |
| 2. Stela Cave | 8. Caxon Pec |
| 3. Naj Tunich | 9. Cueva de los Quetzales |
| 4. Cueva de El Duende | 10. Actun Balam |
| 5. Cueva de Sangre | 11. Actun Polbilche |
| 6. Cueva de Murcielagos | 12. Eduardo Quiroz |

Figure 4-1. General Location of Caves Sites in Belize and Guatemala.

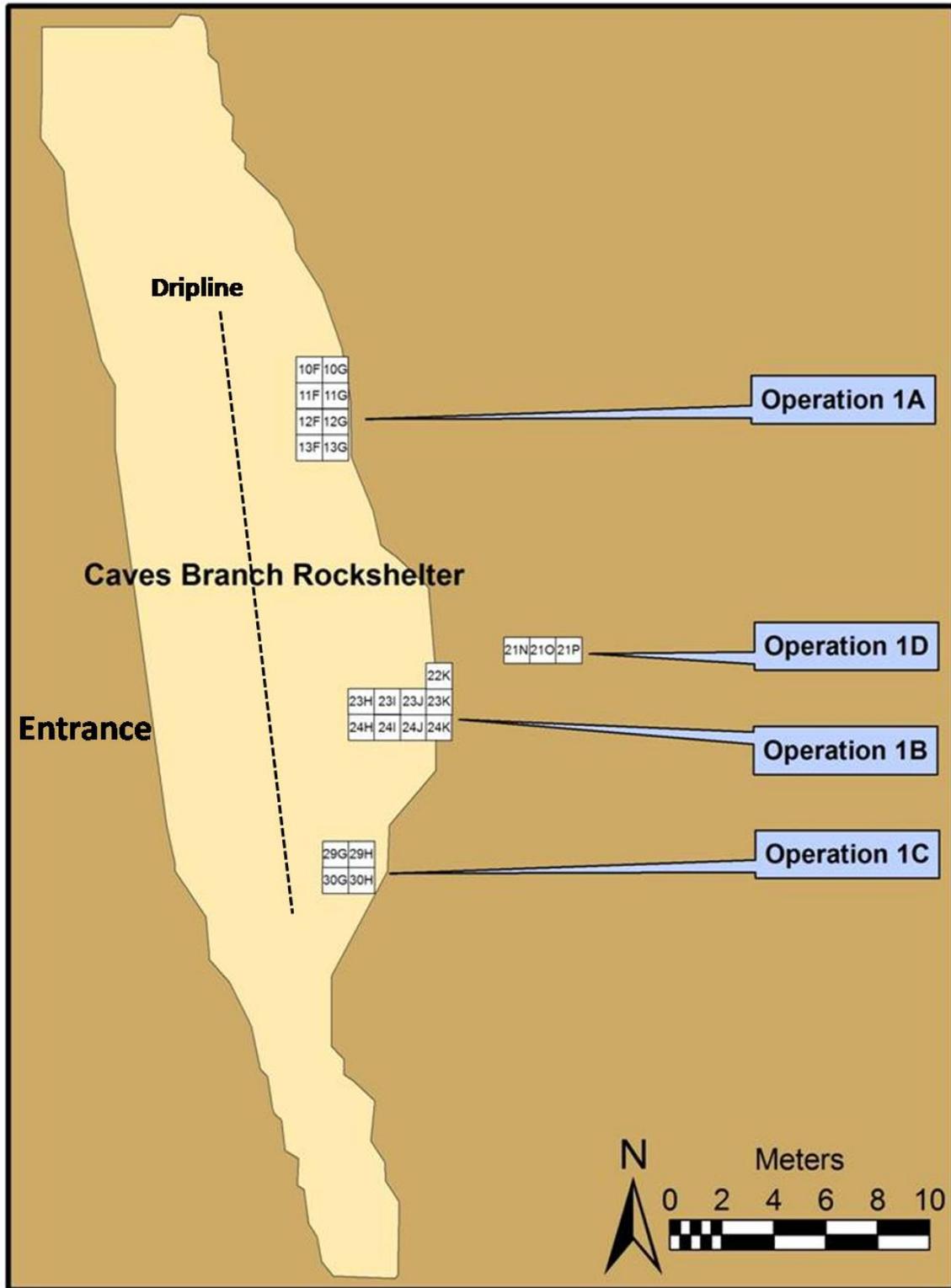


Figure 4-2. Location of Operations and Units for Caves Branch Rockshelter, Belize

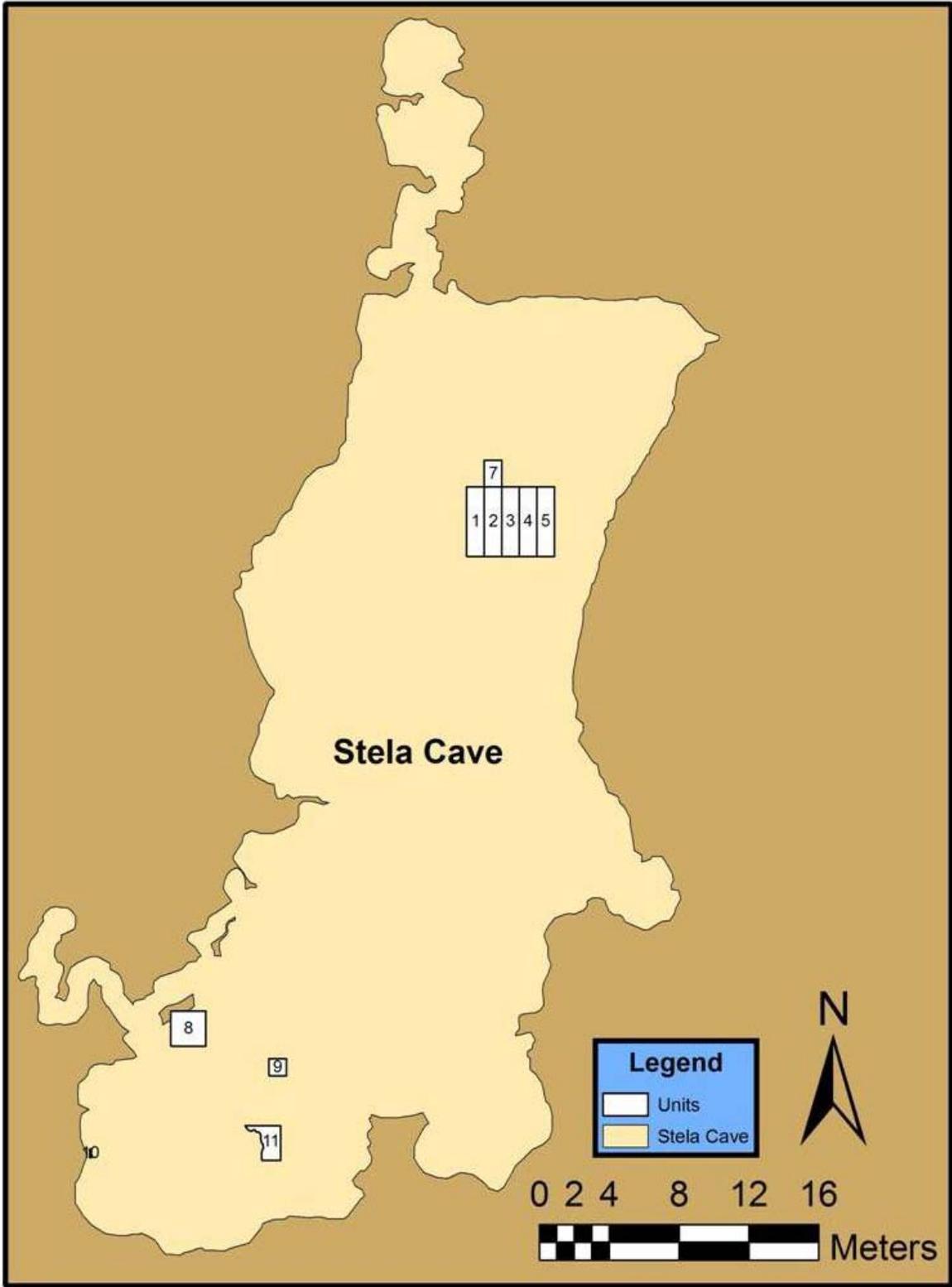


Figure 4-3. Location of Units for Stela Caves, Belize

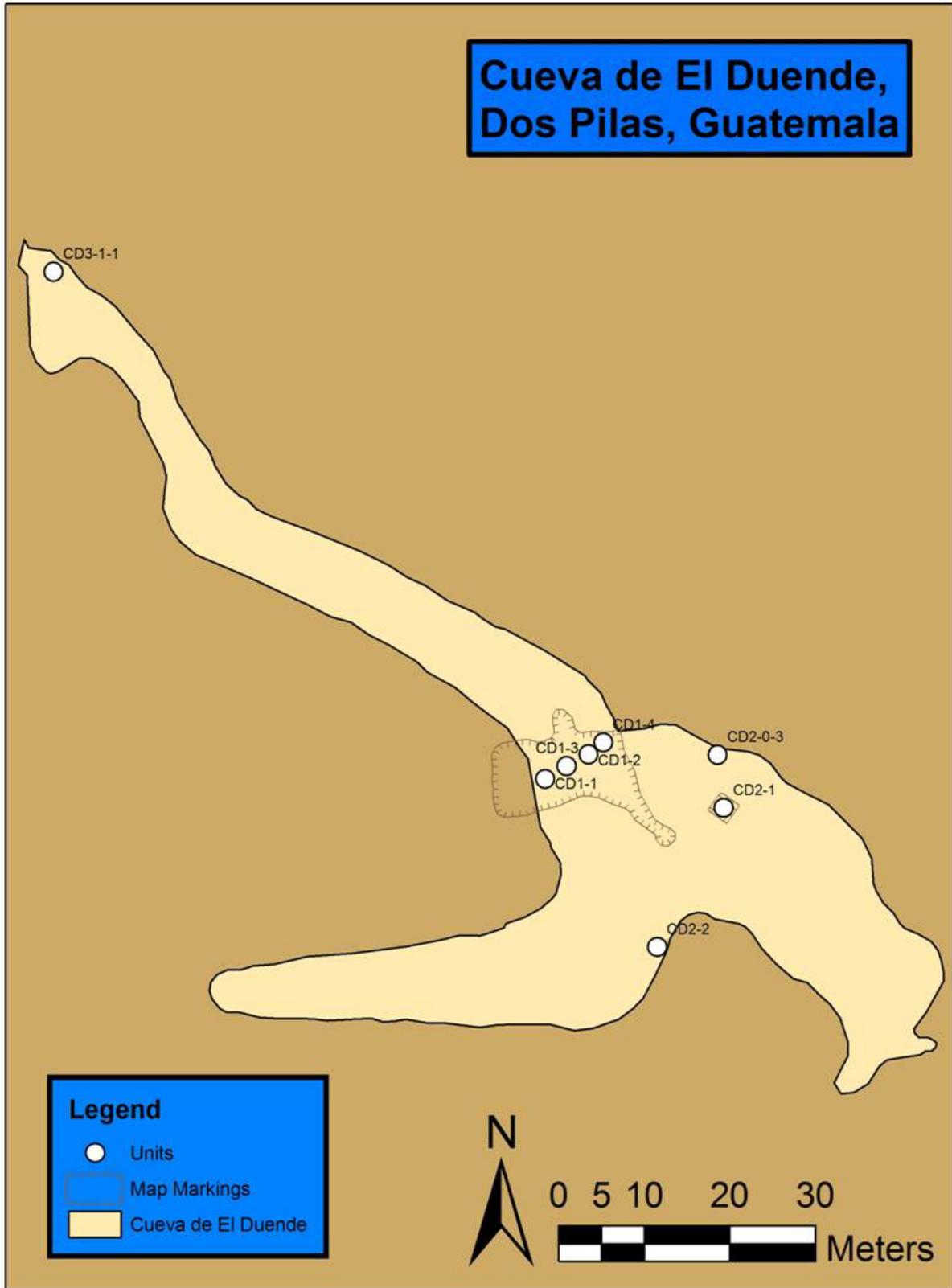


Figure 4-5. Location of Excavation Units for Cueva de El Duende, Guatemala

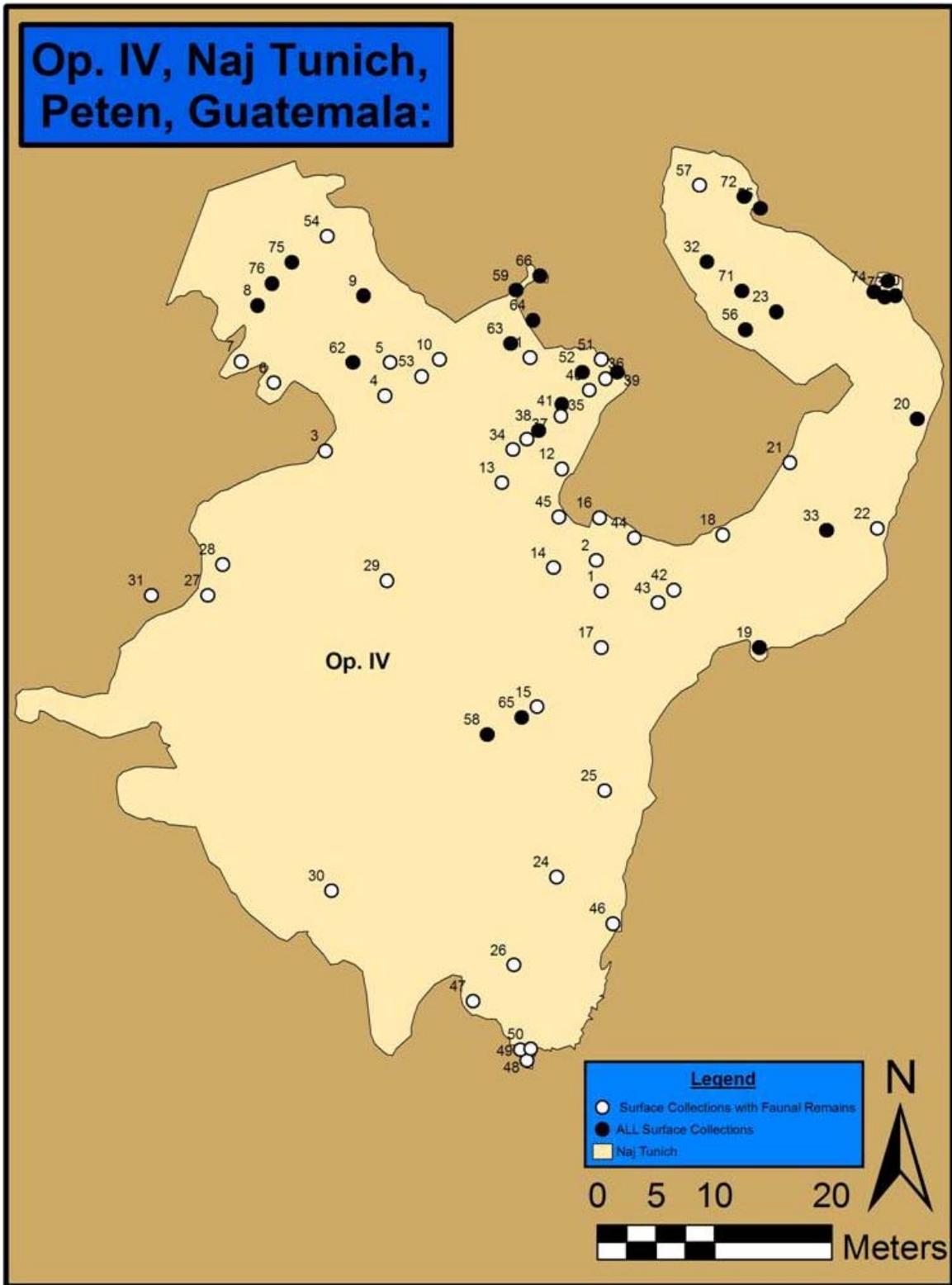


Figure 4-6. Location of Lots for Operation IV, Naj Tunich, Guatemala

Table 4-1. Five Cave Site Information Including Proximity to Sites, Time Periods, and Excavation Methods.

Cave Site	Proximity to Identified Sites	Time Periods	Excavation Methods
Caves Branch Rockshelter	Small site nearby	Late Preclassic to the Early Classic	Excavation
Stela Cave	No identified sites nearby	Preclassic to the Late Classic	Excavation
Cueva de Sangre	Within Large Ceremonial Center	Late Preclassic to the Late Classic	Excavation / Surface Collection
Cueva de El Duende	Within Large Ceremonial Center	Late Preclassic to Early Classic	Excavation
Naj Tunich	No identified sites nearby	Late Preclassic to the Late Classic	Surface Collection

CHAPTER 5
ZOOARCHAEOLOGY, GIS, AND VISUAL ANALYSIS METHODS

Introduction

This thesis examines the ancient Maya use of cognized space in caves by describing the distribution of animal remains across cave use surfaces. To test the spatial distribution of animal remains I used Geographic Information Systems (or GIS) to compare the distribution of animal remains from five caves to various cognized spatial patterns suggested by ethnographic, ethnohistoric, and archaeological research.

In this chapter I review the zooarchaeological methods I used in the primary identification and analysis of animal remains from four cave sites, Caves Branch Rockshelter, Stela Cave, Cueva de El Duende, and Cueva de Sangre and the methods that I have used in incorporating data from published zooarchaeological information from the cave of Naj Tunich. In this discussion I also note the biases that must be recognized in the assemblages as a result of different excavation, identification, and quantification/presentation methods.

In the second section I review the methods used in incorporating maps from each site using GIS. The two spatial analysis tools, Spatial Autocorrelation and Cokriging, are discussed. Also, my need to use a visual analysis to help with the interpretations of the sites is addressed. The standards I used in defining the cognized spaces are identified and the spatial analyses that are used to test them. In this study I concentrated on the following categories of the separation of space within each cave: the cardinal directions (north versus south and east versus west), the dichotomies between the right/left, dark/light, and open/restricted spaces in the cave.

These are not the only cognized spaces in the probable Maya universe, but they are the ones best suited to the analysis of these cave assemblages. To test these separations of space, I compared the differential placement of specific species. If larger assemblages of identified faunal

remains were available, I would have also included the analysis of ages, elements, body portions, body sides and specimen treatment such as burning and alterations by butchering or artifact manufacture. The separation of space within the caves was based on excavation unit placement and therefore the spatial distinctions are somewhat limited. As well, some of the patterns overlap, for example, when the right and left sides of the cave are also east and west. Therefore, in this section I discuss the biases inherent in my spatial analysis.

Zooarchaeological Methods

In 2007, the faunal remains from Cave Branch Rockshelter and Stela Cave were exported to Dr. Kitty Emery of the Environmental Archaeology Program of the Florida Museum of Natural History (EP-FLMNH) under a permit from the Belize Institute of Archaeology to Dr. Jaime Awe, project director. The animal remains from Caves Branch Rockshelter were excavated from 2005 to 2007 by Dr. Gabriel Wrobel, and those from Stela Cave were excavated in 2003 by a PhD student Cameron Griffith. Both cave sites were excavated as part of the Belize Valley Archaeological Reconnaissance Project directed by Dr. Jaime Awe. As the first stage of my research project, I worked with the project excavators in Belize to organize, label, and choose appropriate samples for export, and I hand-carried the remains to the FLMNH laboratories.

The faunal remains from Cueva de Sangre and Cueva de El Duende are on loan to Dr. Kitty Emery from Dr. James Brady by permit from the Guatemalan Institute of Archaeology and History and are housed in the Environmental Archaeology collections of the FLMNH. These two cave sites were excavated in the 1990s by Dr. James Brady and his colleagues as part of the Petexbatun Regional Archaeology Project directed by Dr. Arthur Demarest. The remains were imported to the USA in 1998 following initial analysis and sorting by Dr. Emery, and were transferred to the EAP-FLMNH in 2001. Preliminary reports on their faunal remains have been published by Dr. Kitty Emery and her identifications are included with my own in this study with

her permission. I also used published data from the sites of Naj Tunich (Brady 1989) from Guatemala. This cave site was excavated by Brady in 1982 and 1983 and the animal remains were identified by Susan Colby at UCLA in 1984. The result from this analysis was presented as an appendix in Brady's dissertation.

The four sites from which I analyzed animal remains are Caves Branch Rockshelter (2005-2006 seasons only), Stela Cave (2003 season), Cueva de Sangre (all seasons), and Cueva de El Duende (all seasons). In this analysis, animal remains excavated from cave sites were identified using standard zooarchaeological methods such as those described in Reitz and Wing (2008) and elsewhere. The identifications relied on the comparative collections of the Environmental Archaeology Program of the Florida Museum of Natural History. In general, all materials were identified to the lowest taxonomic grouping. However, due to the high diversity and lack of comparative specimens at the species level, specifically rodents (Rodentia), bats (Chiroptera), and birds (Aves) these remains were only identified to these broader taxonomic groupings. However, these specimens were otherwise treated identically to all others in that I recorded the same element, age, and treatments as with other groups.

For each specimen, I recorded where possible the lowest taxonomic identification, type of element, body portion of the element, the region of the element from which the specimen originated (distal, proximal, mid-region), the completeness of the specimen (by percent), the sidedness of the element, the age and sex characteristics of the specimen, and the condition of the bone including burning (blackened or calcined), artifactual modification (butchering and worked materials), and natural modifications (water damage, weathering, animal gnawing, root action). In calculating age of the specimens, I used three broad categories: (1) Juvenile, which includes unfused bones with juvenile epiphysis and other clear indications of very young ages (2) Juvenile

+ Immature, which are defined by characteristics such as unfused epiphyses and unerupted dentition, (3) Subadult + Adult, identified by characteristics such as bone showing fusion lines or that are completely fused, and erupted and worn adult dentition. Burning, natural modifications, and artifactual modifications were categorized as present or absent from the bones. For materials that showed burning, these remains were classified as blackened, calcined gray, and calcined white because these categories can be linked to specific burning temperatures (Reitz and Wing 2008). For the GIS analysis, all taxonomic groups, body portions, elements, degrees of burning, element sides, and age were assigned a numeric code (refer to Tables 5-1, 5-2, 5-3, 5-4, 5-5, 5-6). These are discussed in more detail in the next section.

In zooarchaeology there are two main measurements for quantifying faunal remains. The Number of Identifiable Specimens (or NISP) is the number of remains identified in each taxonomic unit (a single species or other taxon). The NISP can over-estimate the number of actual animals in the assemblage because some animals have multiple small bones and this measurement does not take into account fragmentation of elements (Emery 2004 – Chap 2; Grayson 1984; Reitz and Wing 2008). For example, the NISP of armadillos can be overestimated because each armadillo has over 200 scutes and when calculating the NISP, each scute is identified as a single armadillo specimen. The Minimum Number of Individuals (MNI) calculates the smallest number of individual animals that might be represented by each taxonomic unit (Emery 2004b; Grayson 1984; Reitz and Wing 2008). It is based on the fact that the largest number of discrete elements must be the minimum number of animals represented. For example, if a set of fifteen deer femurs include nine complete left femurs and six complete right femurs, there is only a possibility of the assemblage having nine complete deers.

There is a bias of small sizes when using MNI because the use of specific elements decreases the amount of remains that can be used in the analysis. Therefore, sample sizes are smaller, yet more accurate, estimates of the living faunal assemblage; but, they are a misrepresentation of the actual number of possible animals at the site. In this study I have used the NISP as the basis for all calculations because sample sizes are small enough to affect the MNI accuracy. However, the MNI is presented for comparison in all tables. The NISP for this study included the larger and general taxonomic units, even including some of the classes and specific number of individual bones identified in these groups.

Geographic Information Systems (GIS)

The second part involved mapping the sites using ArcGIS, a GIS program that is used as a tool to define and quantify the spatial distribution of the faunal materials within the cave sites. I created the ArcGIS maps by scanning and transferring older published and excavation field maps to computer images that were then incorporated into ArcGIS based on their known coordinate systems (as provided by the archaeologists). The only site to have a georeferenced map with correct scale and spatial position is Stela Cave and this was provided by Cameron Griffith the main excavator at the site. Scale was kept from the mapped images for all caves and those without specific coordinates were used for analysis and reconstructed from these published maps.

There are two forms of images that are used in GIS, including vector and raster images. Vector images are represented by points, lines, and polygons that are used to mark specific locations and outlines of areas. While raster images consists of a series of pixels to represent values that are continuous or discrete. For example, elevation is best represented by raster images because there are not well-defined areas for these data. Maps are made into vector images so that each unit can have a single area represented by it in the cave. Once these maps are made the

faunal data can be incorporated and linked to the parts of the map so that animal remains distribution can be analyzed and quantified on a unit to unit, and possibly level to level, basis.

The caves that I am using for this analysis were not fully excavated, nor were animal remains point-plotted (mapped with specific coordinates per find); therefore, this analysis is based on relative proportions of animal remains between excavation units and surface collections at each site. The faunal remains were from both excavated units and surface collections and were either represented using points or polygons because the size for each collection was not recorded at every site. I used these spatial analyses, Spatial Autocorrelation and Cokriging, to test for possible patterning of faunal remains in the caves. Spatial autocorrelation identifies the spatial distribution of species within the cave as being either dispersed, random, or clustered throughout the cave. Cokriging was used to identify the spatial patterning of the faunal specimens in relation to the dichotomy between the five separations of space, including left versus right sides of the cave, north versus south, east versus west, light versus dark, and open versus restricted space.

The spatial analyses used in this study have certain sample size criteria in order to produce viable data outputs. Spatial autocorrelation needs a sample size of at least ten but works more efficiently with a sample of thirty or more. For cokriging to analyze, a sample of ten units is needed. Therefore, some of the caves, including Stela Cave (eight units) and Cueva de El Duende (eight units) did not run a cokriging spatial analysis. Due to the small sample size, I also conducted a visual analysis of the faunal remains to test for patterns related to the cardinal directions (east/west and north/south), right/left sides of the caves, restricted/open spaces that are and are not blocked off, and dark/light areas within the caves, in relation to the type of elements, side of the elements, body portions, age, and bone conditions. I defined these separations of

space by identifying them manually and then incorporating these findings into the analysis. There are areas of overlap between these separations which I address in this chapter.

GIS can better recognize and sort by numbers than by alphanumeric representations because ArcGIS is very specific in how text is identified and incidental spaces in sections are considered separate entries. To prepare the spreadsheets with all of the faunal identifications from the cave sites, I am using specific number scales in each of the fields recorded. The number number scheme is being used to represent taxonomic groupings (Table 5-1), elements (Table 5-2), body portions (Table 5-3), sides of elements (Table 5-4), age characteristics (Table 5-5), and the conditions of burning and charring (Table 5-6). For example, I am using a numbering system for the taxonomic identifications of the faunal remains; this list worked with both the general taxonomic groupings of class, order, family, genus and species identification and common names. The numbering for the taxonomic groups is provided in Table 5-1 and consisted of a much more indepth numbering system because of the amount of taxonomic groups identified. For the other parameters, I used a simple numbering system for the identification of the elements, left/right sides, portions, age identification, and the burning/charring of the bones. Due to the small sample size of the faunal remains from each cave, the GIS spatial analysis of the sites only includes the taxonomic groupings and identifications.

I decided on using single excavation units or surface collections as the divisions of analysis because caves in the Maya region are known to have mixed contexts. Also, most of the units were not excavations, but surface collections. I did not take the size of the units into account during my spatial analysis, and most of the units were treated as single points. The location of recovery (provenience) of each of the bones has been recorded by the excavators. For each site, the detail of provenience information is slightly different, but at CBR and Stela Cave the faunal

remains have a specific catalogue number that is related to the Operation, Unit, Level, and Lot. At CBR in particular, each of these units were taken from an arbitrary 1 meter by 1 meter grid that was placed over the site before excavation. The numbers increase from north to south with letters that increase from the west to east. Many of the sites include surface collections and each of these surface collections were recorded and identified as individual units. Spatial pattern recognition was facilitated by using the maps with labeled excavation units. These maps are the important part of the next step in the analysis of these faunal remains in the caves.

Separation of Space within the caves

I am working under the idea that each cave presents a completely different space since no two caves are the same. These differences might also have an important role in the type of ceremonies that may have occurred within the caves (Awe 1998; Brady 1989). Therefore, I first compared the animal remains between caves to look for patterning. I also looked at many different types of delineation of space within each of the caves. I have defined four different measurements including cardinal directions (north versus south and east versus west), left versus right sides, light versus dark regions, and open versus restricted spaces. During the analysis of space within the caves some of these delineations may overlap or not exist within certain cave contexts. Separations of space were both for the whole cave and also within different sections of the cave. The extent to which I compared these divisions was limited by the type and placement of excavations within the caves. There is also overlap in some of these patterns in most of the caves. This led me to discuss each of the spatial patterns of space individually when trying to identify patterns.

The four delineations of space that I analyzed for each cave and the use of the separations of space depended on the size and formation of each cave. Cardinal directions are and were important to the Maya, and simple separations of space were used for this analysis as each cave

is split into the north versus south and the east versus west. The use of quadrants would be difficult to do because of the small sample sizes from the caves that are being analyzed. There is a strong ritual component in the left and right sides of buildings and this might also be important in caves as well. The cave was split into the left and right side from the cave's perspective as an individual or agent by facing. The light versus dark regions of the cave was defined by the archaeologists. Light is defined as naturally lit and dimly lit parts of the cave, usually located near the opening, while dark is located in the recesses of the cave that are not lit by natural light. Finally, the open versus restricted spaces are defined by the construction of walls or natural formations that limited access to parts or chambers of the cave. Cokriging involves adding different variables; I analyzed the total NISP per species within each unit or surface collection in relation to each of the above mentioned separations of space.

The faunal remains were quantified using the sum NISP for each unit or surface collection. To start off my analysis I looked simply at the overall distribution and pattern of distribution of burnt or charred bones at all cave sites. I am interested in seeing if there are any specific patterns that form between all of the caves. All faunal remains, including those that have not been identified to specific species, were used for the analysis of burnt remains. For the next step in the spatial distribution of remains, I identified possible patterning in the distribution of identified species, which were grouped in these specific taxonomic groupings: both large and small taxonomic groups including crustaceans (Decapoda, infraorder Brachyura), Actinopterygii (ray-finned fishes), Lepisosteidae (gar family), Siluriformes (catfish family), Amphibia (amphibians), Testudines (turtles), Sauria (lizards), Serpentes (snakes), Aves (birds), *Meleagris gallopavo* (wild turkey), Didelphidae (opossum family), *Dasyus novemcinctus* (nine-banded armadillo), Chiroptera (bats), Primates, Canidae (canid family), Felidae (cat family), Procyonidae (raccoon

family), *Tapirus bairdii* (Baird's tapir), Artiodactyla (even-toed ungulates), Tayassuidae (peccary family), Cervidae (deer family), *Odocoileus virginianus* (white-tailed deer), *Mazama* sp. (brocket deer), Rodentia (rodents), Scuridae (squirrel family), Agoutidae (pacas family) and Dasyproctidae (agouti family), and *Sylvilagus* sp. (cottontail rabbits). Identifying possible patterns in terms of species and family distributions of remains is an important step in the process. Species patterns were analyzed to see if species are placed into certain parts of the cave in relation to my spatial separations. Due to the small sample size from each of the caves, I was unable to work within the other parameters of interest, including elements, body portions, left/right elements, and age of identified specimens. If given a larger sample I would have performed both of the spatial analyses on these specific parameters.

Summary

My goal of this chapter is to provide the methods for the analysis for identifying the spatial patterning of the faunal materials at ancient Maya cave sites using GIS. Due to the small sample sizes from these cave sites, I was only able to test taxonomic groupings of animals in this analysis using GIS. I include the visual analysis of these small samples to help with the identification of spatial patterning of animal remains from these cave sites. I have provided an outline of a possible method of analysis using GIS with a larger sample that is from a well excavated context. The use of a numerical system to represent the identifiable aspect of these remains is a necessary part of preparing the information for its use in larger zooarchaeological collections. The inclusion of zooarchaeology and GIS at archaeological sites allow for more complex identifications of patterned use of animal remains from archaeological sites and as a possible proxy for understanding the ritual use of animals by the ancient Maya. The use of GIS also allows for the creation of a database of zooarchaeological materials which have a spatial relationship within archaeological sites.

Table 5-1. Gentax Numbers for Taxonomic Classification of Faunal Remains

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
1		Class unknown			
2		taxa identifiable			
3	Gastropoda				univalves or snails
4	Gastropoda, freshwater				freshwater snails
5	Gastropoda: Prosobranchia				
6		Neotaenioglossa	Thiaridae	<i>Melania</i> sp.	river snail
7		Mesogastropoda	Pleuroceridae	<i>Pachychilus</i> sp	jute
8		Mesogastropoda	Pleuroceridae	<i>Pachychilus indiorum</i>	
9		Mesogastropoda	Pleuroceridae	<i>Pachychilus glaphyrus</i>	
10		Mesogastropoda	Ampullariidae	<i>Pomacea flagellata</i>	apple snail
11	Gastropoda, terrestrial/arboreal				land and tree snails
12	Gastropoda, terrestrial/arboreal	Mesogastropoda	Cyclophoroidea	<i>Neocyclotus dysoni</i>	
13	Gastropoda, terrestrial/arboreal	Stylommatophora	Oleacinidae	<i>Euglandina</i> cf. <i>cumingii</i>	tree snails
14	Gastropoda, terrestrial/arboreal	Stylommatophora	Bulimulidae	<i>Orthalicus</i> sp.	
15	Gastropoda, terrestrial/arboreal	Stylommatophora	Bulimulidae	<i>Orthalicus undatus</i>	
16	Gastropoda, terrestrial/arboreal	Stylommatophora	Bulimulidae	<i>Orthalicus vivans</i>	
17	Gastropoda, terrestrial/arboreal	Archaeogastropoda, srf Neritacea	Helicinidae	<i>Helicina amoena</i>	
18		Gastropoda, marine			marine snails
19		Mesogastropoda, srf Strombacea	Strombidae		
20		Mesogastropoda, srf Strombacea	Strombidae	<i>Strombulus</i> sp.	conch
21		Mesogastropoda, srf Strombacea	Strombidae	<i>Melongena melongena</i>	brown conch [crown conch?]
22		Mesogastropoda, srf Strombacea	Strombidae	<i>Strombus gigas</i>	queen conch
23		Mesogastropoda, srf Strombacea	Strombidae	<i>Strombus alatus</i>	Florida stromb
24		Mesogastropoda, srf Strombacea	Strombidae	<i>Strombus pervianus</i>	
25		Mesogastropoda, srf Strombacea	Strombidae/Cassidae		

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
26		Mesogastropoda, srf Doliacea	Cassidae	<i>Cassis madagascariensis</i>	Clench's helmet
27		Neogastropoda, srf Volutacea	Xancidae	<i>Xancus angulatus</i>	West Indian chank [lamp shell]
28		Neogastropoda, srf Volutacea	Columbellidae	<i>Columbella mercatoria</i>	dove shells
29		Neogastropoda, srf Volutacea	Olividae		olive shells
30		Neogastropoda, srf Volutacea	Olividae	<i>Oliva</i> sp.	
		Neogastropoda, srf Volutacea	Olividae		
31				<i>Oliva caribaeensis/sayana</i>	
32		Neogastropoda, srf Volutacea	Olividae	<i>Oliva reticularis</i>	
33		Neogastropoda, srf Volutacea	Olividae	<i>Oliva sayana</i>	
34		Neogastropoda, srf Volutacea	Olividae	<i>Olivella dealbata</i>	
35		Neogastropoda, srf Volutacea	Olividae	<i>Olivella nivea</i>	
36		Neogastropoda, srf Volutacea	Fascioliariidae	<i>Pleuroploca gigantea</i>	horse conch
37		Neogastropoda, srf Volutacea	Marginellidae	<i>Prunum apicinum</i>	
38		Pelecypoda			bivalves
39		Pelecypoda, marine			marine bivalves
40		Pelecypoda, marine		<i>Arca imbricata</i>	
41		Pelecypoda, marine	Spondylidae	<i>Spondylus</i> sp.	
42		Pelecypoda, marine	Spondylidae	<i>Spondylus americanus</i>	
43		Pelecypoda, marine		<i>Isognomon alatus</i>	flat tree oyster
44		Pelecypoda, freshwater			freshwater bivalves
45		Pelecypoda, freshwater	Unionidae		unionid clams
46		Pelecypoda, freshwater	Unionidae	<i>Lampsilis</i> sp.	freshwater mussel/clam
47		Pelecypoda, freshwater	Unionidae	<i>Nephronaias</i> sp.	freshwater mussel/clam
48		Pelecypoda, freshwater	Unionidae	<i>Psoronaias</i> sp.	
49		Decapoda, infraorder Brachyura			unidentifiable crab
50		Decapoda, infraorder Brachyura	Gecarcinidae		crab
51		Decapoda, infraorder Brachyura	Gecarcinidae	<i>Cardisoma</i> sp.	land crab
52	Vertebrata				animals with backbones
53					fishes

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
54	Chondrichthyes	Myliobatiformes	Dasyatidae/ Myliobatidae		eagle and stingrays
55	Actinopterygii				ray-finned (bony) fishes
56	Actinopterygii	Lepisosteiformes	Lepisosteidae		gars
57	Actinopterygii	Lepisosteiformes	Lepisosteidae	<i>Atractosteus tropicus</i>	broad-head gar
58	Actinopterygii	Lepisosteiformes	Lepisosteidae	<i>Lepisosteus</i> sp.	slender gars
59	Actinopterygii	Cypriniformes	Catostomidae	<i>Ictiobus</i> sp.	suckers
60	Actinopterygii	Cypriniformes	Catostomidae	<i>Ictiobus meridionalis</i>	Usumacinta buffalo sucker
61	Actinopterygii	Siluriformes			catfishes
62	Actinopterygii	Siluriformes	Ariidae	<i>Arius</i> sp.	sea catfish
63	Actinopterygii	Siluriformes	Ictaluridae/ Pimelodidae		freshwater catfishes
64	Actinopterygii	Siluriformes	Ictaluridae		ictalurid catfishes
65	Actinopterygii	Perciformes	Cichlidae		freshwater cichlids
66	Actinopterygii	Perciformes	Cichlidae	<i>Cichlasoma</i> sp.	freshwater mojarra
67	Actinopterygii	Perciformes	Scaridae	<i>Sparisoma</i> sp.	parrotfish
68	Tetrapods				limbed animals
69	Amphibia				amphibians
70	Amphibia	Anura			frogs and toads
71	Amphibia	Anura, intermediate			
72	Amphibia	Anura, small			
73	Amphibia	Anura	Ranidae		frogs
74	Amphibia	Anura	Bufo	<i>Bufo</i> sp.	bufonid toads
75	Amphibia	Anura	Bufo	<i>Bufo marinus</i>	marine/cane toad
76	Reptilia				reptiles
77	Reptilia	Crocodylia	Crocodylidae	<i>Crocodylus</i> sp.	
78	Reptilia	Testudines			turtles
79	Reptilia	Testudines		Testudines, large	<i>Dermatemys mawii</i> /Staurotyphlops triporcatatus
80	Reptilia	Testudines		Testudines, small	

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
81	Reptilia	Testudines	Kinosternidae		mud and musk turtles
82	Reptilia	Testudines	Kinosternidae	<i>Kinosternon</i> sp.	mud turtle
83	Reptilia	Testudines	Kinosternidae	<i>Kinosternon scorpiodes</i>	scorpion mud turtle
84	Reptilia	Testudines	Kinosternidae	<i>Kinosternon cruentatum</i>	red-spotted mud turtle
85	Reptilia	Testudines	Kinosternidae	<i>Staurotypus triporcatus</i>	Mexican giant musk turtle
86	Reptilia	Testudines	Dermatemyidae		river turtles
87	Reptilia	Testudines	Dermatemyidae	<i>Dermatemys mawii</i>	Central American river turtle
88	Reptilia	Testudines	Emydidae		box and freshwater (pond) turtles
89	Reptilia	Testudines	Emydidae	<i>Trachemys scripta</i>	slider
90	Reptilia	Testudines	Emydidae	<i>Terrapene carolina</i>	Yucatan box turtle
91	Reptilia	Testudines	Emydidae	<i>Rhinoclemys areolata</i>	black-bellied (furrowed) turtle
92	Reptilia	Squamata: Suborder Sauria			lizards
93	Reptilia	Squamata: Suborder Sauria	Iguanidae		iguanas
94	Reptilia	Squamata: Suborder Sauria	Iguanidae	<i>Iguana iguana</i>	green/common iguana
95	Reptilia	Squamata: Suborder Serpentes			snakes
96	Reptilia	Squamata: Suborder Serpentes	Viperidae		pitvipers
97	Reptilia	Squamata: Suborder Serpentes	Viperidae	<i>Crotalus durissus</i>	Neotropical rattlesnake
98	Aves/Mammalia				mammal or bird
99	Aves				birds
100	Aves, large				
101	Aves, large/intermediate				
102	Aves, intermediate				
103	Aves, small				
104	Aves	Ciconiiformes Gruiformes	Ardeidae		herons and egrets
105	Aves		Rallidae	<i>Laterallus ruber/ jamaicensis</i>	Black Rail or Ruddy Crake
106	Aves	Gruiformes	Rallidae	<i>Gallinula chloropus</i>	common gallinule/moorhen
107	Aves	Psittaciformes	Psittacidae		parrots and macaws
108	Aves	Psittaciformes	Psittacidae	<i>Ara macao</i>	macaw

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
109	Aves	Piciformes	Ramphastidae		toucans
110	Aves	Strigiformes	Strigidae	<i>Tyto alba</i>	barn owl
111	Aves	Falconiformes Falconiformes	Accipitridae	<i>Buteo platypterus</i>	broad winged hawk
112	Aves		Falconidae	<i>Herpetotheres cachinnans</i>	laughing falcon curassow, bobwhite, quail, turkey
113	Aves	Galliformes			
114	Aves	Galliformes	Phasianidae	<i>Colinus</i> sp.	bobwhites
115	Aves	Galliformes	Phasianidae	<i>Colinus nigrogularis</i>	black-throated bobwhite
116	Aves	Galliformes	Phasianidae: Meleagridinae	<i>Meleagris</i> sp.	turkeys
117	Aves	Galliformes	Phasianidae: Meleagridinae	<i>Meleagris gallopavo</i>	northern/domestic turkey
118	Aves	Galliformes	Cracidae	<i>Penelope purpurascens</i>	crested guan
119	Aves	Passeriformes			passerine or perching birds
120	Aves	Passeriformes	Hirundinidae	<i>Tachycineta albilinea</i>	tree swallows
121	Aves	Passeriformes	Hirundinidae	<i>Petrochelidon</i> sp.	cave/cliff swallows
122	Aves	Passeriformes	Emberizidae	<i>Ammodramus savannarum</i> <i>Aimophila</i> sp.	Grasshopper, Rusty, or Botteri's Sparrow
123	Aves	Passeriformes	Emberizidae	<i>Cardinalis</i> sp.	cardinals
124	Aves	Columbiformes	Columbidae		doves and pigeons
125	Mammalia				
126	Mammalia, very large				
127	Mammalia, large				
128	Mammalia, large/intermediate				
129	Mammalia, intermediate				
130	Mammalia, intermediate/small				
131	Mammalia, small				
132	Mammalia	Didelphimorphia	Didelphidae		

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
133	Mammalia	Didelphimorphia	Didelphidae	<i>Didelphis</i> sp.	opossums
134	Mammalia	Didelphimorphia	Didelphidae	<i>Didelphis marsupialis</i>	common opossum
135	Mammalia	Didelphimorphia	Didelphidae	<i>Chironectes minimus</i>	water opossum
136	Mammalia	Didelphimorphia	Didelphidae	<i>Philander opossum</i>	four eyed opossum
137	Mammalia	Didelphimorphia	Didelphidae	<i>Marmosa mexicana</i>	Mexican mouse-opossum
138	Mammalia	Insectivora	Soricidae	<i>Cryptotis micrura</i>	small-eared shrew
139	Mammalia	Xenarthra (or Edentata)	Dasypodidae		
140	Mammalia	Xenarthra (or Edentata)	Dasypodidae	<i>Dasypus novemcinctus</i>	nine-banded armadillo
141	Mammalia	Chiroptera			bats
142	Mammalia	Chiroptera	Phyllostomidae: Stenodermatinae		leaf nosed bats
143	Mammalia	Chiroptera	Phyllostomidae: Stenodermatinae	<i>Artibeus</i> sp.	
144	Mammalia	Chiroptera	Phyllostomidae: Stenodermatinae	<i>Artibeus</i> sp., small	
145	Mammalia	Chiroptera	Phyllostomidae: Stenodermatinae	<i>Artibeus jamaicensis</i>	Jamaican fruit-eating bat
146	Mammalia	Chiroptera	Phyllostomidae: Stenodermatinae	<i>Artibeus literatus</i>	great fruit-eating bat
147	Mammalia	Chiroptera	Phyllostomidae: Desmodontinae	<i>Desmodus rotundus</i>	
148	Mammalia	Microchiroptera			small bats
149	Mammalia	Primata	Cebidae	<i>Alouatta/Ateles</i>	howler/spider monkey
150	Mammalia	Primata	Cebidae	<i>Alouatta</i> sp.	howler monkeys
151	Mammalia	Primata	Cebidae	<i>Ateles</i> sp.	spider monkeys
152	Mammalia	Primata	Cebidae	<i>Ateles geoffroyi</i>	Central American spider monkey
153	Mammalia	Primata	Hominidae	<i>Homo sapiens sapiens</i>	Homo sapiens
154	Mammalia	Carnivora			
155	Mammalia	Carnivora, large			
156	Mammalia	Carnivora, intermediate			

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
157	Mammalia	Carnivora, small			
158	Mammalia	Carnivora	Canidae/Felidae		cats and dogs
159	Mammalia	Carnivora	Canidae		dogs, foxes, coyotes, wolves
160	Mammalia	Carnivora	Canidae, small		foxes, small dogs
161	Mammalia	Carnivora	Canidae	<i>Canis</i> sp.	dogs, coyotes
162	Mammalia	Carnivora	Canidae	<i>Canis lupus familiaris</i>	domestic dog
163	Mammalia	Carnivora	Canidae	<i>Urocyon cinereoargentus</i>	gray fox
164	Mammalia	Carnivora	Procyonidae		racoons, coatis
165	Mammalia	Carnivora	Procyonidae	<i>Procyon lotor</i>	northern raccoon
166	Mammalia	Carnivora	Procyonidae	<i>Nasua narica</i>	white nosed coati
167	Mammalia	Carnivora	Procyonidae	<i>Poto flavus</i>	kinkajou
168	Mammalia	Carnivora	Mustelidae		
169	Mammalia	Carnivora	Mustelidae	<i>Spilogale/Conepatus</i> sp	spotted/hog-nosed skunk
170	Mammalia	Carnivora	Felidae		
171	Mammalia	Carnivora	Felidae, large		Puma concolor and Panthera onca
172	Mammalia	Carnivora	Felidae, intermediate		ocelot, jaguarundi
173	Mammalia	Carnivora	Felidae, small		ocelot, margay
174	Mammalia	Carnivora	Felidae	<i>Leopardus pardalis</i>	ocelot
175	Mammalia	Carnivora	Felidae	<i>Leopardus weidii</i>	margay
176	Mammalia	Carnivora	Felidae	<i>Herpailurus yagouroundi</i>	jaguarundi
177	Mammalia	Carnivora	Felidae	<i>Panthera onca</i>	jaguar
178	Mammalia	Perissodactyla	Tapiridae	<i>Tapirus bairdii</i>	Baird's tapir
179	Mammalia	Artiodactyla			even-toed ungulates
180	Mammalia	Artiodactyla, large			white-tailed deer, peccaries
181	Mammalia	Artiodactyla, intermediate			brocket deer
182	Mammalia	Artiodactyla	Tayassuidae		peccaries
183	Mammalia	Artiodactyla	Tayassuidae	<i>Tayassu</i> sp.	peccaries
184	Mammalia	Artiodactyla	Tayassuidae	<i>Tayassu tajacu</i>	collared peccary

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
185	Mammalia	Artiodactyla	Cervidae		deers
186	Mammalia	Artiodactyla	Cervidae	<i>Odocoileus virginianus</i>	white tailed deer
187	Mammalia	Artiodactyla	Cervidae	<i>Odocoileus hemionus</i>	mule deer
188	Mammalia	Artiodactyla	Cervidae	<i>Mazama</i> sp.	brocket deer
189	Mammalia	Rodentia			
190	Mammalia	Rodentia, large			
191	Mammalia	Rodentia, intermediate			
192	Mammalia	Rodentia, small			
193	Mammalia	Rodentia	Sciuridae		squirrels
194	Mammalia	Rodentia	Sciuridae	<i>Sciurus</i> sp.	tree squirrels
195	Mammalia	Rodentia	Geomyidae		pocket gophers
196	Mammalia	Rodentia	Geomyidae	<i>Orthogeomys</i> sp.	
197	Mammalia	Rodentia	Geomyidae	<i>Orthogeomys hispidus</i>	Hispid's pocket gopher
198	Mammalia	Rodentia	Heteromyidae		pocket mice
199	Mammalia	Rodentia: Myomorpha			
200	Mammalia	Rodentia: Myomorpha	Muridae (Cricetidae)		New World rats and mice, voles, hamsters, etc.
201	Mammalia	Rodentia: Myomorpha	Muridae (Cricetidae)	<i>Oryzomys</i> sp.	rice rats
202	Mammalia	Rodentia: Myomorpha	Sigmodontinae Muridae (Cricetidae)	<i>Ototylomys phyllotis</i>	big-eared climbing rat
203	Mammalia	Rodentia: Myomorpha	Sigmodontinae Muridae (Cricetidae)	<i>Sigmodon hispidus</i>	Hispid's cotton rat
204	Mammalia	Rodentia: Myomorpha	Sigmodontinae	<i>Peromyscus</i> sp.	deer mice
205	Mammalia	Rodentia: Caviomorpha	Erethizontidae	<i>Coendu</i> sp.	porcupines
206	Mammalia	Rodentia: Caviomorpha	Agoutidae/ Dasyproctidae		

Table 5-1. Continued

GEN TAX	Phylum/Class	Order	Family	Taxa	Common name
207	Mammalia	Rodentia: Caviomorpha	Dasyproctidae	<i>Dasyprocta punctata</i>	
208	Mammalia	Rodentia: Caviomorpha	Agoutidae	<i>Agouti paca</i>	
209	Mammalia	Lagomorpha	Leporidae	<i>Sylvilagus</i> sp.	rabbits
210	Mammalia	Lagomorpha	Leporidae	<i>Sylvilagus floridanus</i>	cottontail rabbit
211	Mammalia	Lagomorpha	Leporidae	<i>Sylvilagus brasiliensis</i>	forest rabbit

Table 5-2. Element Numbers for Element Types

El#	Element	El#	Element	El#	Element	El#	Element	El#	Element
1	carapace	32	quadrate	63	maxillary molar 2	94	humerus	125	metatarsal, vestigial
2	carapace/plastron	33	parasphenoid	64	maxillary molar 3	95	radius	126	tarsal centrali - 4
3	plastron	34	pharyngeal, lower	65	maxillary molar 4	96	ulna	127	tarsal centrali + 4
4	scale	35	preoperculum	66	mandible	97	wing element	128	tarsometatarsus
5	scute	36	operculum	67	mandibular incisor	98	wing element + spur	129	phalanx
6	vertebra	37	cleithrum	68	mandibular incisor 1	99	radioulna	130	phalanx, proximal
7	vertebra, atlas	38	supracleithrum	69	mandibular incisor 2	100	carpometacarpus	131	phalanx, intermediate
8	vertebra, axis	39	postcleithrum	70	mandibular incisor 3	101	carpal/tarsal	132	phalanx, distal
9	vertebra, cervical	40	branchiostegal ray	71	mandibular canine	102	metapodial	133	phalanx, terminal
10	vertebra, lumbar	41	pterygiophore	72	mandibular carnassial	103	metacarpal	134	phalanx/metapodial
11	vertebra, thoracic	42	basipterygiophore	73	mandibular premolar	104	metacarpal 2	135	long bone
12	vertebra, sacral	43	pterygoid	74	mandibular premolar 1	105	metacarpal 3	136	postcranial element
13	coccyx	44	spine	75	mandibular premolar 2	106	metacarpal 4	137	element identifiable
14	vertebra, precaudal	45	spine, dorsal	76	mandibular premolar 3	107	metacarpal 5	138	bacculum
15	vertebra, caudal	46	spine, pectoral	77	mandibular premolar 4	108	innominate	139	worked bone
16	vertebra, ultimate	47	antler	78	mandibular molar	109	femur	140	shell
17	rib	48	cranium	79	mandibular molar 1	110	patella	141	valve
18	sternum	49	maxilla	80	mandibular molar 2	111	tibia	142	dactyl
19	keel	50	maxillary canine	81	mandibular molar 3	112	fibula	143	UID
20	neurocranium	51	maxillary carnassial	82	mandibular molar 4	113	synsacrum	144	tibiofibula
21	basioccipital	52	maxillary incisor	83	tooth	114	tibiotarsus	145	supraethnoid
22	vomer	53	maxillary incisor 1	84	incisor	115	astragalus	146	radius/ulna
23	angular	54	maxillary incisor 2	85	canine	116	astragalus/calcaneus		
24	articular	55	maxillary incisor 3	86	premolar/molar	117	calcaneum		
25	dentary	56	maxillary premolar	87	premolar	118	metatarsal		
26	ceratohyal + epihyal	57	maxillary premolar 1	88	molar	119	metatarsal 3		
27	ceratohyal	58	maxillary premolar 2	89	pre-coracoid	120	metatarsal 3 or 4		
28	epihyal	59	maxillary premolar 3	90	coracoid	121	metatarsal 4		
29	hyoid	60	maxillary premolar 4	91	scapula	122	metatarsal 5		
30	hyomandibular	61	maxillary molar	92	scapula/coracoid	123	metatarsal 5, cf		
31	premaxilla	62	maxillary molar 1	93	clavicle	124	metatarsal, cf		

Table 5-3. Body Portion Numbers for Body Portions

<u>BP #</u>	<u>Body Portion</u>
0	UID
1	cranial
2	axial
3	axial, pectoral
4	axial, pelvic
5	front limb, upper
6	front limb, lower
7	front limb, distal
8	hind limb, upper
9	hind limb, lower
10	hind limb, distal
11	postcranial
12	distal

Table 5-4. Sidedness Numbers for Element Sidedness

<u>L1/R2</u>	<u>Element Sides</u>
0	N/A
1	Left
2	Right
3	Both

Table 5-5. Age Class Numbers for Age Classes

<u>Age #</u>	<u>Age Classes</u>
0	N/A
1	Juvenile Juvenile +
2	Immature
3	Subadult + Adult

Table 5-6. Burning and Charring Numbers for Burning and Charring Descriptions

<u>Bu/Ch #</u>	<u>Burning/Charring</u>
0	None
1	Blackened
2	Calcined Gray
3	Calcined White

CHAPTER 6 RESULTS

Introduction

Two methods of analysis were used in this study, a visual or descriptive comparison, and a statistical analysis using ArcGIS. The comparative use of these methods is appropriate for this study because there were a limited number of excavations done at most sites, and the sample sizes within any of these excavations were small, therefore the interpretations available through GIS analyses were limited. The spatial statistical methods used in this study, Spatial Autocorrelation (Morans I) and Cokriging, both need specific sample sizes for accuracy as identified by ArcGIS. Spatial autocorrelation requires a sample size of more than ten and ideally above thirty specimens and cokriging needs a sample size of ten units or surface collections. Larger taxonomic groupings that included multiple species were used to increase sample sizes for the GIS analysis. Therefore, the patterns revealed by the GIS study are best interpreted with reference to the specific species and specimen distributions which are assessed using the descriptive visual comparison.

In this chapter, the distribution of taxonomic groups within each cave site as revealed by both visual assessment and GIS analyses. When large enough sample sizes are available I also include information about the elements, sides, and regions of the faunal remains in the visual analysis. The GIS spatial statistical methods used in this study, spatial autocorrelation and cokriging, both provide information on specific patterns. The specific information about both of these spatial statistical tools is taken from the ArcGIS computer program. Spatial autocorrelation can be defined as the evenness of distribution of variable, in this case taxonomic groups, throughout a defined space or area, in this case the entire cave site. For the descriptions of each cave site below, distribution is defined as clustered, dispersed, or random. Clustered remains are

identified as having a positive autocorrelation and falling into defined spatial groupings.

Dispersed remains are identified as having a negative spatial autocorrelation and a spatial pattern that varies across the site. Random patterns are defined as those that show no spatial autocorrelation and are neither clustered nor dispersed. Small sample sizes can skew the results and the lowest number of samples for an accurate measurement for spatial autocorrelation is thirty. In those cases, spatial autocorrelation is defined as “failed.”

Kriging is defined as a geostatistical analysis that identifies the spatial relationship of a specific single dataset (in this case the taxonomic groups). It can be used to identify areas of possible high concentration and to quantify the evenness of spatial distribution of remains across a site. Therefore, while spatial autocorrelation defines a distribution as being random, clustered, or dispersed, it is cokriging that identifies the area of clustering and quantifies the evenness of the dispersion of the animal remains. Cokriging analyzes the same dataset and spatial relationships but allows for simultaneous analysis of multiple variables or, in this case, different spaces within the cave site. Therefore, cokriging was used to analyze the taxonomic group distributions in relation to the separations of space within each cave. This test compared NISP values in caves with more than ten excavated units. The interpretive value of this test is limited by the patchy nature of excavation, so it can only reveal clustering between operations/units, not over the entire surface of the site.

The surface view (presented in the chapter figures) is an estimate or assumption of continuous patterning based on the distributions revealed in the units/operations for which data is available. Cokriging maps use a graded scale of color to represent areas of low and high concentrations. Therefore, not all areas fit into a specific and easily identifiable grouping and a brief description of the area and possible distributions noted by cokriging must be provided.

Therefore in this chapter, areas of higher concentration and possible distribution are described for each taxonomic group that was processed using cokriging analysis. Distributions defined by cokriging are defined as being associated with a specific locale, including an individual unit or group of units, or as being within or between certain areas within the site. Cokriging analysis is described by the specific areas of highest concentrations in relation to actual units or by their relationship between or adjacent to specific areas within the site. For both spatial autocorrelation and cokriging, a small sample size or limited distribution can lead to exaggerated or failed attempts for these to programs to analyze the spatial distribution of remains at the site.

I present measures of ubiquity, taxonomic distributions as described above for GIS spatial analyses in relation to each of the cave spaces in this study, and relative proportions of the different taxa, elements, and sides, and burned specimens. For this analysis, ubiquity is the measure of the number of operations, units or surface collections that contained specific taxonomic groups. All other values are based on relative proportion of NISP or number of identified specimens in the group. Sample size issues are discussed for specific taxonomic groups to aid in interpreting the GIS and visual assessment results. I present some limited information on species habitats and habits where it pertains to the specific cave findings, although generalized details of species habitats, uses, and meanings are presented in Chapter 7, Interpretation.

Caves Branch Rockshelter

Cave Branch Rockshelter (CBR) is made up of six operations, and the materials excavated during the 2005 and 2006 seasons are found in four of these areas, Operations 1A, 1B, 1C, and 1D (Figure 4-2). These four operations are located in the northern (Op. 1A), central (Op. 1B and Op.1D) and southern (Op. 1C) regions of the rockshelter. Within these four operations were 24 units that contained faunal remains and were included in this analysis. Op 1A contained eight

units with faunal remains, Op 1B had nine units, Op 1C had four units and Op 1D had three units. These 24 units are on a grid system, each measuring as 1 meter by 1 meter square.

The spatial divisions, or separations of cave space, defined for CBR included the left (1A) versus the right (1B, 1C, 1D) sides of the cave, northern (1A) versus southern (1B, 1C, 1D) parts of the cave, and the dark, cave, (1D) and light (1A, 1B, 1C) regions of the cave (Figure 6-1, Table 6-2). Location and placement of the excavation units did not allow for any distinctions to be made between the eastern and western parts of the site. Due to the open nature of the rockshelter and no architectural impasses, no distinctions were made for areas of open and restricted parts of the site.

A total of 381 remains were identified to specific taxonomic groups out of the total sample of 1276 specimens identified at CBR. These, listed in ranked order from high to low relative frequency, include *Dasypus novemcinctus* (7.99%), Crustaceans (5.09%), Testudines (3.29%), Serpentes (2.90%), Rodentia (2.35%), Agoutidae/Dasyproctidae (1.88%), Aves (1.65%), Artiodactyla (1.41%), Actinopterygii (1.02%), Cervidae (0.86%), *Odocoileus virginianus* (0.71%), Didelphidae (0.63%), Sauria (0.47%), Amphibia (0.39%), Procyonidae (0.31%), Canidae (0.24%), Tayassuidae (0.24%), Chiroptera (0.08%), *Mazama* sp. (0.08%), and *Sylvilagus* sp. (0.08%) (Table 6-1). In total the spatial distribution of twenty taxonomic groups are described in detail below, along with details of body portion, body side, and specimen treatment.

Crustaceans

A total of 65 remains were identified as Crustaceans (Decapoda, infraorder Brachyura) at the site of CBR. Most of the units (20 out of the 24 units and four of four operations) contained crustacean remains (Figure 6-1). Spatial autocorrelation identified the crustacean remains as being clustered and having less than 1% likelihood that this clustered pattern could be the result

of random chance. Cokriging of the site showed that a higher concentration of crustacean remains were located in Operation 1A than in other site areas (Figure 6-6). This can be interpreted as a higher concentration of crustaceans (crabs) in relation to the left (n=33, 50.8%) versus right (n=32, 49.2%) sides of the cave, the northern (n=33, 50.8%) versus southern (n=32, 49.2%) part of the cave, and the light (n=62, 96.9%) versus dark (n=2, 3.1%) regions of the cave. These higher concentrations were also identified in the visual analysis. Operation 1A (n=33, 50.8%) included the largest concentration of crustacean remains at the site. Although there are drastic differences between the light and dark regions of the cave, there are no real distinctions in the concentration of remains in the left over the right side of the cave or the northern over the southern parts of the cave. Visual inspection showed that the crustacean remains were almost ubiquitous throughout the site and were located in all excavated areas of the cave. Almost all of the remains (n=64, 98.5%) were dactyl or claw fragments and were the distal part of the front limbs. There are no differences in the proportion of left (n= 28, 50%) and right (n=28, 50%) elements of the crustaceans remains within the site. None of these remains were burned.

Actinopterygii

A total of thirteen Actinopterygii (fish) remains were identified throughout the site. These were found in each operation although only in seven of the 24 units excavated. Cokriging was not possible because of the limited number of samples. Spatial autocorrelation testing indicated that the materials were slightly clustered, but probably randomly distributed at the site. There are no areas that GIS identified as having a specific concentration of fish remains. Only one bone (n=1, 7.7%) was specifically identified to a genus, *Sparisoma* sp., or the parrotfish family. The rest were unidentifiable (n=12, 92.3%) and could be the remains of either local freshwater fish or other marine fish. CBR is located adjacent to a riverine area and fish remains may be from this local source. The parrotfish, which is a saltwater species, could only have gotten to the site by

human activity since the site is located many hundreds of miles from the coast. This single bone was located in Unit 30G, Operation 1C, located on the right side of the cave, in the southern most part of the excavated region, and in the light area of the site (Figure 6-1). The lack of any other identified taxa limits identification of any specific patterning in fish remains at the site. The fish remains were distributed with more remains on the right (n=10, 76.9%) over the left (n=3, 23.1%) sides of the cave, the southern (n=10, 76.9%) over northern (n=3, 23.1%) part of the cave, and the light (n=7, 53.8%) over the dark (n=6, 46.2%) regions of the cave.

Amphibia

A total five specimens were identified to the class of Amphibia (amphibians) at CBR and all of these remains were identified as being from the Order Anura (frogs and toads). The remains were only located in Operations 1A and 1B and within five out of the 24 units (Figure 6-1). Small sample size and the limited distribution of amphibian remains did not allow use of the spatial analyses programs (spatial autocorrelation and cokriging). There was a slightly higher number of remains in the right and south (n=3, 60%) than the left and north (n=2, 40%) sides of the cave, and all of the remains were found within the light (n=5, 100%) rather than in the dark (n=0, 0%) regions. These five bones do not demonstrate any specific pattern and there are no higher concentrations of these remains in different parts of the site. Amphibia, particularly the large *Bufo marinus*, are known residents of caves (Emery, pers. comm. 2009). There is a slow moving river located near the site (Bonor 1998, 2003; Wrobel 2008; Wrobel and Tyler 2006) and may be where these amphibian remains came from. The majority of these remains were from the appendicular region of the body including humerus (n=2, 40%), femur (n=1, 20%), and a tibiofibula (n=1, 20%). One bone (20%) was identified from the axial region of the body, and was identified as an innominate fragment. This distribution suggests a fairly complete skeletal representation. Three remains were sided, two to the left and none to the right.

Testudines

A total of 42 Testudines (Turtle) specimens were identified at the site of CBR and these remains were located in all of the operations and within 16 of the 24 units. Most of the remains (n=22, 52.4%) were identified within the order Testudines; however, there were three specific taxonomic groups identified, including Kinosternidae (mud and musk turtles) (n=17, 40.5%), *Trachemys scripta* (common slider) (n=2, 4.8%), and *Dermatemys mawii* (Mesoamerican river turtle) (n=1, 2.4%). Spatial Autocorrelation identified a random pattern of distribution of Testudines remains at CBR while cokriging identified some patterning that was not centered on a single operation. The highest area of cokriging occurred between Operations 1A, 1B, and 1D in an area not specifically identifiable by an operation or unit (Figure 6-7). Visual analysis of the distribution of turtle remains shows that the left and north sides of the cave contained 14 (33.3%) turtle specimens while the right and south sides contained 28 (66.7%) specimens. The light region had 36 (85.7%) specimens and the dark region had only six (14.3%) remains. Most of the turtle specimens were from the carapace/plastron (n=39, 92.8%) or axial region of the skeleton with a few of the remains from the pelvic region (n=2, 4.8%) or long bones (n=1, 2.4%). Eleven of the remains could be sided and these included nine right elements (81.8%) and two left elements (18.2%). CBR is located adjacent to a river and many of these turtles may have been easily captured and utilized from this area.

Sauria

A total of six remains were identified as being Sauria (Lizard) remains and within each operation at least one unit contained these remains. Five out of the 24 units contained lizard remains including units 10G, 12G, 23J, 30H, and 21O (Figure 6-1). These remains were evenly distributed in the left (n=3, 50%) and right (n=3, 50%) sides of the cave, and the northern (n=3, 50%) and southern (n=3, 50%) parts of the cave. There was a slightly higher concentration of

lizard remains in the light (n=5, 83.3%) over the dark (n=1, 17.7%) regions of the cave. Four out of the six lizard remains were specifically identified as being from the Iguanidae (iguana) family, located in 10G, 21O, and 23J. These iguana remains were located in equal amounts in both the northern and left sides (n=2, 50%) and right and southern sides (n=2, 50%) of the cave and fewer remains were identified the dark region (n=1, 25%) than in the light region (n=3, 75%) of the cave. Spatial Autocorrelation identified random patterning. The sample size was too small and there were too few remains for cokriging. Visual inspection showed no specific patterns in the overall distribution of either the general group of lizards or the iguana family. The iguana remains were identified as humerus (n=1, 25%), mandible (n=1, 25%), maxilla (n=1, 25%), and innominate (n=1, 25%) fragments. The remains identified to Sauria were all vertebrae. There were four elements, all identified as iguana, that were sided and three were right-sided and one was left-sided.

Serpentes

A total of 37 Serpentes (snakes) remains were identified, distributed in all four operations and in 13 of the 24 units at CBR. Spatial Autocorrelation identified a random pattern that was recognized as being neither clustered nor dispersed throughout the site. Cokriging identified Operation 1D as the region with the highest interpolation, or the highest concentration, of snake remains (Figure 6-8). The disparity between the random distribution identified by spatial autocorrelation and the region of high interpolation with cokriging is due to the small sample size. Having such small samples does not allow for these spatial analysis tools to identify true patterns within the site. These findings identified a higher concentration of remains within the right and southern (n= 31, 83.8%) section over the left and northern (n=6, 16.2%) section of the cave, and the light (n=22, 59.5%) over the dark (n=15, 40.5%) region. A large number of snake remains (n=15, 40.5%) were located within the dark region of the site in a single unit, 21O,

suggesting that in fact the dark region has a much higher concentration of snake remains than the light region despite the GIS findings. All of the remains were vertebrae, no cranial segments or ribs were recovered. Some of the remains had signs of burning (n=13) in units 24J, 23H, and 21O, located in the central portion of the site. Ten of these burnt remains were located in the small cave-like opening of 21O and were located in the dark region of the site.

Aves

A total of 21 remains were identified to the class Aves (birds), with these remains being on the smaller size scale and probably from smaller passerines. These remains were found in Operations 1A, 1B, and 1C and within 11 out of the 24 units. Spatial autocorrelation identified the pattern as being random but showing a slight clustering within the site (z-score = 1.22). Cokriging identified a higher concentration of remains in Operation 1A, which is located in the left and northern sides of the cave. Visually there were similar distributions of bird remains on the left (n=11, 52.4%) and the right (n=10, 47.6%) sides of the cave and the northern (n=11, 52.4%) and the southern (n=10, 47.6%) regions of the cave. One of the patterns formed by the distribution of bird remains is the lack of remains within Operation 1D or the dark region of CBR. All other remains are found within the other three operations located under the rockshelter dripline in the light region. The majority of the elements were from the appendicular (n=14, 66.7%) regions of the body, with a few axial (n=4, 19%) and some unidentifiable (n= 3, 14.3%) remains. Only four of the 21 elements could be sided, and there was a higher proportion of right (n=3, 75%) than left (n=1, 25%) sides.

Didelphidae

A total of eight remains were identified to the family Didelphidae (opossum) and these remains are evenly distributed throughout all of the operations, each containing two remains, but only within 7 out of the 24 units. Spatial autocorrelation found the pattern of opossum remains to

be clustered with a less than 5% chance of this being a random distribution. The limited distribution of remains in only seven units did not allow for cokriging to be calculated. Through a visual analysis the majority of remains were located on the right (n=6, 75%) over the left (n=2, 25%) side, in the southern (n=6, 75%) rather than the northern (n=2, 25%) areas, and the light (n=6, 75%) over dark (n=2, 25%) parts of the cave. The elements of opossums identified at the site include, in order of frequency, cranial (n=4, 50%), axial (n=3, 37.5%), and humerus (12.5%) remains. Seven of the remains were sided, including five right (71.4%) and two left (28.6%) sided elements. The small sample size and even distribution of remains throughout the site make it difficult to identify specific patterns of spatial distribution.

Dasypus novemcinctus

Dasypus novemcinctus (nine-banded armadillo) represented the highest amount of specimens from all of the taxonomic categories, with a total of 102 remains. These remains were distributed in all of the operations and within 19 out of the 24 units. Spatial autocorrelation identified the pattern of armadillo remains as being random and neither clustered nor dispersed within the site. Cokriging identified through interpolation that there was a higher probability for armadillo remains in the north over the south, the left over the right, and the dark over the light regions. Visual analysis confirmed that there was a slightly higher concentration of remains within the right (n=52, 51%) over the left (n=50, 49%) side of the cave and the southern (n=52, 51%) rather than the northern (n=50, 49%) parts of the cave. These are the same areas that cokriging identified. However, more armadillo remains were found in the light (n=78, 76.5%) over the dark (n=24, 23.5%) areas of CBR than those identified in the patterns from cokriging. This may be due to the larger number per few excavation units of armadillo remains identified in the dark region than in the light regions of the cave.

The number of armadillo specimens at the site (NISP) is an overestimate of the actual concentration of animals because a single armadillo can have an estimated 50 to 75 scutes on their nine bands for a total of between 450 and 625 scutes (McBee and Baker 1982). The sample from CBR contained 75 scutes (73.5%). Only 27 (26.5%) armadillo specimens were identified to other elements. These non-scute elements are found in Operation 1A, 1B, and 1D. The non-scute elements included metapodials (n=15), vertebrae (n=6), radii (n=2), fibula (n=2), calcaneum (n=2), humeri (n=1), ulna (n=1), tibia (n=1), and astragalus (n=1). Eleven elements were sided and seven were from the right side of the body (63.7%) while four were from the left (36.3%). The right elements are located in Operations 1A and 1D, while the left elements are located in Operations 1A and 1C. The sample size is too small to consider a specific meaning for the lack of both sided elements in all regions within the cave.

Chiroptera

Only a single Chiroptera (bat) bone was identified at the site of Caves Branch Rockshelter. This was found in one operation (1B) and unit (23J) (Figure 6-1). Due to the lack of Chiroptera remains from the site none of the spatial analyses were possible. I was also unable to identify a specific pattern from the single left innominate fragment located in a unit that was part of the right side, southern, and light regions of the cave. CBR is the only site from this study that lacks a larger sample of bat remains since caves and rockshelters are known habitation sites for these animals.

Canidae

A total of three bones were identified to the family Canidae (coyotes, dogs, and foxes). At CBR, all three bones were identified as *Canis lupus familiaris* (domestic dog). The bones were located in Operations 1A and 1C and within only three units, but they do not seem to form a specific pattern. Due to the small sample size no GIS spatial analyses, spatial autocorrelation and

cokriging, were performed. The distribution of remains were concentrated on the left (n=2, 66.7%) over the right (n=1, 33.3%) side, the northern (n=2, 66.7%) over the southern (n=1, 33.3%) portions, and the light (n=3, 100%) over the dark (n=0, 0%) of the cave. The dog elements included a maxilla, cranium, and metatarsus. These parts of the body may be more of a representation of dog skin rather than the remains from a meal. Only two of these bones were identified to a specific side of the body, and each side was represented.

Procyonidae

A total of four specimens were identified to Procyonidae (raccoon) family. These were identified in two out of the four operations and within three of the 24 units. Two of these remains were located in Operation 1A and the other two were located in Operation 1D. Due to the small number of identified remains, spatial correlation and cokriging were not performed by ArcGIS. Operation 1A is identified as being part of the left (n=2, 50%) and northern (n=2, 50%) side of the site, and Operation 1D is in the dark (n=2, 50%) region of the site. All of the remains were evenly distributed in each of the dichotomies analyzed in this site. The elements identified to the raccoon family include two ulnae (50%) and two tibiae (50%). Three of the raccoon remains were from the left side (75%) of the body, while only one (25%) of the remains was from the right side. These element sides did not form any patterns in their distribution because they are even distributed within all of the spatially distinct areas.

Artiodactyla

A total of eighteen remains were identified to the order Artiodactyla (even-toed ungulates). The general taxonomic group of artiodactyls, including the Tayassuidae (peccary) and Cervidae (deer) families were used for analysis because the larger grouping provided a larger sample for analysis. They are an appropriate grouping because these animals together represent the largest and most commonly used species in the Maya region. Artiodactyls were found in all of the

operations and within eleven of the 24 units. The spatial autocorrelation identified their distribution pattern as random and neither dispersed nor clustered within the site (i.e., evenly distributed). Cokriging identified areas of interpolation around Operation 1A in the north over the south direction and on the left over the right side. Cokriging also identified the dark region of Operation 1D being more clustered than the light region of CBR. There were a higher number of artiodactyl remains in Operation 1A (n=9, 50%) than there are at the rest of the site. Spatially, there was an even distribution of specimens on the left (n=9, 50%) and right (n=9, 50%) sides of the cave and also an even number of those remains in the north (n=9, 50%) and south (n=9, 50%) directions. There were more Artiodactyls in the light (n=16, 88.9%) than in the dark (n=2, 11.1%). This distribution pattern may have been caused by the larger number of units that were excavated in the light than in the dark parts of CBR. The two major family groups, Tayassuidae and Cervidae, have been analyzed separately below and that section includes a discussion on the types of elements and siding of these elements.

Tayassuidae

A total of three Tayassuidae (or peccary) family specimens were located in three out of the four Operations (Op 1A, Op 1B, and Op 1C) and within three out of the 24 units. Due to the small sample size and limited distribution of remains, spatial autocorrelation and cokriging were not performed. A majority of the peccary remains were located on the right and southern (n=2, 66.7%) over the left and northern (n=1, 33.3%) sides of the cave. Peccary specimens were only found in the light (n=3, 100%) region and not the dark region (n=0, 0%). All of the peccary remains at CBR were identified as tooth fragments. Two of these teeth were sided to the left side of the body.

Cervidae

A total of eleven remains were identified to the Cervidae (deer) family specimens. These were located in all four operations and in nine out of the 24 units. There are two major genera of deer species in the Maya region including *Odocoileus virginianus* (white-tailed deer) (n=9) and *Mazama* sp. (brocket deer) (n=1). Cervidae and white-tailed deer remains had sample sizes large enough for spatial autocorrelation and both were identified as randomly distributed at the site. Brocket deer remains were not spatial autocorrelated because of their small sample size. None of the Cervidae assemblages, including the two separate genera, were large enough for cokriging. Each operation contained at least one remain from the *Odocoileus virginianus*, but only one *Mazama* sp. remain was identified at the site, and it was found in Operation 1A. Only the remains from the white-tailed deer are addressed in relation to the spatial separations of space. A higher number of specimens were located on the right (n=5, 55.6%) over left (n=4, 44.4%) sides of the cave, the southern (n=5, 55.5%) over the northern (n=4, 44.4%) regions of the cave, and the light (n=7, 77.8%) over the dark (n=2, 22.2%) parts of the cave. The elements identified for the white-tailed deer included appendicular (n=6, 66.7%), cranial (n=2, 22.2%), and axial (n=1, 11.1%) body portions. There was an even number of left (n=4, 50%) and right (n=4, 50%) sided elements from the white-tailed deer. The brocket deer element was a tarsal centrali – 4 from the right side of the body located in unit 12G in Op 1A. The element identified only as Cervidae was a metapodial located in unit 21O in Op 1D or the cave.

Rodentia

The number of small Rodentia (or rodent) remains should be high at most cave sites both because caves serve as a home for these species and because many cave dwelling animals also consume them. However, a total of only 30 specimens were identified at CBR. These remains were distributed throughout all of the Operations, with the largest concentration (n=14, 46.6%)

found in Op 1B located on the right side, southern, and light parts of the cave. Rodent remains were also identified in fifteen out of the 24 units. Spatial autocorrelation identified the distribution of rodent remains as random and being neither clustered nor dispersed within the site. Cokriging identified the concentration of rodent remains to be greater around Op 1B and Op 1C (right, south, and light regions) than any other part of the cave. By the numbers, rodent remains were more likely to be located in the right (n=22, 73.3%) over left (n=8, 26.7%) side of the site, on the south (n=22, 73.3%) over the north (n=8, 26.7%) direction, and the light (n=26, 86.7%) over the dark (n=4, 13.3%) regions of CBR. Rodent remains were located in the appendicular (n=19, 63.3) and the cranial (n=11, 36.7%) parts of the body. Twenty-six of these elements were sided and the larger amount of rodent remains were from the left (n=19, 73%) than the right (n=7, 27%) side of the body.

Agoutidae and Dasyproctidae

The combined appearance of Agoutidae (paca) and Dasyproctidae (agouti or tepescuintle) families are some of the largest rodents found within the Maya region. There were a total of 24 remains identified to these families. All four operations within eleven units contained Agoutidae and Dasyproctidae remains. Spatial autocorrelation identified the distribution of remains as random, but did find some clustering attributed to random chance. Cokriging identified a high interpolation around Operation 1D, which includes the area identified as being on the right side, the south direction, and the dark region of CBR. Visual patterning identified that the remains were evenly distributed on the right (n=12, 50%) and the left (n=12, 50%) sides and in the northern (n=12, 50%) and the southern (n=12, 50%) directions. There were more remains identified in the light (n=18, 75%) and than in the dark (n=6, 25%) regions of the cave. The majority of elements were tooth fragments (n=18, 75%) and the rest of the remains were from

the appendicular (n=6, 25%) part of the body. There were slightly more left-sided (n=12, 52.2%) than right-sided (n=11, 47.8%) elements.

Sylvilagus sp.

A total of one *Sylvilagus* sp. (rabbit) specimen was identified in the collection from CBR. This single bone was located in Operation 1B and is in one out of the 24 units. Due to the low number of specimens and the limited distribution of remains, neither spatial autocorrelation nor cokriging were processed. The rabbit remain was located on the right hand side, the southern region, and the light area of the cave. The single bone was identified as a metatarsal for which side could not be determined.

Stela Cave

Stela Cave (STC) contained ten excavation units of various sizes and only eight of these units contained faunal material. Chamber 1 consisted of units 1-5 and 7, while Chamber 3 contained units 8 to 11 with only eight and eleven containing faunal remains. At the STC I was able to look at multiple spatial dichotomies including the north versus the south, the east versus the west, the light versus the dark, and the open versus the restricted areas within the cave. Chamber 1 is identified as the part of the cave within the left, north, east, light, and open area. Chamber 3 is identified as the section within the right, south, west, dark, and restricted part of STC (Figure 6-2, Table 6-3). With only eight units containing faunal remains, cokriging was unable to run a formal analysis because it needs ten units to run in ArcGIS. Spatial autocorrelation was used in those samples that contained larger numbers of remains.

A total of 529 faunal remains were identified into 21 specific taxonomic groups. This represents 30.8% of the 1718 remains identified from the 2004 season. These groups include rodents (12.92%), armadillos (4.66%), turtles (2.50%), birds (2.27%), artiodactyls (1.75%), snakes (1.05%), deer (0.93%), bats (0.76%), opossums (0.76%), crustaceans (0.64%), pacas and

agoutis (0.47%), peccaries (0.41%), ray-finned fishes (0.23%), dogs (0.23%), white-tailed deer (0.23%), brocket deer (0.23%), squirrels (0.23%), cotton-tailed rabbits (0.23%), raccoons (0.17%), amphibians (0.06%), and lizards (0.06%) (Table 6-1). Each of the taxonomic groups is discussed in taxonomic order below.

Crustaceans

A total of eleven remains were identified as crustaceans. All crustacean remains were located in Chamber 1, from Units 1 to 5 and 7 at STC (six out of eight units) (Figure 6-2). Spatial autocorrelation identified the distribution of remains as being randomly distributed and neither clustered nor dispersed within the site. This may have been due to the small sample size and the need for more than thirty samples to get a more accurate identification of spatial patterning. However, it is interesting that the entire crustacean remains (n=11, 100%) were located within the part of chamber identified as being on the left side, in the northern and eastern part of the cave, and in the light and open regions. Most of these remains were identified as dactyl (n=10, 90.9%) with only one remain (9.1%) identified as a shell fragment. These dactyl were sided to both the right (n=6, 66.7%) and the left (n=3, 33.3%).

Actinopterygii

A total of four remains were identified as ray-finned fishes. These four remains were located in Units 1, 2, 3, and 8 (four out of eight units) (Figure 6-2). With such a small sample size, spatial autocorrelation was unable to process. The remains were not specifically patterned within STC, but the majority of remains were located in Chamber 1 (n=3, 75%) and are associated with the left, north, east, light, and open area. while only one (25%) was identified in Chamber 3 which includes those remains identified within the right, south, west, dark, and restricted areas of the cave. The elements identified for the ray-finned fish includes dentary (n=2,

50%), a vertebrae (n=1, 25%), and an unidentifiable fragment (n=1, 25%). Both of the dentary remains were sided and there was a single right-sided and left-sided bone in the collection.

Amphibia

One amphibian remain was identified at STC, located in Chamber 1, Unit 7 (Figure 6-2). Spatial autocorrelation was unable to process. The bone was located in Chamber 1 which associates it with left, north, east, light, and open regions of the cave. The specimen was identified as a left humerus.

Testudines

A total of 43 turtle remains were identified and all of these remains were located in Chamber 1, Units 1 to 5 and 7 (6 out of 8 units) (Figure 6-2). Spatial autocorrelation identified the distribution of turtle remains as somewhat dispersed, but the pattern was still random in its distribution. The remains were located only in Chamber 1 which was identified as being on the left, north, east, light, and open parts of the cave. The turtle remains were almost exclusively plastron and carapace fragments (n=42, 97.7%) with only one (3.3%) bone identified as a humerus. There were twenty elements that were sided and there was an even distribution of left (n=10, 50%) and right (n=10, 50%) sided elements.

Sauria

A total of one lizard remain was identified in Chamber 1, Unit 3 (Figure 6-2). Spatial autocorrelation was unable to process. The lizard remain was located in Chamber 1 and therefore within the left, north, east, light, and open regions of the cave. This remain was identified as a mandible fragment and it could not be sided.

Serpentes

A total of eighteen specimens were identified as snake remains which were located in Chamber 1 (Units 2, 3, 5, and 7) and Chamber 3, Unit 8 (five of eight units) (Figure 6-2). Spatial

autocorrelation identified the pattern somewhat clustered, but still random in its overall distribution. Most of the remains (n=17, 94.4%) were identified in Chamber 1, in the north, east, left, open, and light regions of the cave. All of the serpent remains were vertebrae (n=18, 100%) and therefore from the axial part of the body.

Aves

A total of 39 remains were identified as bird and all of these remains were located in Chamber 1, Units 1 to 5, 7 (six out of eight units) (Figure 6-2). Spatial autocorrelation identified the remains as the pattern being random and neither dispersed nor clustered. All of the bird remains (n=39, 100%) are in Chamber 1, the north, east, left, open, and light part of the cave. The elements identified from the bird remains include limb elements (n=27, 69.2%), axial (n=9, 23.1%), unidentifiable (n=3, 7.7%). A total of 27 bird specimens were sided, and the right-sided (n=16, 59.3%) elements slightly outnumbered the left- sided (n=11, 40.7%) elements.

Didelphidae

A total of thirteen specimens were identified to the opossum family and they were all located in Chamber 1, Units 2 to 5, and 7 (five out of eight units) (Figure 6-2). Spatial autocorrelation identified the distribution of remains as random and being neither dispersed nor clustered. Since all of these remains were identified in Chamber 1 they were associated with the northern, eastern, left, light, and open regions of the cave. The opossum materials were found from two portions of the body, including the cranial (n=7, 53.8%) and the axial (n=6, 46.2%) regions. Six specimens were sided, all of which were mandible fragments, this included four left (66.7%) sided and two right (33.3%) sided elements.

Dasypus novemcinctus

A total of 80 specimens were identified to the nine-banded armadillo and were located in Chamber 1, Units 1 to 5, 7, and Chamber 3, Unit 8 (seven of eight units) (Figure 6-2). Spatial

autocorrelation identified the armadillo material as being somewhat clustered, but the pattern may have still been due to random chance. A majority of the remains were scutes (n=51, 63.8%), and these bones can number 450 to 625 scutes per armadillo (McBee and Baker 1982) and can therefore skew the representation of remains within the cave. Visually the armadillo material was distributed with 78 (97.5%) remains being located in the left, north, eastern, light, and open regions of the cave, while 2 (2.5%) remains were located in the right, south, west, dark, and restricted parts of the cave. The two remains located in Chamber 3 were scutes and may have been unintentionally brought to this part of the cave, since these bones are small, light and easily transported. Along with the 51 scutes identified at the site there were other elements identified including vertebrae (n=4), rib (n=1), scapula (n=1), humeri (n=2), ulna (n=3), metapodials (n=7), innominate (n=1), patella (n=1), tibia (n=4), fibula (n=2), astragalus (n=1), and calcaneus (n=1). All of these elements were located in Chamber 1. A total of 15 specimens were sided and the distribution of sided remains includes 9 left (60%) sided bones and 6 right (40%) sided bones.

Chiroptera

Only thirteen remains were identified to order Chiroptera and all of these remains were located in Chamber 1, Units 1-5, and 7 (six of eight units) (Figure 6-2). Spatial autocorrelation found the pattern to be random, showing neither a clustered nor dispersed pattern. At STC, a large number of bats currently live in Chamber 3 and therefore it is here that we would have expected to find a larger amount of specimens (personal communication Griffith 2009).

However, bat specimens were only located in Chamber 1, associated with the left, north, east, light, and open parts of the cave. The bat elements included a small number of cranial elements (n=3, 23.1%) and the other elements were front limb bones (n=10, 76.9%). There were seven bones that were sided; all from the left side.

Canidae

A total of four remains were identified to the canid family; including two remains from the domestic dog and two remains from the gray fox. The canid assemblage from STC was found in Chamber 1, Units 2, 3, and 4 and Chamber 3, Unit 11 (four of eight units) (Figure 6-2). Due to the small sample size spatial autocorrelation failed to process the canid remains. Three (75%) of the remains, two of which were fox remains, were found in the left, north, east, light, and open regions of the cave and one (25%) specimen, a dog remains, was found in the right, south, west, dark, and restricted areas. The elements included three (75%) limb bones and one (25%) cranial fragment from a fox. Three of the canid bones were sided and there were two (66.7%) left-sided, one of these bones was from the fox and one (33.3%) right-sided elements in STC.

Procyonidae

A total of three remains were identified to the raccoon family, and all of these remains are located in Chamber 1, Units 3 and 5 (two of eight units) (Figure 6-2). Spatial autocorrelation failed because of the small sized sample of raccoon materials at STC. All three of the remains were located in Chamber 1, associated with the left, north, east, light, and open parts of the cave. The elements included one (33%) cranial fragment, one (33%) metapodial, and one (33%) scapula. Two of these remains were sided, both to the left side.

Artiodactyla

A total of 30 artiodactyls remains located in both Chamber 1, Units 1 to 5, and 7 and Chamber 3, Unit 8 (seven of eight units) (Figure 6-2). Spatial autocorrelation identified the pattern of artiodactyl remains as random, not showing a dispersed or clustered pattern. The majority of remains were in Chamber 1 (n=27, 90%) rather than in Chamber 3 (n=3, 10%) and this may be due to the different proportion of excavation units in both of these areas. With the majority of artiodactyls in Chamber 1 these remains were identified with the left, north, east,

light, and open regions of the cave. The elements were from the limb (20, 66.7%), cranial (9, 30%), and axial (n=1, 3.3%) parts of the body. A total of nineteen elements were sided, including eight (42.1%) left-sided and eleven (57.9%) right-sided bones. The artiodactyl materials were separated into two families, the peccary and deer, which are discussed below.

Tayassuidae

A total of seven specimens were identified to the peccary family and all of them were located in Chamber 1, Units 1, 2, 3, and 5 (four of eight units), therefore associated with the left, north, east, light, and open parts of caves (Figure 6-2). Spatial autocorrelation identified the peccary material as being randomly distributed within the site. The elements included three (42.8%) cranial fragments, two (28.6%) teeth fragments, and two (28.6%) metapodials. There were five sided elements, including two (40%) left-sided and three (60%) right-sided bones.

Cervidae

Sixteen specimens were identified for the deer family and these remains are located in both Chamber 1, Units 1 to 5, and 7, and Chamber 3, Unit 8 (six of eight units) (Figure 6-2). Of these, four were identified as white-tailed deer, located in Chamber 1, Units 1, 5, and 7, and four were identified as the brocket deer, located in Chamber 1, Units 2, 4, 5, and 7. Spatial autocorrelation found the distribution of deer remains as being neither clustered nor dispersed, and randomly distributed at the site. However, spatial autocorrelation failed during processing for both the white-tailed deer and the brocket deer material because the sample size was too small for analysis. Most deer remains, and all securely identified white-tail and brocket deer, were concentrated in Chamber 1 (n=15, 93.8%), spatially associated with the left, north, east, light, and open areas of the cave. The elements were from the cranium (n=5, 31.3%), hind limb (n=6, 37.5%), front limb (n=2, 12.5%), metapodials (n=3, 18.8%), and a scapula (n=1, 6.3%). A total of eleven deer elements were sided, seven (63.6%) from the right side and four (36.4%) from the

left side. There was a higher proportion of right (n=3, 75%) to left (n=1, 25%) sided elements from the white-tailed deer and from the brocket deer (right n=2, 66.7%, left n=1, 33.3%).

Rodentia

The largest concentration of remains at the STC, both numerically and spatially, was from the rodent order with a total of 222 remains. These were distributed throughout all of the units in Chamber 1 and Chamber 3 (eight of eight units) (Figure 6-2). Spatial autocorrelation of the rodent specimens identified them as being random distributed and neither dispersed nor clustered. A total of 181 (81.5%) remains were located in areas identified as left, north, east, light, and open parts of the cave, while 41 (18.5%) specimens were located to the right, south, west, dark, and restricted regions of the cave. The rodent remains were from the hind limb (n=120, 54.1%), cranium (n=67, 30.2%), front limbs (n=22, 9.9%), and axial region (n=13, 5.8%). A total of 213 elements were sided to the left (n= 114, 53.5%) and right (n= 99, 46.5%) sides.

Scuiridae

Four specimens of the family Scuridae (squirrels) were found in Chamber 1, Units 1 and 4 (two of eight units) (Figure 6-2). With only four remains identified to the squirrel family, spatial autocorrelation failed to process. Since the remains were only located in Chamber 1 they were distributed in the left, north, east, light, and open regions of the cave. The elements included a mandible (25%), two femurs (50%), and 1 tibia (25%). The majority of the elements were sided to the left (n=3, 75%) over the right (n=1, 25%).

Agoutidae and Dasyproctidae

A total of eight remains were identified to the Agoutidae and Dasyproctidae families in both Chamber 1, Units 1 to 5 and Chamber 3, Unit 8 (six of eight units) (Figure 6-2). These two families were processed using spatial autocorrelation and the remains were found to be

somewhat dispersed, but pattern was still due to random chance. The majority of remains (n=7, 87.5%) were identified to the left, north, east, light, and open parts of the cave. The element distribution includes five (62.5%) teeth, one (12.5%) ulna, one (12.5%) tibia, and one astragalus (12.5%). A total of seven elements were sided; there were four (57.1%) left-sided elements and three (42.9%) right-sided elements.

Sylvilagus sp.

A total of four remains were identified as rabbit, and were located in both Chamber 1, Units 1, 2, and 4 and Chamber 3, Unit 8 (four of eight units) (Figure 6-2). Spatial autocorrelation failed to process these remains. The rabbit remains were mainly concentrated (n=3, 75%) in the left, north, east, light, and open regions of the cave. All four bones were sided and there was an even distribution of two (50%) right-sided and two (50%) left-sided elements.

Cueva de El Duende

Cueva de El Duende (CD) consists of three excavated operations that were analyzed for this study including CD1 located near a collapsed area, CD2 located within an open area, and CD3 which is located within the dark regions of the cave. The separations of space within CD include the north versus the south, the east versus the west, the dark versus the light, and the open versus the restricted regions of the cave (Figure 6-3). Each separation is described using the specific units that were excavated in this cave. The northern part of the cave is represented by CD1-1, CD1-2, CD1-3, CD1-4, CD2-0-3, and CD3-1-1 (75%), while the southern part of the cave includes CD2-1 and CD2-2 (25%). Split along the other directional axis, the western part of the cave is represented by CD1-1, CD1-2, CD1-3, CD1-4, and CD3-1 (62.5%), while the eastern part of the cave includes CD2-0-3, CD2-1 and CD2-2 (37.5%). The light and open regions include CD2-0-3, CD2-1, and CD2-2 (37.5%), those units located in the dark and restricted regions include CD1-1, CD1-2, CD1-3, CD1-4, and CD3-1 (62.5%) (Table 6-4).

There were a total of eighteen taxonomic groups and 2496 total specimens identified at the site of Cueva de El Duende. These groups include bats (25.32%), ray-finned fishes (15.99%), snakes (2.00%), birds (1.48%), even-toed ungulates (1.20%), opossums (1.16%), canids (0.88%), rodents (0.84%), deer (0.72%), white-tailed deer (0.60%), turtles (0.60%), amphibians (0.44%), cats (0.32%), pacas and agoutis (0.32%), lizards (0.20%), armadillos (0.08%), brocket deer (0.04%), and crustaceans (0.04%) (Table 6-1). Each of these taxonomic groups is discussed in detail below. When applicable, information about the elements or body portions and element siding are included.

Faunal remains were only identified in eight excavation units and therefore cokriging, which requires ten units, was not processed. Spatial autocorrelation was also limited because of the small sample sizes since this program also needs at least thirty samples to function accurately. Therefore, most of the analysis from Cueva de El Duende relied on the visual analysis of the site and the overall distribution of these remains at the site.

Crustacean

One crustacean specimen was identified and it was located in CD2-1, in the southern, eastern, light, and open region of the cave (one of eight units) (Figure 6-3). The single crustacean remain was a claw fragment that could not be sided. With only one specimen, little can be said about this finding. Cueva de El Duende is located near the El Duende pyramid and is part of an underground river system which connects five of the cave sites at Dos Pilas (Minjares 2003) and the crustacean fragment maybe from this nearby river.

Actinopterygii

A total of 399 remains were identified to the ray-finned fish class. All of these remains were located in excavation units near the opening of the cave in CD1-1, CD1-4, CD2-0-3, and CD2-1 (four of eight units) (Figure 6-3). Spatial autocorrelation identified the pattern of

distribution of the fish remains as being random and neither clustered nor dispersed at the site. There were differences in the distribution of fish remains within the cave, with the majority located in the southern (n=359, 90%) over the northern (n=40, 10%), and the eastern/light/open part (n=377, 94.5%) over the western/dark/restricted part (n=22, 5.5%). Although there were many fish remains identified in this cave, very few (n= 48, 12%) of these were identified into more specific taxonomic groups. Of these, 39 (9.8%) were identified to the family Lepisosteidae (or gars) which were only found in CD2-0-3, and CD2-1 (Figure 6-3). The gar remains identified include a majority of ganoid scales (n=25), cranial fragments (n=10) and vertebrae (n=4) fragments. There were also eight (2%) remains from the order Siluriformes (or catfish) located in CD1-1, CD1-4, and CD2-1 (Figure 6-3). Both gars and catfish are freshwater species and were probably from the surrounding areas, but are not inhabitants of the underground rivers connecting five of the caves at Dos Pilas. The fish remains identified at CD included unidentifiable remains (n=148, 37.1%), cranial (n=51, 12.8%), ribs (n=76, 19%), vertebrae (n=39, 9.8%) ganoid scales (n=25, 6.3%), spines (n=19, 4.8%), and axial fragments (n=60, 15%). A total of 43 fish remains were sided and these bones included 25 (58.1%) right-sided and 18 (41.9%) left-sided fish bones.

Amphibia

The class Amphibia (or Amphibians) was represented by very few remains (n=11), most from the order Anura or frogs and toads. Amphibian remains were found in CD1-4 and CD2-1 (two of eight units) (Figure 6-3). Most were found in the south/east/open/light region (n=7, 63.6%) as opposed to north/west/restricted/dark region (n=4, 36.4%). The breakdown of amphibian elements identified at CD include 4 (36.4%) innominates, 3 (27.2%) humeri, 2 (18.2%) long bones, 1 (9.1%) vertebra, and 1 (9.1%) maxilla. A total of eight elements were

sided and these were evenly distributed between the right (n=4, 50%) and left (n=4, 50%) sides of the body.

Testudines

A total of 15 remains were identified as turtle at CD and these were located in CD2-1 (n=13, 86.6%), CD2-2 (n=1, 6.7%), and CD1-3 (n=1, 6.7%) (three of eight units) (Figure 6-3). The majority of turtle remains (n=14, 93.3%) were located in CD2-1 and CD2-2 which are associated with the southern, eastern, light and open regions of the cave. Although this is a small sample size, they do seem to cluster in this part of the cave. The elements identified from turtles includes the carapace (n=12, 80%), coracoid (n=1, 6.7%), humerus (n=1, 6.7%), and innominate (n=1, 6.7%). From these elements, nine of the turtle specimens were sided including six (66.7%) to the right side and three (33.3%) to the left sides of the body.

Sauria

A total of five lizard remains were identified in a single unit, CD2-1, which is located in southern, western, light, and open area of the cave (Figure 6-3). The five lizard remains were all identified as dentary bones. Out of the five lizard remains, two (40%) were identified as being from the iguana family. Three specimens were sided including two left (66.7%) and one right (33.3%).

Serpentes

A large number of snake remains (n=50) were identified at the site. The largest concentration was located in CD2-1 (n=45, 90%), and the other remains were identified in CD2-0-3 (n=2, 4%) and CD1-4 (n=3, 6%) (Figure 6-3). The highest concentration of snake materials was located spatially in the southern (n=45, 90%) and eastern/light/open (n=47, 94%) regions of the cave. The snake remains included 38 (76%) ribs and 12 (24%) vertebrae. None of the snake materials were sided.

Aves

There are 37 remains that have been identified to the class of Aves (or bird). These remains were located within CD2-1 (n=32, 86.5%), CD1-1 (n=1, 2.7%) and CD1-4 (n=4, 10.8%) (Figure 6-3). The highest concentration of the remains was in CD2-1 (n=32, 86.5%) which is located within the southern, eastern, light and open part of the cave. The body portions of the bird remains from CD include hind limbs (n=15, 40.5%), front limbs (n=10, 27%), axial (n=6, 16.2%), cranial (n=3, 8.1%), and long bone fragments (n=3, 8.1%). A total of 25 elements were sided including 13 (52%) left-sided and 12 (48%) right-sided elements.

Didelphidae

A total of 29 opossum remains were identified at Cueva de El Duende. There were 18 (62.1%) identified within CD2-1 and a total of 11 (37.9%) from CD1. CD1-1 had three (10.3%) and CD1-4 had eight (27.6%) remains (Figure 6-3). The opossum remains were more highly concentrated in the southern, eastern, light, and open (n=18, 62.1%) than the northern, western, dark, and restricted (n=11, 37.9%) areas of the cave. The body portions represented by the opossum remains include the cranial (n=14, 48.3%), axial (n=5, 17.2%) front limb (5, 17.2%), and hind limb (n=5, 17.2%). A total of 26 remains were sided and they were fairly evenly distributed between the left side (n=14, 53.8%) and the right side (n=12, 46.2%).

Dasypus novemcinctus

A total of two armadillo remains were identified from the collection at CD. These two bones were scutes and they were located in CD2-1 (Figure 6-3). CD2-1 is located in the southern, eastern, light, and open regions of the cave. The small size of scutes and their mobility through water movement and trampling may have affected their distribution at the site.

Chiroptera

The largest proportion of identified remains from the faunal assemblage of Cueva de El Duende was from the order Chiroptera with a total of 632 identified specimens. These remains were found in the following Operations CD2-1 (n=509, 80.5%), CD2-0-3 (n=117, 18.5%), CD1-4 (n=5, 0.8%), and CD1-1 (n=1, 0.2%) (Figure 6-3). Spatial autocorrelation found the pattern of faunal remains to be somewhat clustered, but still due to random chance. The largest part of the sample was located within the northern (n=509, 80.5%) rather than in the southern (n=123, 19.5%) part of the cave. There was a higher number of bats remains (n=626, 99.1%) in the eastern, light and open parts of the cave. The bat body portions identified from this faunal assemblage includes phalanges (n=309, 48.9%), front limbs (n=224, 35.4%), axial (n=38, 6%), hind limb (33, 5.2%), and cranial (n=28, 4.4%) regions of the body. A total of 116 (55.5%) bat elements were left-sided while 93 (44.5%) were right-sided.

Canidae

A total of 22 specimens were identified to the canid family, none to a more specific genus. These remains were located in units CD2-1 (n=18, 81.8%), CD2-2 (n=2, 9.1%), CD1-4 (n=1, 4.5%), and CD3-1-1 (n=1, 4.5%) (Figure 6-3). Spatial autocorrelation identified the pattern of canid remains as random, and neither clustered nor dispersed. The majority of remains were located in CD2-1 and CD2-2 (n=20, 90.0%) which were both located in the southern, eastern, light, and open areas of CD. There was one canid bone located in CD3-1-1 which is located in the deepest part of the cave that was excavated, therefore dark, restricted, and also on the northern and western parts of the cave. The elements identified include teeth (n=8, 36.4%), front limbs (n=6, 27.2%), hind limbs (n=4, 18.1%), innominates (n=2, 9%), a cranial fragment (n=1, 4.5%), and an atlas vertebrae (n=1, 4.5%). A total of 21 remains were sided, and these included ten (47.6%) left-sided and eleven (52.4%) right-sided remains.

Felidae

A total of eight Felidae (cat) remains were identified and all of these were located in CD2-1 (one out of eight units) associated with the southern, eastern, light, and open regions of the cave (Figure 6-3). All eight (100%) of the remains were cranial fragments. A total of five (62.5%) of the cat remains were from the right side of the body, while only three (37.5%) were from the left side of the body.

Artiodactyla

A total of 30 specimens were identified to the artiodactyl order, the largest sized mammals at the site. The artiodactyl remains were distributed within four units at the site including CD2-1 (n=14, 46.7%), CD1-1 (n=2, 6.7%), CD1-2 (n=4, 13.3%), and CD1-4 (n=10, 33.3%) (Figure 6-3). Spatial autocorrelation identified the pattern of artiodactyls remains as being random; showing neither clustered nor dispersed patterning. The remains were distributed throughout the site in nearly even amounts with 16 (53.3%) specimens located in the north, west, dark, and restricted parts of the cave, and the other 14 (46.7%) remains located in the south, east, light, and open areas within the cave. The body portions of the artiodactyls at CD included the hind limbs (n=11, 36.7%), distal appendages (n=8, 26.7%), axial (n=5, 16.7%), front limb (n=4, 13.3%), and cranial (n=2, 6.7%) portions of the body. A total of 13 elements were sided, and this included ten (76.9%) left-sided and three (23.1%) right-sided elements.

Cervidae

Within the artiodactyls, there were 18 bone fragments identified to the deer family, and none specifically identified to the peccary family. Deer materials were identified in units CD2-1 (n=11, 61.1%), CD1-2 (n=1, 5.6%), and CD1-4 (n=6, 33.3%) (Figure 6-3). Within the deer family, fifteen specimens were identified as white-tailed deer and one was identified a brocket deer. There were eleven (61.1%) cervid remains within the southern, eastern, light, and open

areas, while only seven (38.9%) remains were found in the other spatial distinctions including northern, western, dark, and restricted areas within the cave. The body portions identified for the deer specimens include the hind limbs (n=9, 50%), front limbs (n=4, 22.2%), distal appendages (n=2, 11.1%), cranial (n=2, 11.1%), and axial (n=1, 5.6%) portions. There was a total of eleven remains that were able to be sided including eight (72.7%) left-sided and three (27.3%) right-sided elements. The distribution of white-tailed deer includes nine (60%) of the remains located in the southern, eastern, light, and open areas, while six of the remains were found in the northern, western, dark, and restricted. The distribution of body elements from the white-tailed deer include cranial (n=1), axial (n=1), front limb (n=2), hind limbs (n=8), and distal (n=2). There was one brocket deer remain, a metacarpal, identified in the southern, eastern, light, and open regions of the cave.

Rodentia

Rodent remains were found in very small numbers at Cueva de El Duende with a sample of twenty-one specimens. The rodent materials were identified in units CD1-2 (n=12, 57.1%), CD2-1 (n=5, 23.8%), and CD1-4 (n=4, 19.1%) (Figure 6-3). The majority of Rodentia remains (n=16, 76.2%) were within the northern, western, dark, and restricted parts of the cave. The body portions of rodents within CD include the hind limbs (n=9, 42.9%), axial (n=7, 33.3%), cranial (n=4, 19%), and front limb (n=1, 4.8%) of the body. The numbers of sided elements were very similar with eight (53.3%) left-sided and seven (46.7%) right-sided elements identified.

Agoutidae and Dasyproctidae

A total of eight remains were identified to both Agoutidae and Dasyproctidae families. The majority of remains were located in CD2-1 (n=6, 75%). The remainder were located in CD1-4 (n=1, 12.5%) and CD3-1-1 (n=1, 12.5%) (Figure 6-3). The majority of these remains (n=6, 75%) were located within the southern, eastern, lit, and open parts of the cave. The elements included

the tibia (n=3, 37.5%), humerus (n=2, 25%), femur (n=2, 25%), and ulna (n=1, 12.5%). Six out of eight (75%) remains were sided to the right side while only two (25%) were sided to the left.

Cueva de Sangre

Cueva de Sangre (CS) is a formed by several long and thin passageways with multiple entrances into the cave (Figure 6-4). There were a large number of surface collections and some large soil samples that were deflocculated from the site by James Brady and Anne Scott (1997). A total of 81 of these collection areas were found to contain faunal materials. Due to the large number of surface collections cokriging analysis was able to process for those taxonomic groups with large samples. However, due to the shape of this cave many of the spatial separations were unable to process. A visual analysis was also conducted on the remains from this site. For analysis of the left versus right side of the cave, only remains identified from CS1 (n=57) are used because the maps provided the best information for this division. The separation of space includes the left (n=26, 45.6%) versus the right (n=31, 54.4%) sides of the cave, the northern (n=64, 79%) versus the southern (n=17, 21%) regions, and the eastern (n=20, 24.7%) versus western (n=61, 75.3%) parts of the cave (Figure 6-4) (Table 6-5).

A total of sixteen taxonomic groups were identified from CS. These include rodents (10.07%), pacas and agoutis (4.61%), turtles (3.60%), even-toed ungulates (3.55%), opossums (3.29%), deer (2.97%), canids (2.07%), brocket deer (1.85%), white-tailed deer (1.01%), bats (0.64%), crustaceans (0.42%), peccary (0.26%), birds (0.21%), snakes (0.16%), armadillos (0.08%), and ray-finned fishes (0.11%) (Table 6-1). Each of these taxonomic groups is discussed in detail below and includes elements or body portions and side of elements when applicable.

Crustaceans

Eight crustacean specimens were identified within CS1-7-1, CS1-9-1, and CS1-78-1 (3 of 81 surface collections) (Figure 6-4). Due to the limited distribution and small sample size of the

crustaceans at CS, both spatial autocorrelation and cokriging failed to process. All of the crustacean remains were located on the right side, in the northern and eastern regions of Cueva de Sangre. These remains were also located in an area of the cave that was known to have a high amount of run-off and clayey soil at the site. All of the eight bones identified to crustacean were claw fragments and the siding of these remains include three (60%) right-sided and two (40%) left-sided claws.

Actinopterygii

A total of two remains were identified to the ray-finned fish and were located in a single surface collection, CS1-9-1 (Figure 6-4). The fish materials failed spatial autocorrelation and cokriging because of the small sample size and limited distribution. The small size and brittleness of fish remains may be a reason for these bones not being found in Cueva de Sangre. They were also not found in the large mud samples that were later deflocculated, which was water screened through a fine mesh that was 4 mm in size (Brady and Scott 1997). The two bones identified as fish remains included one vertebra and one postcranial element. Neither of these bones could be sided.

Testudines

A total of 70 remains were identified as turtles, which were present within 30 out of the 81 surface collections at Cueva de Sangre (Figure 6-4). Spatial autocorrelation identified the pattern as being random and showing neither clustered nor dispersed distributions. Cokriging was only able to be processed for the right versus the left side of the cave, and the highest concentrations were located near the main entrance of the cave in CS1 (Figure 6-9). All of the turtle remains were located within the northern and eastern part of the cave while there were more remains located on the right (n=41, 58.6%) than the left (n=29, 41.4%) sides of the cave. Most of the turtle remains were from the carapace and plastron (n=69, 98.6%) and there was also a single

vertebra (n=1, 1.4%) fragment as well. Eleven remains were sided and they included both left-sided (n=6, 54.5%) and right-sided (n=5, 45.5%) elements.

Serpentes

A total of three snake remains were identified in Cueva de Sangre and they were found in surface collections of CS1-9-1 and CS1-13-1 (Figure 6-4). Both spatial autocorrelation and cokriging failed due to small sample size. There were slightly more snake remains located on the right (n=2, 66.7%) than the left (n=1, 33.3%) sides of the cave. All of the snake remains were located on the northern and eastern part of the cave, nearest to the main cave entrance of CS1. The snake remains were also from the axial part of the body (vertebrae) and none of these were sided.

Aves

A total of four remains were identified to the class of birds, and all were found in surface collections of CS1-77-2, CS1-78-1, and CS6-8-1 (Figure 6-4). Spatial autocorrelation and cokriging were both unable to process this taxonomic group. The majority of remains were located on the left (n=2, 66.7%) rather than the right (n=1, 33.3%) sides of the cave. All of the remains were located in the north, and more were concentrated in the western (n=3, 75%) than the eastern (n=1, 25%) parts of the cave. The four remains were identified as one humerus, one ulna, one vertebra, and one unidentifiable fragment. There were only two remains that could be sided, including a left-sided humerus and a right-sided ulna.

Didelphidae

A total of 62 specimens were identified to the family Didelphidae and found in five collection units including CS1-9-1, CS1-46-1, CS1-78-1, CS1-77-2, and CS11-4-1 (Figure 6-4). Spatial autocorrelation identified 5 to 10% likelihood that this clustered pattern is the result of random chance. Most of the remains were located in the right (n=33, 54.1%) over the left (n=28,

45.9%), and the north and west (n=61, 98.4%) over the south and east (n=1, 1.6%), respectively. The opossum elements identified at the site included vertebrae (n=28, 45.2%), teeth (n=11, 17.7%), mandible (n=8, 12.9%), cranium (n=5, 8.1%), humerus (n=5, 8.1%), radius (n=2, 3.2%), scapula (1, 1.6%), ulna (n=1, 1.6%), and astragalus (n=1, 1.6%). There were a total of 32 remains sided, and these remains were evenly distributed between the left (n=16) and right (n=16) sides.

Dasypus novemcinctus

A total of three armadillo remains were identified within three surface collections including CS1-10-1, CS1-13-1, and CS6-8-1 (Figure 6-4). Due to the limited distribution and small sample size autocorrelation and cokriging could not be processed. The remains were only located on the left (n=2, 100%) side of the passage and the northern (n=3, 100%) regions of the cave, but the majority of remains were located on the western (n=2, 66.7%) not the eastern (n=1, 33.3%) side of the cave. The armadillo elements included two (66.7%) scutes and one (33.3%) caudal vertebrae. None of the armadillo remains from CS could be sided.

Chiroptera

A total of 12 bat remains were identified and were located in a two surface collections, CS1-78-1 and CS6-3-1 (Figure 6-4). Both spatial autocorrelation and cokriging were unable to process. Most of the remains were from surface collection CS1-78-1 (n=9) which includes the area that was deflocculated and water screened through a fine mesh size. The bat remains at CS were only located on the right (n=9, 100%) side and northern (n=12, 100%) sections of the cave, and more were found in the western (n=9, 75%) than in the eastern (n=3, 25%) parts of this cave. The elements identified from the bat remains include humeri (n=4, 33.3%), ulnas (n=4, 33.3%), femurs (n=1, 8.3%), and phalanx (n=3, 25%). Five specimens were sided and their distribution was similar including left (n=3, 60%) and right (n=2, 40%) sides.

Canidae

Cueva de Sangre contained the largest amount of canid remains from the caves in this study, with a total of 39 remains located within 9 out of the 81 surface collections (Figure 6-4). Due to the larger sample size, spatial autocorrelation identified the pattern as being somewhat clustered, but the pattern may be due to random chance. Cokriging was unable to process because only nine and not the necessary ten surface collections included canid remains. The majority of remains were located on the right (n=11, 64.7%) over the left (n=6, 35.3%) sides of the cave, the northern (n=38, 97.4%) over the southern (n=1, 2.6%) regions, and the western (n=23, 59%) over the eastern (n=16, 41%) regions of the cave. One of the remains was identified as *Urocyon cinereoargentes* and the rest were identified as *Canis lupus familiaris* (n=38). Most of the canid specimens were identified as teeth fragments (n=37, 94.8%). The rest of the elements include one (2.6%) cranium, identified as *Urocyon cinereoargentes*, and one (2.6%) domestic dog baculum. The only specimens sided were the teeth and these included 17 (53.1%) teeth sided to the left and 15 (46.9%) sided to the right.

Artiodactyla

A total of 67 specimens were identified as artiodactyls and these were located within 26 of the 81 surface collections with faunal material (Figure 6-4). Spatial autocorrelation identified the pattern of remains as random and being neither clustered nor dispersed. Cokriging analysis found a higher concentration around surface collections CS7-3-1 and CS11-1-1, for all of the spatial distinctions including left versus right, north versus south, and east versus west. Visual analysis of this material identifies a slightly higher concentration of remains on the right (n=15, 57.7%) over the left (n=11, 42.3%), the south (n=40, 59.7%) over the north (n=27, 40.3%), and the east (n=41, 61.2%) over the west (n=26, 38.8%). Specific elements and the side of elements distributions are discussed for each family separately.

Tayassuidae

A total of five specimens were identified to the peccary family and were located in surface collections of CS1-9-1, CS1-27-1, CS9-2-1, CS11-2-1, and CS11-6-1 (5 out of 81 surface collections) (Figure 6-4). Both spatial autocorrelation and cokriging failed for the analysis of peccary remains. These remains were visually assessed and it was found that all of the remains were located on the left (n=2, 100%) side of CS1. There was a higher amount of peccary on the southern (n=3, 60%) versus northern (n=2, 40%) areas and on the western (n=3, 60%) versus eastern (n=2, 40%) regions. The elements identified as peccary included teeth (n=3, 60%), a mandible (n=1, 20%), and a metacarpal (n=1, 20%). Three of these elements were sided and two (66.7%) were sided to the right and one (33.3%) was sided to the left.

Cervidae

The majority of artiodactyl remains are from the cervid family (n=56) and these remains were located within 19 of the 81 surface collections with faunal materials (Figure 6-4). Deer remains were identified as being somewhat clustered, the pattern may be due to random chance. Cokriging analysis identified the same probability distribution of remains around CS7-3-1 and CS11-1-1 for the relationship between left versus right, north versus south, and east versus west (Figure 6-10). Upon a visual analysis of the site, the majority of remains in CS1 were located on the right (n=13, 65%) versus the left (n=7, 35%), in the south (n=35, 62.5%) versus the north (n=21, 37.5%), and in the east (n=36, 64.3%) versus the west (n=20, 35.7%). Out of the 56 remains identified to cervids, 48 of these remains were sided and the distribution was even between the left (n=24, 50%) and the right (n=24, 50%) sides.

Between the two major subgroups of the cervids the white-tailed deer accounted for 19 remains and was distributed within 16 surface collections. The brocket deer accounted for 35 specimens but was only found in four of the surface collections. Spatial autocorrelation identified

both the white-tailed deer and brocket deer patterns as being random and neither clustered nor dispersed. Due to the limited distribution of remains only the white-tailed deer was able to be processed using cokriging and the results from this analysis identify a large concentration of remains within CS1 for the relationship between north versus south and east versus west. It also identified a pattern for left versus right at the mouth of the cave within the CS1 area. Brocket deer material were not well-represented in CS1 (n=1) so the analysis of their distribution is inconclusive. However, there was a higher concentration of remains within the south (n=33, 94.3%) than the north (n=2, 5.7%) and in the east (n=34, 97.1%) than the west (n=1, 2.9%). White-tailed deer the remains were somewhat evenly distributed in CS1 in relation to the left (n=10, 58.8%) and right (n=7, 41.1%) sides of the cave. However, there was a higher concentration in the north (n=17, 89.5%) over the south (n=2, 10.5%) and in the west (n=17, 89.5%) over the east (n=2, 10.5%). Visually the brocket deer material was identified at three of the cave entrances within sections CS1, CS6, CS7, and CS11. That is an interesting pattern considering that the white-tailed deer remains are well distributed further into the cave at CS1 and also within CS11.

Rodentia

Accounting for the largest number of specimens (n=190) of faunal remains from Cueva de Sangre, rodent remains were only located within ten of the 81 surface collections (Figure 6-4). Spatial autocorrelation identified the distribution of remains as random, being neither clustered nor dispersed. Cokriging analysis identified the highest concentrations centered on CS6-8-1 and CS6-3-1 to varying degrees for left versus right, the north versus the south, and the east versus the west (Figure 6-11). The highest concentration of remains were identified for CS6-8-1 (n=112, 58.9%). In CS1 a total of 22 remains were identified, most on the left (n=18, 81.8%) rather than the right (n=4, 18.2%) sides. There were more remains in the north (n=187, 98.4%)

than the south (n=3, 1.6%) and the east (n=168, 88.4%) than the west (n=22, 11.6%). The body portions identified for the rodent remains includes cranial (n=54, 28.4%), axial (n=55, 28.9%), front limbs (n=28, 14.7%), hind limbs (n=40, 21.1%), and distal (n=13, 6.8%) parts of the body. A total of 124 remains were sided and most were from the left (n=79, 63.7%) side rather than the right (n=45, 36.3%) side.

Agoutidae and Dasyproctidae

A total NISP of 87 was identified for the medium- and large-sized rodents including the families Agoutidae and Dasyproctidae within nineteen of the surface collections (Figure 6-4). Spatial autocorrelation identified the pattern as being neither clustered nor dispersed, but it was considered a random distribution. Cokriging analysis was performed for the Agoutidae and Dasyproctidae specimens and although there were no areas of high concentrations identified by specific surface collections, they were centered within the lower region of CS1, around collection CS1-84-1. Visual analysis identified a slightly higher concentration of Agoutidae and Dasyproctidae material in the left (n=22, 29.7%) over the right (n=52, 70.3%) sides of the cave. There was a disproportionate number of remains in the northern (n=76, 87.4%) versus the southern (n=11, 12.6%) half of the cave and within the western (n=74, 85.1%) versus the eastern (n=13, 14.9%) half. The body portions identified for these two families include cranial (n=61, 70.1%), front limb (n=15, 17.2%), hind limb (n=6, 6.9%), distal (n=4, 4.6%), and innominate (n=1, 1.1%) parts of the body. There were an even proportion of sided elements including the left side of 39 (48.8%) remains and the right side with 41 (51.3%) remains.

Naj Tunich

Excavations at the site of Naj Tunich were completed in the early 1980s and it was here that some of the first hypotheses were developed for the ritual use of cave sites in the Maya region. The faunal remains from the site of Naj Tunich were identified by Susan Colby at UCLA

in 1984 (Brady 1989). This published resource is used to show how more information can be obtained from the analysis of older research projects, particularly when well-scaled maps are also available. As in the other sites, there was a varied sample size for taxonomic groups at the site so spatial autocorrelation analysis varied within the site. However, due to the large number of surface collections and some large sample sizes, Naj Tunich provided enough information for cokriging analysis to be performed at the site. All identified patterns through visual analysis were completed with the recreation of the map with the identified surface collection faunal assemblage from Operation IV. Some patterns were identified by Brady in 1989, and I plan on adding to these initial observations by identifying the spatial patterns of these faunal remains using left versus right sidedness, directionality, and light versus dark.

A total of 44 surface collections from Operation IV at Naj Tunich contained faunal remains (Figure 6-5). These surface collections are referred to by Lot by the researchers. The spatial distinctions identified for these Lots with Operation IV include the left (n=30, 68.2%) versus right (n=14, 31.8%) sides, the north (n=33, 75%) versus south (n=11, 25%), the east (n=32, 72.7%) versus west (n=12, 27.2%), and the light (n=13, 29.5%) versus dark (n=31, 70.5%) regions of the cave (Figure 6-5) (Table 6-6). A total of twenty taxonomic groups were identified within Operation IV at Naj Tunich. These taxonomic groups include even-toed ungulates (16.91%), deer (14.32%), white-tailed deer (11.83%), birds (2.70%), peccary (2.59%), pacas and agoutis (2.59%), rodents (2.07%), brocket deer (1.66%), *Meleagris gallopavo* (domestic turkey) (1.45%), *Tapirus bairdii* (Baird's tapir) (1.14%), opossums (1.04%), turtles (0.83%), crustaceans (0.62%), bats (0.62%), armadillos (0.62%), primates (0.62%), canids (0.41%), cats (0.31%), raccoons (0.31%), and cottontail rabbit (0.21%) (Table 6-1). Each of these taxonomic groups is

discussed in detail below and includes elements or body portions and side of elements when applicable.

Crustacean

There was a small sample (n=6) of crustacean remains identified in Operation IV at Naj Tunich and they were located in Lots 12, 45, 50, and 51 (Figure 6-5). Spatial autocorrelation identified the pattern as somewhat clustered, but this pattern was probably due to random processes. Due to the limited distribution into only four Lots, cokriging was unable to be performed. There was an even distribution of these remains, three in each region, in relation to the left and right sides and the north and south directions. However, all of the crustacean remains were located within the dark part of the cave and on the eastern section. All of the remains were identified as claws and none of them were sided.

Testudines

A total of eight turtle remains were identified within Operation IV. The turtle materials were identified in Lots 2 (n=1, 12.5%), 50 (n=3, 37.5%), and 51 (n=4, 50%) (Figure 6-5). Due to the small sample size and limited distribution, both spatial autocorrelation and cokriging failed to process the spatial patterns for the turtle specimens. There are four (50%) remains found in both the left and right sides and the north and south directions, while all turtle remains (n=8, 100%) were found within the dark regions and eastern portion of the cave. A majority of the remains were identified as carapace (n=6, 75%) with some long bones (n=2, 25%) also being identified. None of the bones identified as turtle were sided.

Aves

Twenty-six avian remains were identified within Operation IV in Lots 2, 3, 10, 13, 14, 15, 16, 22, 34, 36, 42, 46, 50, and 51 (Figure 6-5). These bird remains included both possible cave dwellers, including *Buteo platypterus* (broad-winged hawk), and those not known to live within

cave habitats, including Ardeidae (herons and bitterns family), Ramphastidae (toucans family), Psittacidae (parrots and cockatoos family), Columbidae (doves and pigeons), and *Meleagris gallopavo* (Brady 1989). Spatial autocorrelation identified the pattern as being random and neither clustered nor dispersed within Operation IV. Cokriging analysis identified the pattern of distribution as being concentrated around IV 3, on the northern over the southern, the western over the eastern, the left over the right sides, and the dark regions over the light regions (Figure 6-12).

A majority of the Aves remains are located in the left (n=19, 73%) versus the right (n=7, 27%), to the north (n=22, 85%) versus the south (n=4, 15%), to the east (n=19, 73%) versus the west (n=7, 27%), and within the dark (n=21, 81%) versus the light (n=5, 19%) areas of the cave. A large number of the bird remains (n=14, 53.8%) were identified as *Meleagris gallopavo* (domestic turkey) in Lots 3, 10, 13, 15, 16, 34, 42, and 46 (Figure 6-5). These remains were found to occur in larger numbers in the left (n=11, 78.6%) versus the right (n=3, 21.4%), in the north (n=12, 85.7%) versus the south (n=2, 14.3%), and in the dark (n=12, 85.7%) versus the light (n=2, 14.3%) regions. There was an even number of remains found in the eastern and western parts of the cave. The elements identified from the bird remains in Operation IV include coracoids (n=4, 15.4%), humerus (n=4, 15.4%), femur (n=4, 15.4%), tibiotarsus (n=4, 15.4%), radius (n=2, 7.7%), keel (n=1, 3.8%), cranium (n=1, 3.8%), phalanx (n=1, 3.8%), and unidentifiable fragments (n=5, 13.9%). There were fifteen bird remains that were sided with a majority of remains being from the right (n=10, 66.7%) rather than the left (n=5, 33.3%) side of the body.

Didelphidae

A total of ten opossum remains were identified in Operation IV and were located within Lots 3, 34, 48, 49, 50, and 51 (Figure 6-5). Spatial autocorrelation identified the pattern as

somewhat clustered, but that the pattern was still random in distribution. Cokriging analysis failed to process. These ten remains were all located in the dark regions of the cave. A majority of the remains were located in the left/north (n=7, 70%) over the right/south (n=3, 30%), and in the eastern (n=9, 90%) over the western (n=1, 10%) part of the cave. The elements included mandibles (n=4, 40%), scapulas (n=2, 20%), humeri (n=2, 20%), maxilla (n=1, 10%), and a molar (n=1, 10%). Nine of these opossum remains were sided and there were four (44.4%) left-sided and five (55.6%) right-sided elements.

Dasypus novemcinctus

A total of six armadillo remains were identified within Operation IV at Naj Tunich and were located in Lots 1, 2, and 50 (Figure 6-5). Due to the small sample size and limited distribution both spatial autocorrelation and cokriging failed analysis for armadillo remains. The remains were more concentrated in the right/south (n=4, 66.7%) than the left/north (n=2, 33.3%). All of the bones were collected in the eastern and dark regions of the cave. Unlike the other sites analyzed, all of the materials identified were appendages and a cranial fragment and no scute remains were identified at the site. The elements identified as armadillo included femurs (n=2, 33.3%), a cranium (n=1, 16.7%), a humerus (n=1, 16.7%), an ulna (n=1, 16.7%), and a tibia (n=1, 16.7%). Five of these elements were sided including three (60%) left-sided and two (40%) right-sided elements.

Chiroptera

A total of six remains were identified as bats and these remains were located in Lots 24, 25, 42, and 45 (Figure 6-5). Spatial autocorrelation identified the pattern as being random and neither clustered nor dispersed at the site. Cokriging was unable to process because of the limited spatial distribution of these remains. The bat specimens were only located in the eastern part of the cave. There was a higher distribution of remains on the right (n=4, 66.7%) over the left (n=2,

33.3%) side of the cave. There was also an even distribution between the northern (n=3, 50%) and southern (n=3, 50%) and also the light (n=3, 50%) and dark (n=3, 50%) parts of the cave. The elements included crania (n=2, 33.3%), radii (n=2, 33.3%), an ulna (n=1, 16.7%), and a metapodial (n=1, 16.7%). There was an even distribution of right (2, 50%) and left (2, 50%) sided elements from bats within Operation IV.

Primates

Naj Tunich is the only site under analysis that contained primate material. Two specimens identified as *Alouatta* sp. or howler monkey, were identified from a single surface collection (Lot 1), on the left, north, east, and dark parts of the cave (Figure 6-5). Spatial autocorrelation and cokriging both failed analysis for the primate remains. The materials were identified as a humerus and a tibia. Both of these remains were also left-sided.

Canidae

The Canidae family consisted of only four identified specimens in Operation IV, and those were within Lots 3, 28, and 51 (Figure 6-5). The small number of canid remains and limited distribution meant neither spatial autocorrelation nor cokriging were processed. The canid remains were distributed in only the left and northern part of the cave, while there were higher concentrations of remains in the western/dark (n=3, 75%) regions of the cave. The elements included a premolar (n=1, 25%), a radius (n=1, 25%), an ulna (n=1, 25%), and a metapodial (n=1, 25%). Two out of the four canid remains were sided, and both of these bones were left-sided.

Felidae

There were three cat specimens identified in Operation IV within Lots 1, 6, and 34 (Figure 6-5). Due to the small sample size and limited distribution spatial autocorrelation and cokriging both failed. All of the remains were located in the left, north, and dark parts of the cave, while

there was a higher concentration in the east (n=2, 66.7%) than the west. The three elements identified include a radius (n=1, 33.3%), a humerus (n=1, 33.3%), and a metapodial (n=1, 33.3%). These three elements were sided and included two (66.7%) left-sided and one (33.3%) right-sided bone

Procyonidae

A total of three raccoon remains were identified at the site and within Operation IV they were located in Lots 3, 4, and 37. Due to the small sample size, spatial correlation and cokriging both failed to process. All of the remains were within the left side, and the north and dark regions of the cave, and the majority of remains were located within the western (n=3, 66.7%) area. The elements included a radius (n=1, 33.3%), a scapula (n=1, 33.3%), and a femur (n=1, 33.3%). These remains were sided, and the left-sided (n=2, 66.7%) outnumbered the right-sided (n=1, 33.3%) elements.

Tapirus bairdii

The *Tapirus bairdii* (Baird's tapir) was not identified at any of the other cave sites examined in this study. A total of eleven tapir remains were recorded at Naj Tunich, Operation IV in Lots 1, 3, 16, 24, 42, and 57 (Figure 6-5). Spatial autocorrelation identified the pattern as random and being neither clustered nor dispersed. Due to the limited distribution of remains, cokriging was not able to process. A majority of these remains were located in the left (n=7, 63.6%) over the right (n=4, 36.4%), the north (n=8, 72.7%) over the south (n=3, 27.3%), east (n=10, 90.9%) over the west (n=1, 9.1%), and the dark (n=8, 72.7%) over the light (n=3, 27.3%) regions of the cave. Many of the remains were distal appendages from the body including the carpal or tarsal bones and the metapodials. The elements identified include an atlas vertebra (n=1, 9.1%), a coccyx (n=1, 9.1%), a scapula (n=1, 9.1%), a humerus (n=1, 9.1%),

carpals/tarsals (n=2, 18.2%), long bones (n=2, 18.2%), and metapodials (n=3, 27.3%). Only two out of the eleven specimens were sided and both were identified as being left-sided.

Artiodactyla

The largest identified taxonomic group within Naj Tunich was the artiodactyls that had an total of 163 remains within Operation IV and were located in 26 of the 44 Lots (Figure 6-5). Spatial autocorrelation identified the pattern as clustered with only 5-10% likelihood that this clustered pattern is the result of random chance. The patterns identified by cokriging had the highest concentration of remains centered on Lots 44 and 18 for the relationships between the left and right sides, the north and south, the east and west, and the light and dark regions. The majority of artiodactyls remains were located in the left (n=115, 70.6%) rather than on the right (n=48, 29.4%), on the northern (n=142, 87.1%) rather than on the southern (n=21, 12.9%) side, on the western (n=137, 84.1%) rather than on the eastern (n=26, 15.9%) region, and the dark (n=137, 84.1%) rather than the light (n=26, 15.9%). There was an even distribution of sided elements including rights (n=58) and left (n=60) sided remains. Specific elements are discussed below for the peccary and deer families.

Tayassuidae

A total of 25 peccary remains were located in Operation IV within 12 of the 44 Lots (Figure 6-5). Spatial autocorrelation identified the pattern as being random neither clustered nor dispersed within Operation IV. Cokriging identified a high concentration of peccary materials within several clusters around Lots 1, 16, and 24, and also around Lot 57. Visual analysis identified the majority of peccary remains on the left/north (n=17, 68%) over the right/south (n=8, 32%) regions, in the dark (n=16, 64%) over the light (n=9, 36%), and the eastern (n=20, 80%) over the western (n=5, 20%) parts of Operation IV. The body portions for the peccary from Naj Tunich include the cranial (n=5, 20%), the axial (n=6, 24%), the front limb (n=9, 36%), the

hind limb (n=4, 16%), and the metapodials (n=1, 4%) from the body. There were also eight (72.2%) right-sided elements and only three (27.3%) left-sided elements identified at the site.

Cervidae

Within the artiodactyls, 138 remains were identified to the deer family in Operation IV within 23 of the 44 Lots (Figure 6-5). Of these, most were identified as white-tailed deer (n=114, 82.6%) while a smaller number of remains were within the brocket deer genus (n=16, 11.6%). Spatial autocorrelation identified the pattern of deer as clustered with only 5-10 % likelihood that this pattern was the result of random chance. Within this family, white-tailed deer were identified as being somewhat clustered but the pattern was probably due to random chance. Brocket deer distribution was also described as being random, and neither clustered nor dispersed. Due to the high number of remains identified white-tailed deer cokriging analysis are only described for this specific taxonomic group. Cokriging analysis for all four spatial distinctions identified the highest concentrations for the patterning of remains around Lots 16, 18, and 42 (Figure 6-13). Visual analysis was completed for only the white-tailed deer specimens at the site. A higher concentration of remains was found on the left (n=82, 71.9%) over right (n=32, 28.1%) sides, the north (n=105, 92.1%) over the south (n=9, 7.9%), the east (n=97, 85.1%) over the west (n=17, 14.9%), and the dark (n=100, 87.7%) over the light (n=14, 12.3%) regions. The higher amounts of faunal materials in specific parts of the cave may signify the ritual significance for the deer remains within the site of Naj Tunich. The body portions from the white-tailed deer include the cranial (n=14, 12.3%), the axial (n=51, 44.7%), the front limbs (n=19, 16.7%), the hind limbs (n=27, 23.7%), and the distal (n=3, 2.6%) parts of the body. A total of 62 white-tailed deer remains were sided and slightly more remains were from the left (n=35, 56.5%) than the right (n=27, 43.5%) side of the body.

Rodentia

Only a total of twenty rodent remains were identified from the faunal assemblage from Operation IV in Lots 1, 15, 27, 48, 51, and 53 (Figure 6-5). Spatial autocorrelation identified the pattern as random and found that it was neither clustered nor dispersed at the site. Due to the low number of lots with rodent remains, cokriging failed. Visual analysis did identify some patterns of distribution of rodent remains in Naj Tunich including the higher amount of remains in the left/north (n=17, 85%) over the right/south (n=3, 15%) sides, the west (n=13, 65%) over the east (n=7, 35%) sides, and the light (n=14, 70%) over the dark (n=6, 30%) regions. The elements identified from the rodent remains includes mandibles (n=3, 15%), crania (n=3, 15%), an innominate (n=1, 5%), humeri (n=4, 20%), femora (n=4, 20%), and tibiae (n=5, 25%). Out of the twenty remains a total of seventeen remains were sided and this included six (35.3%) left and eleven (64.7%) right sides.

Agoutidae/Dasyproctidae

The larger rodent remains include the families Agoutidae and Dasyproctidae which had an NISP of 25 within Operation IV and within 14 of the 34 Lots at the site (Figure 6-5). These remains were identified by spatial autocorrelation as having a random pattern of distribution that was neither clustered nor dispersed. Cokriging for the families Agoutidae and Dasyproctidae indicated there were some differences in the area of concentrations for the dichotomies under analysis. Both the left versus right and the north versus south, and the east versus west had a higher concentration around Lot 57. However, the shape of these concentrations differed for these areas under analysis. The concentrations for light versus dark regions were located in two areas including around Lot 57 and Lots 1, 16, and 42. The distribution of these two families were higher on the left (n=14, 56%) side than the right (n=11, 44%) side of the cave, on the northern (n=16, 64%) than the southern (n=9, 36%), in the eastern/dark (n=22, 88%) than the western/lit

(n=3, 12%) part of the cave. The body portions identified include the cranial (n=11, 44%), the axial (n=4, 16%), the front limb (n=4, 16%), and the hind limbs (n=6, 24%) of the body. A total of fourteen remains were sided and the distribution included eight (57.1%) right-sided and six (42.9%) left-sided elements.

Sylvilagus sp.

Only two specimens were identified to the genus *Sylvilagus* sp. in Operation IV in Lots 29 and 49 (Figure 6-5). These remains failed spatial autocorrelation and cokriging because of the small sample size and limited distribution. The cottontail rabbit remains were evenly distributed with one bone located in the left and the right, the east and the west, the north and the south, the light, and the dark regions of the cave. The elements identified as cottontail rabbit include a tibia and a humerus. Both of these elements are right-sided.

Summary

The distribution of the faunal remains by taxonomic groups varied in concentrations and placement within each cave site. GIS and mapping of the site assisted in both the spatial analyses performed by the computer system and also with the visual assessment. The roles of each group within all of the caves are discussed in the next chapter (Chapter 7, Interpretations). It is important to realize that these differences and similarities are all based on the ritual placement, both intentional and unintentional, of faunal remains within these caves.

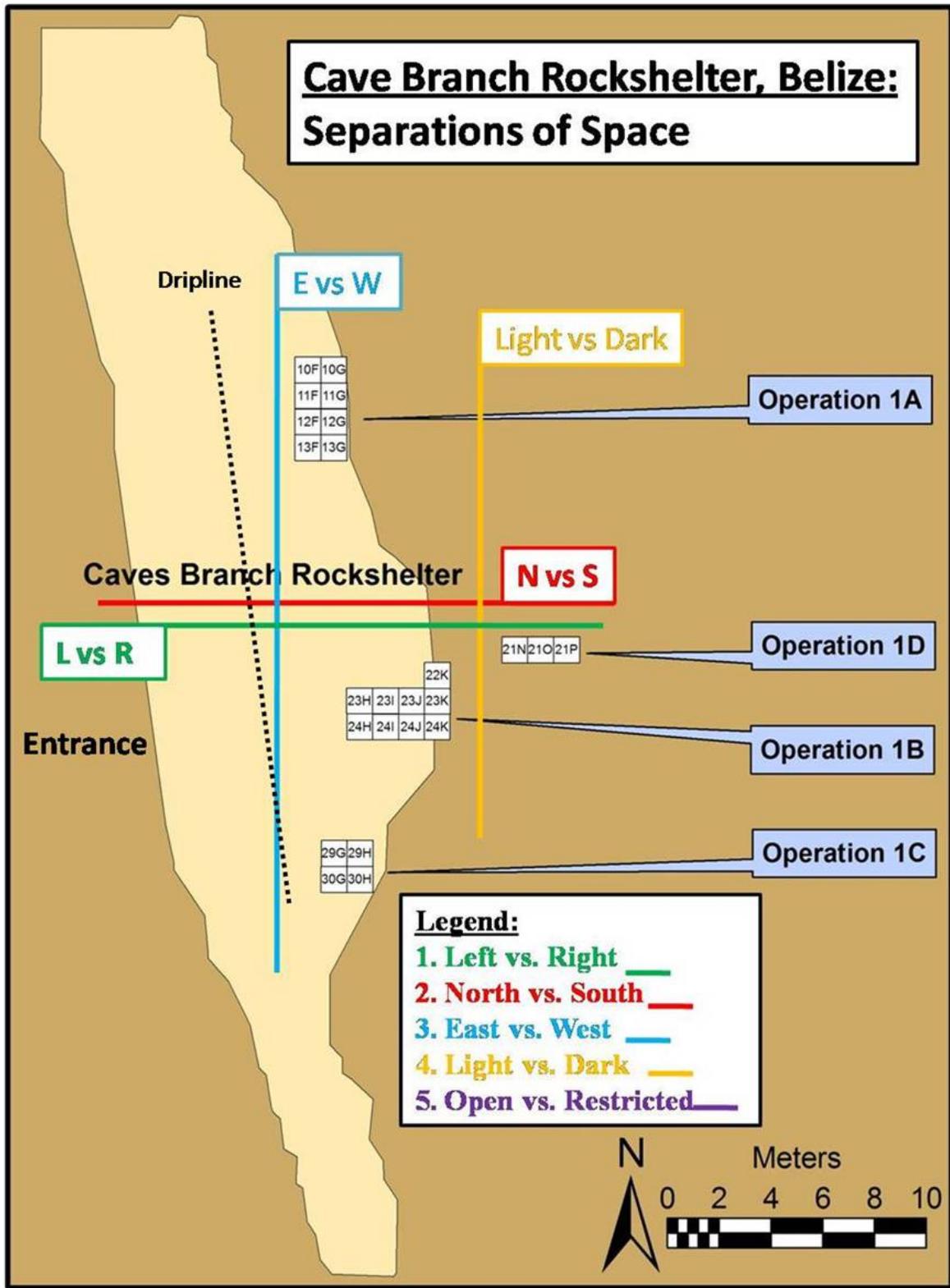


Figure 6-1. Separation of Space at Caves Branch Rockshelter, Belize

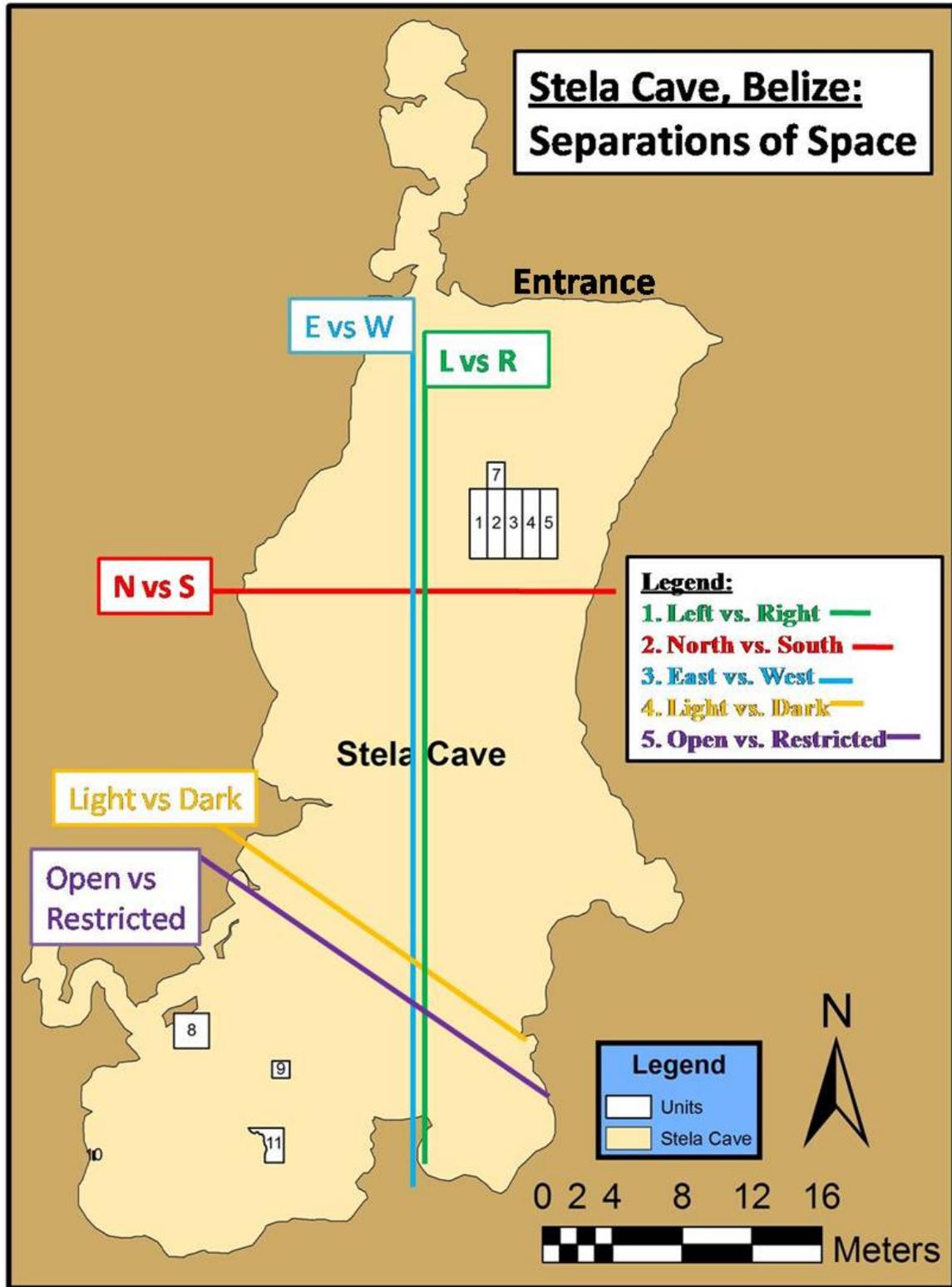


Figure 6-2. Separation of Space at Stela Cave, Belize

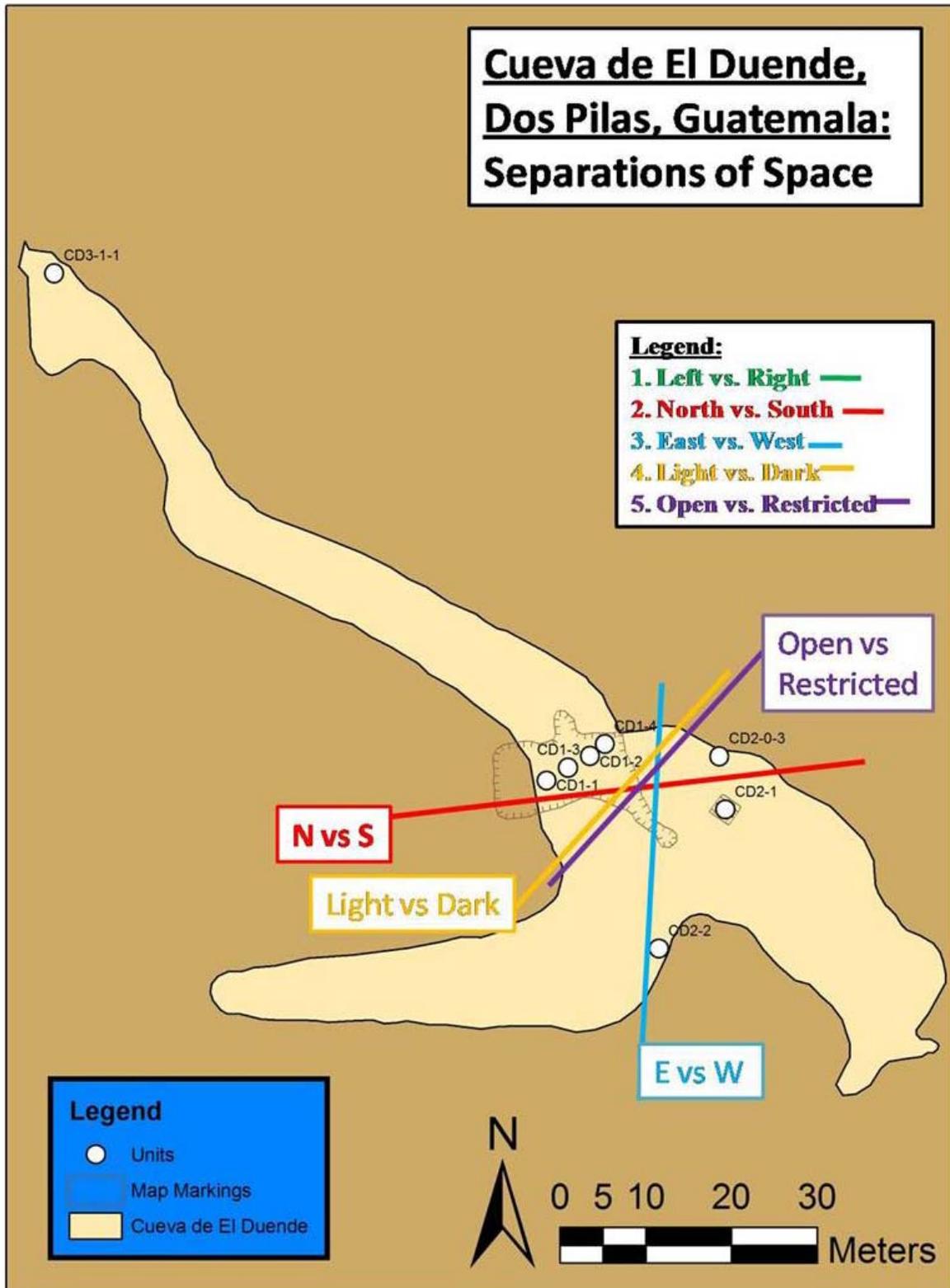


Figure 6-3. Separation of Space at Cueva de El Duende, Guatemala

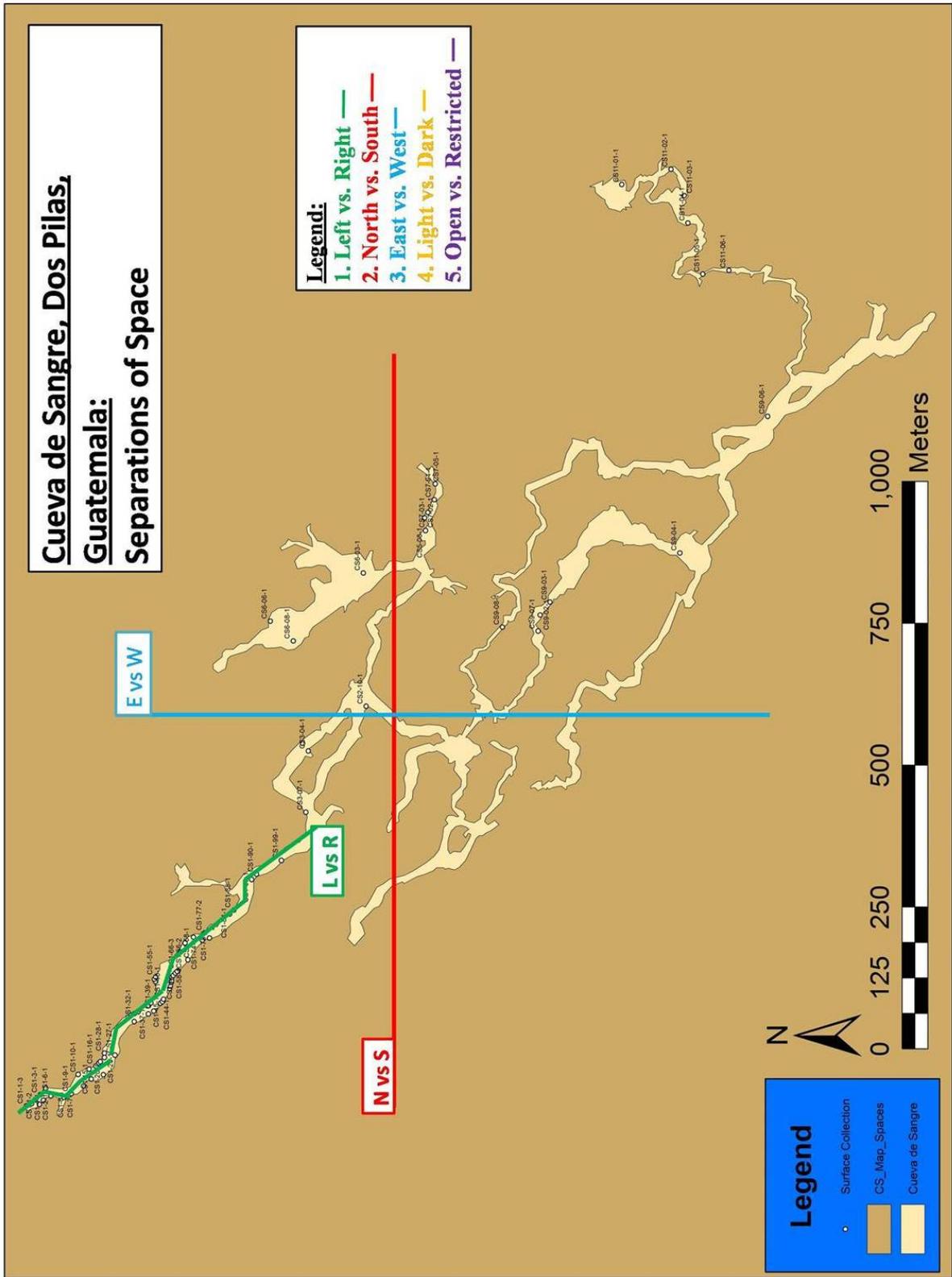


Figure 6-4. Separation of Space at Cueva de Sangre, Guatemala

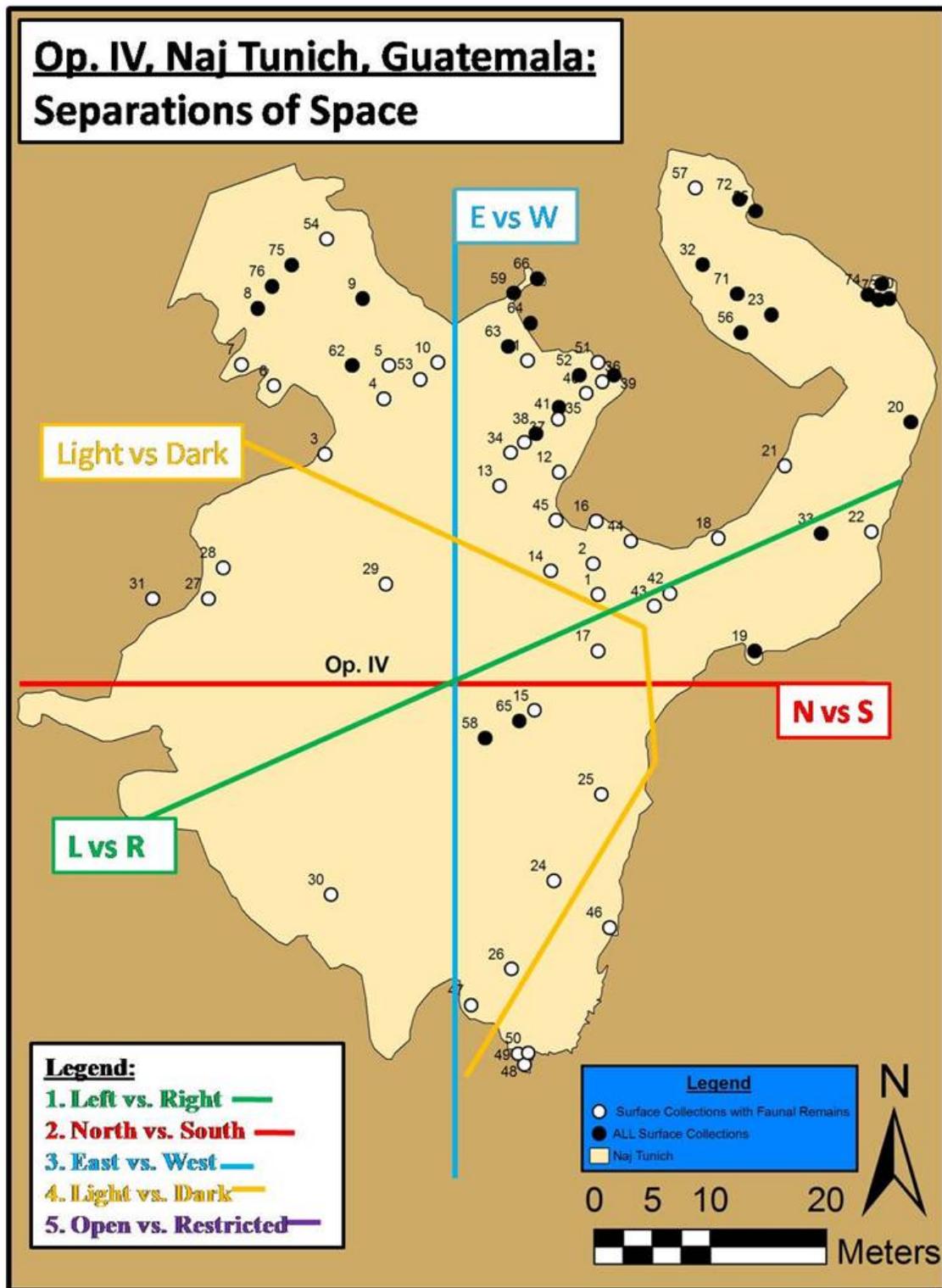


Figure 6-5. Separation of Space at Naj Tunich, Guatemala

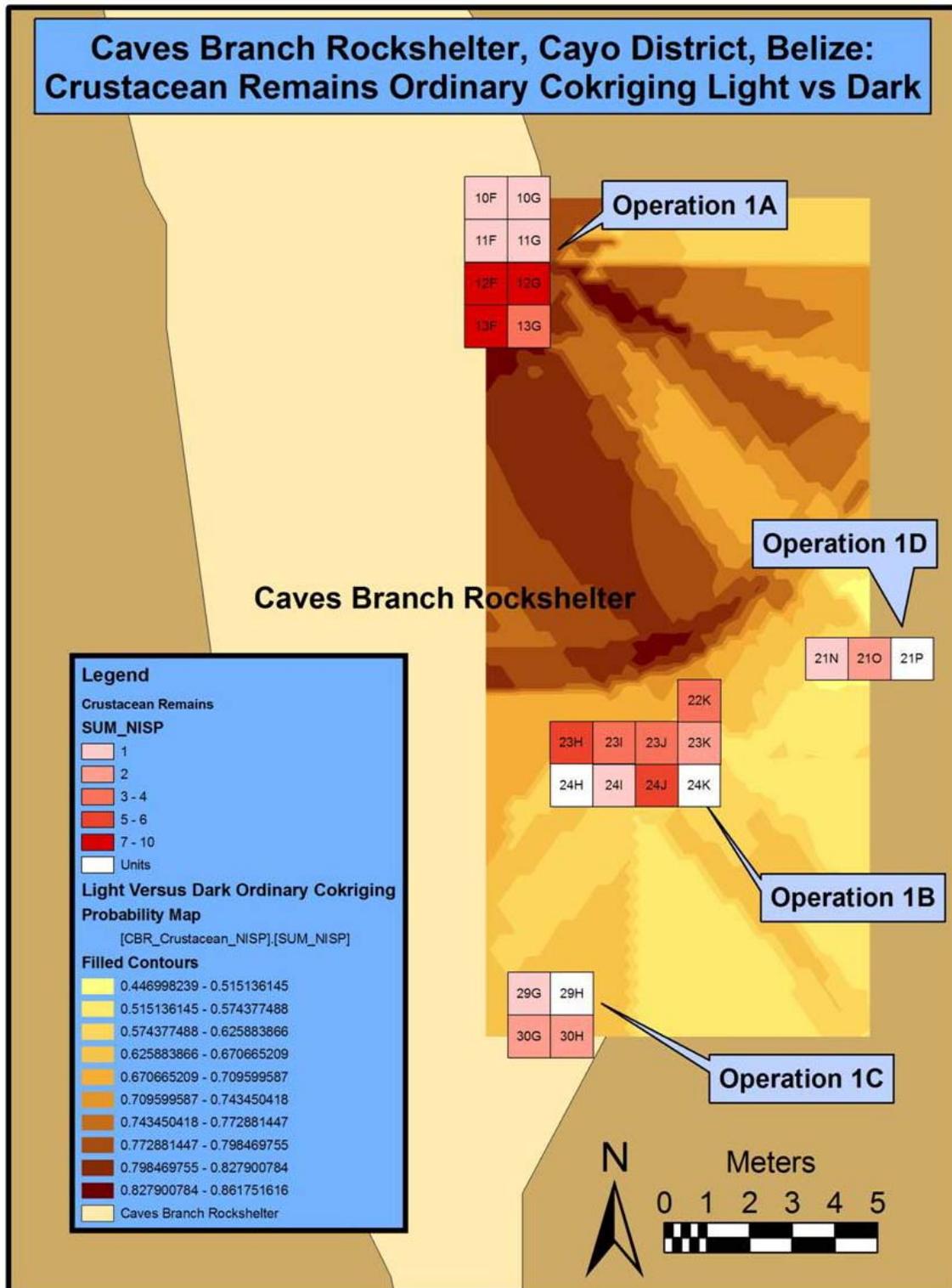


Figure 6-6. Caves Branch Rockshelter, Crustacean Remains Ordinary Cokriging Light versus Dark Regions

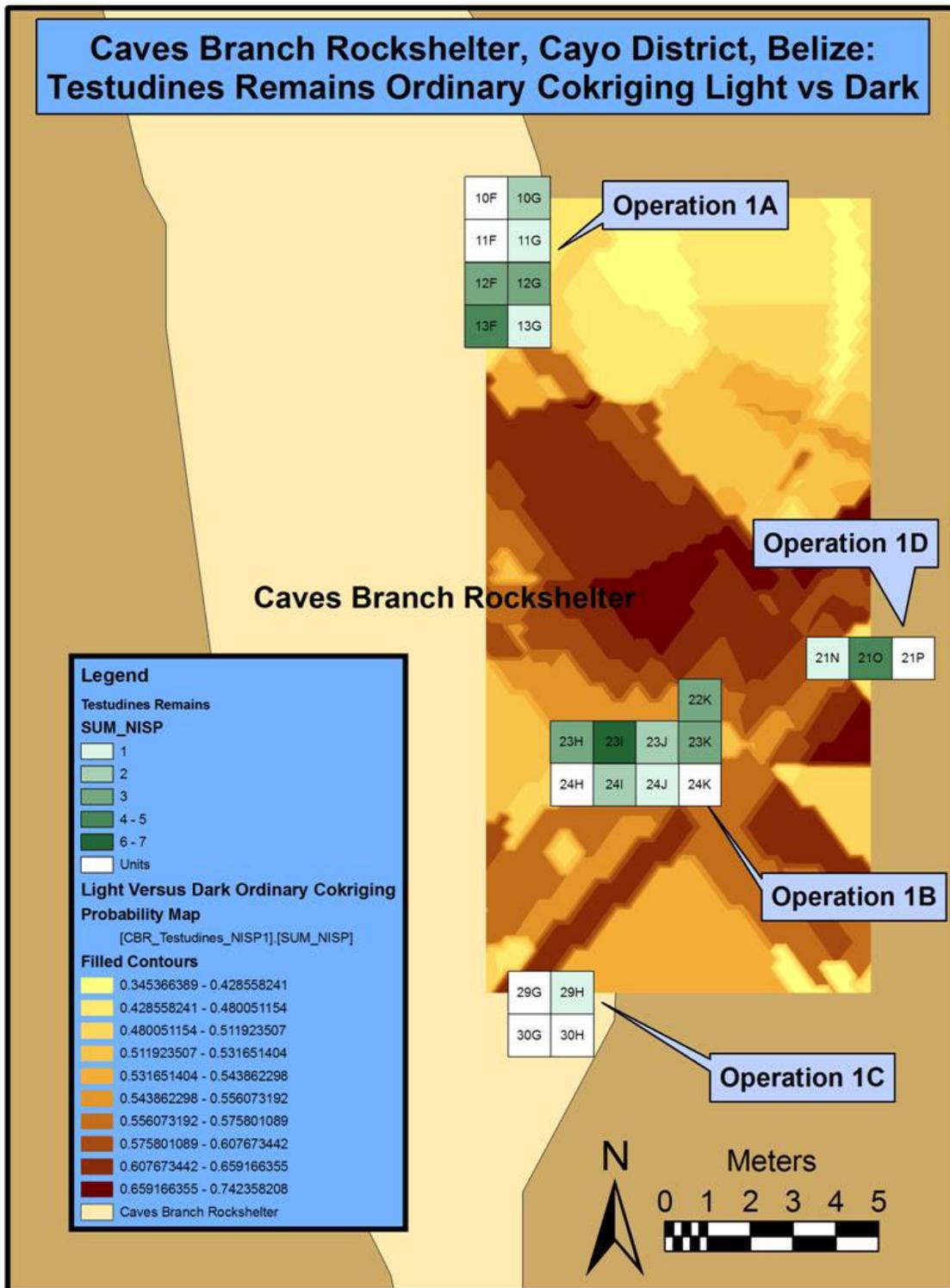


Figure 6-7. Caves Branch Rockshelter, Testudines Remains Ordinary Cokriging Light versus Dark Regions

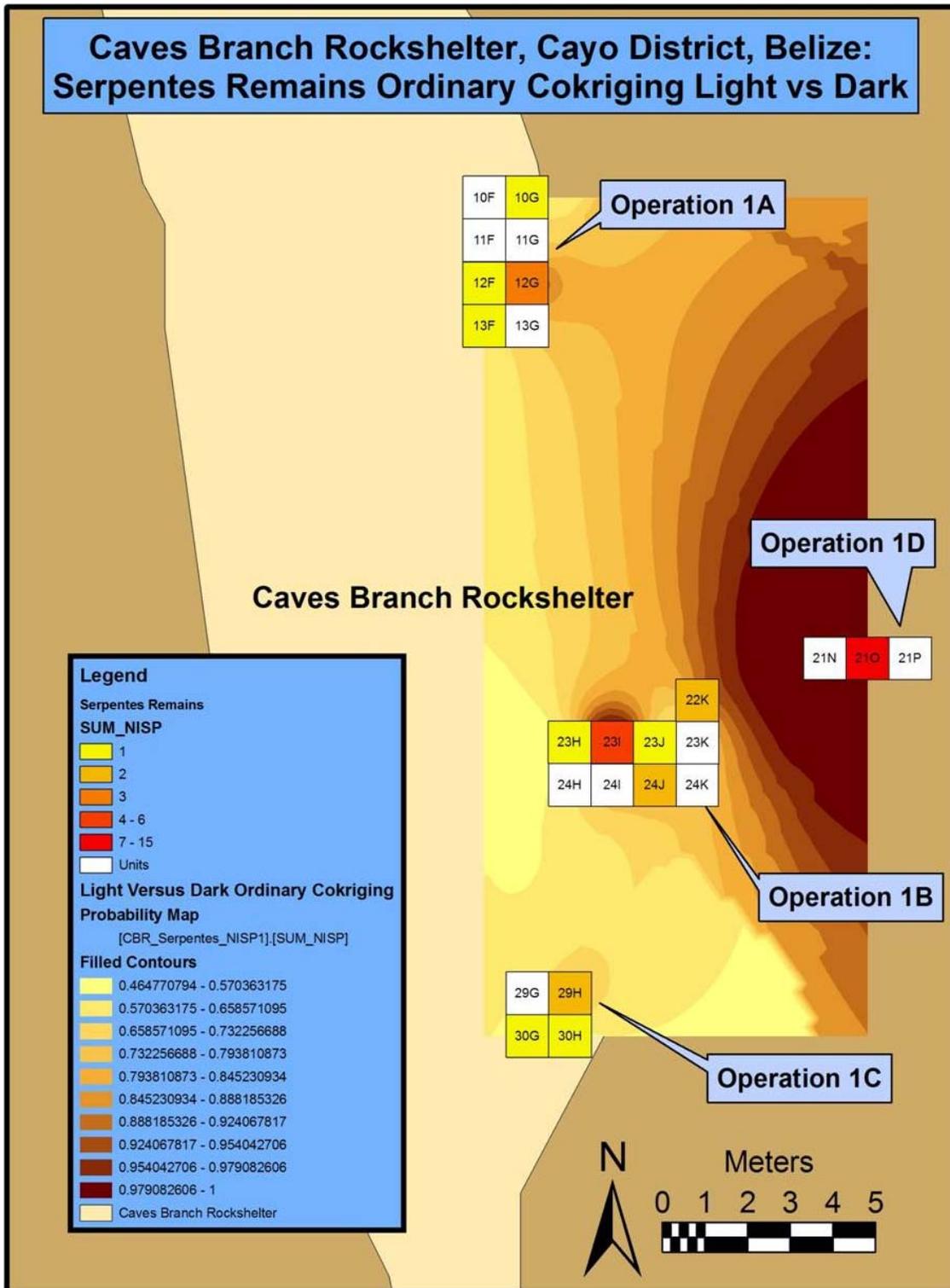


Figure 6-8. Caves Branch Rockshelter, Serpentes Remains Ordinary Cokriging Light versus Dark Regions

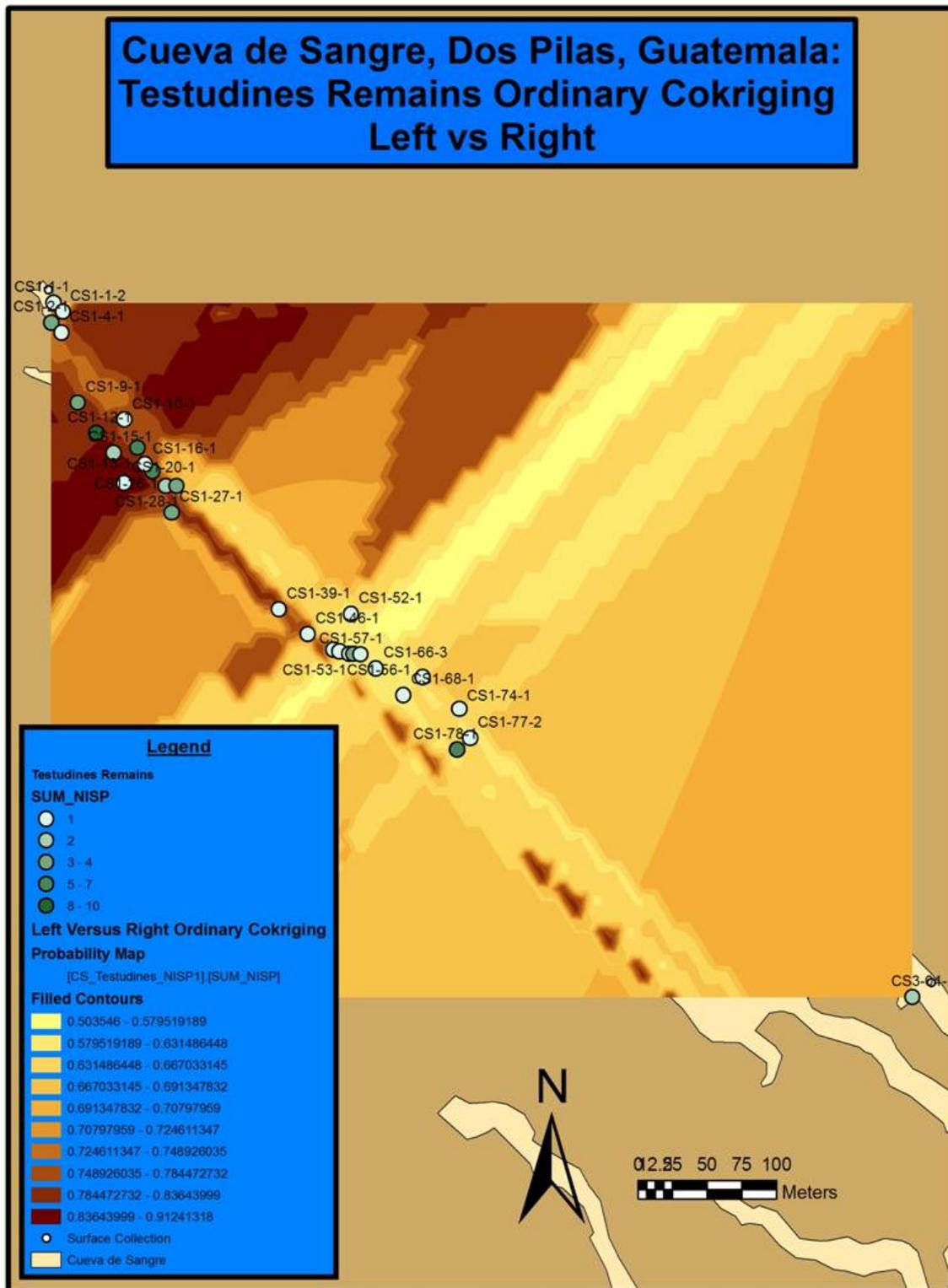


Figure 6-9. Cueva de Sangre, Testudines Remains Ordinary Cokriging Left versus Right Sides

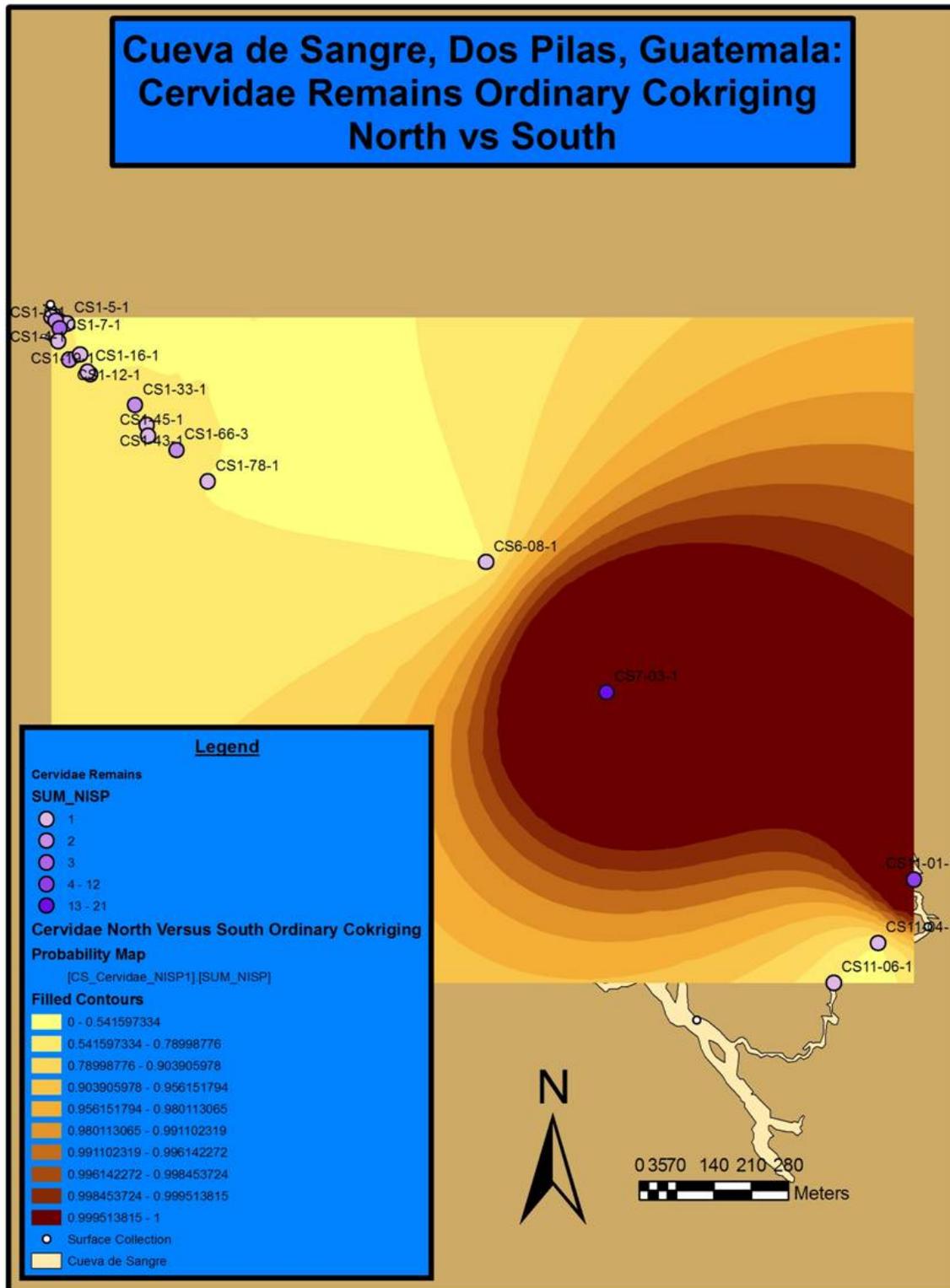


Figure 6-10. Cueva de Sangre, Cervidae Remains Ordinary Cokriging North versus South Regions

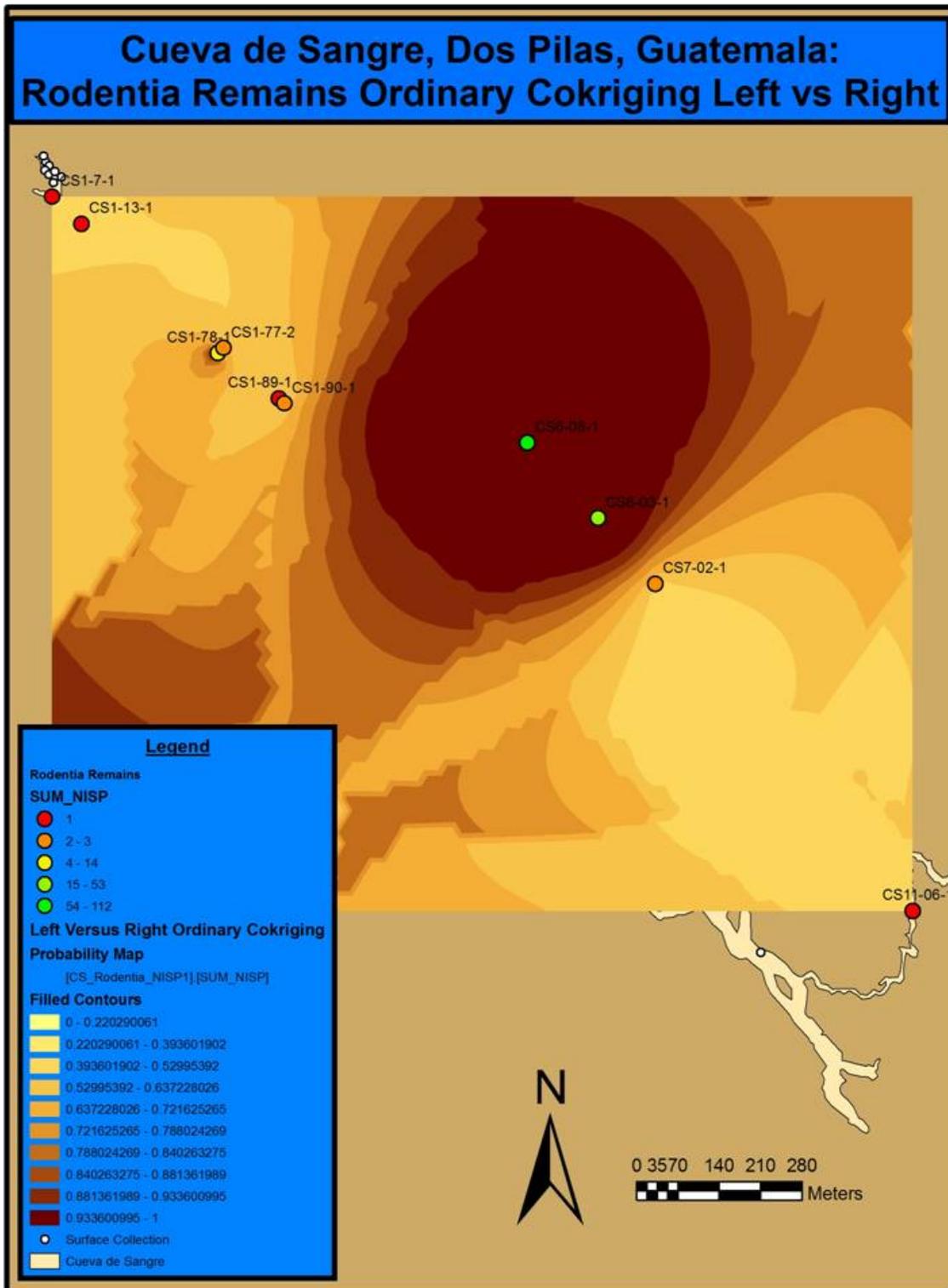


Figure 6-11. Cueva de Sangre, Rodentia Remains Ordinary Cokriging Light versus Dark Regions

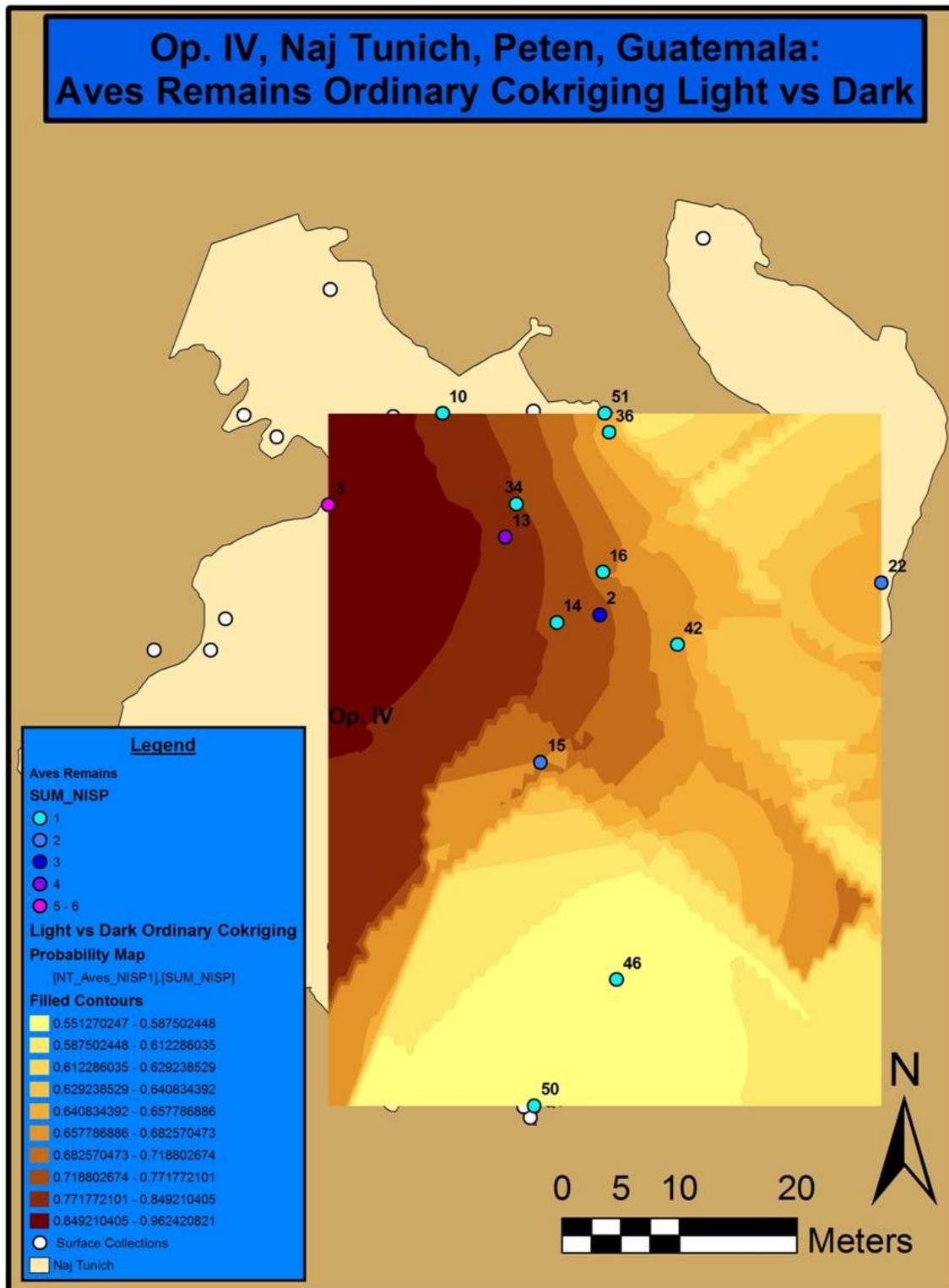


Figure 6-12. Naj Tunich, Aves Remains Ordinary Cokriging Light versus Dark Regions

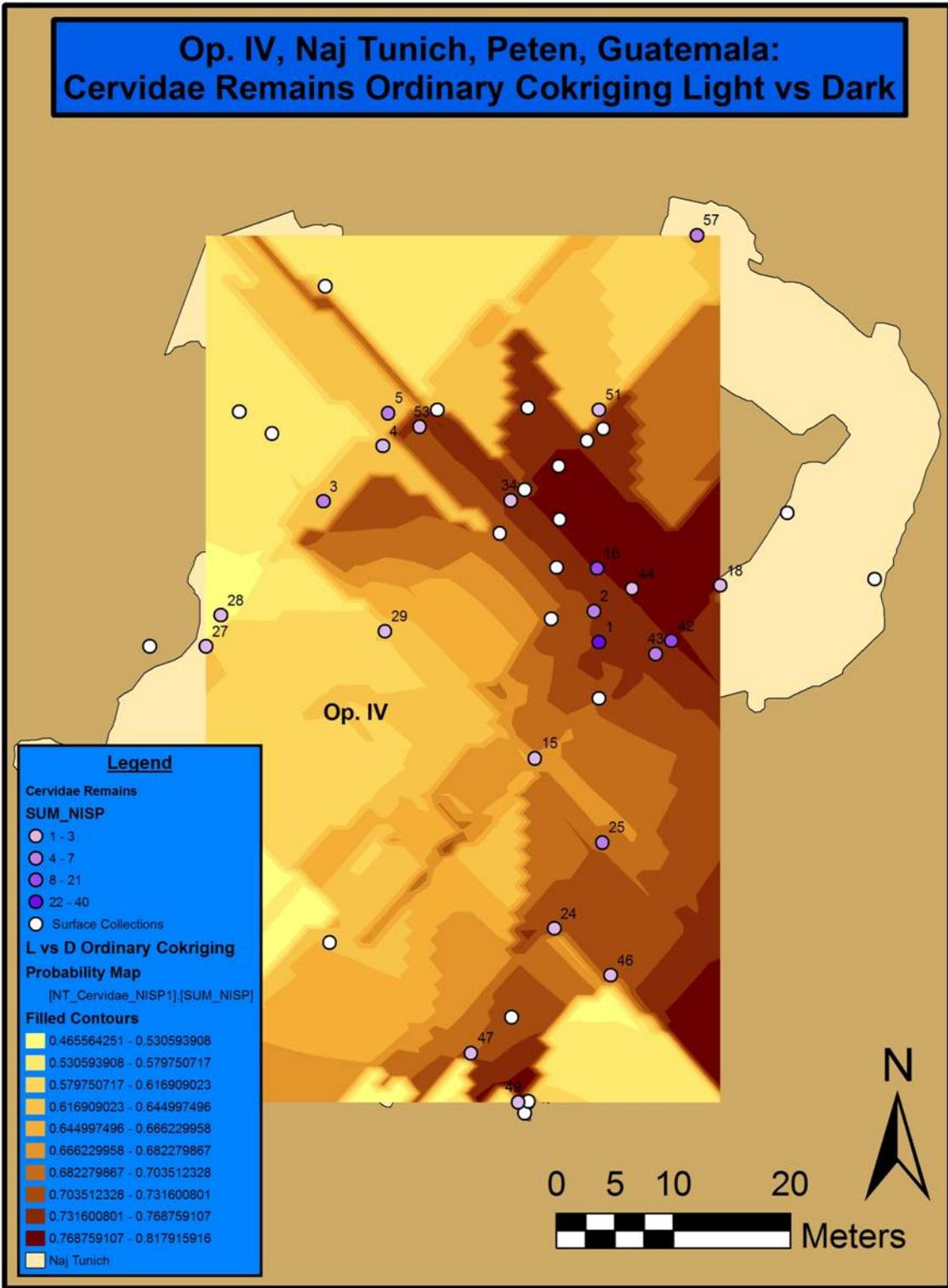


Figure 6-13. Naj Tunich, Cervidae Remains Ordinary Cokriging Light versus Dark Regions

Table 6-1. Relative Frequency Values for Five Cave Sites.

Gentaxa	CBR		STC		CD		CS		NT	
	NISP	RF								
Crustaceans	65	5.09	11	0.64	1	0.04	8	0.42	6	0.62
Actinopterygii (ray-finned fishes)	13	1.02	4	0.23	399	15.99	2	0.11	N/A	N/A
Amphibia (amphibian)	5	0.39	1	0.06	11	0.44	N/A	N/A	N/A	N/A
Testudines (turtle)	42	3.29	43	2.50	15	0.60	70	3.71	8	0.83
Sauria (lizard)	6	0.47	1	0.06	5	0.20	N/A	N/A	N/A	N/A
Serpentes (snake)	37	2.90	18	1.05	50	2.00	3	0.16	N/A	N/A
Aves (bird)	21	1.65	39	2.27	37	1.48	4	0.21	26	2.70
<i>Meleagris gallopavo</i> (domestic turkey)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	1.45
Didelphidae (opossums)	8	0.63	13	0.76	29	1.16	62	3.29	10	1.04
<i>Dasypus novemcinctus</i> (nine-banded armadillo)	102	7.99	80	4.66	2	0.08	3	0.16	6	0.62
Chiroptera (bats)	1	0.08	13	0.76	632	25.32	12	0.64	6	0.62
Primates (primates)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	0.21
Canidae (coyotes, dogs, foxes, jackals, and wolves)	3	0.24	4	0.23	22	0.88	39	2.07	4	0.41
Felidae (cats)	N/A	N/A	N/A	N/A	8	0.32	N/A	N/A	3	0.31
Procyonidae (raccoons)	4	0.31	3	0.17	N/A	N/A	N/A	N/A	3	0.31
<i>Tapirus bairdii</i> (Baird's tapir)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	1.14
Artiodactyla (even-toed ungulates)	18	1.41	30	1.75	30	1.20	67	3.55	163	16.91
Tayassuidae (peccary)	3	0.24	7	0.41	N/A	N/A	5	0.26	25	2.59
Cervidae (deer)	11	0.86	16	0.93	18	0.72	56	2.97	138	14.32
<i>Odocoileus virginianus</i> (white-tailed deer)	9	0.71	4	0.23	15	0.60	19	1.01	114	11.83
<i>Mazama</i> sp. (brocket deer)	1	0.08	4	0.23	1	0.04	35	1.85	16	1.66
Rodentia (rodent)	30	2.35	222	12.92	21	0.84	190	10.07	20	2.07
Scuiridae (squirrel)	N/A	N/A	4	0.23	N/A	N/A	N/A	N/A	N/A	N/A
Agoutidae (pacas) / Dasyproctidae (agoutis + acuchis)	24	1.88	8	0.47	8	0.32	87	4.61	25	2.59
<i>Sylvilagus</i> sp. (cottontail rabbit)	1	0.08	4	0.23	N/A	N/A	N/A	N/A	2	0.21
Total Identified Remains	380		498		1270		547		299	
Total NISP	1276		1718		2496		1887		964	

Table 6-2. Separation of Space for Caves Branch Rockshelter, Belize

Op	Unit	L1 R2	N1 S2	E1 W2	Light1	Dark2	Open1	Restr2
1A	10F	1	1	1	1			N/A
1A	10G	1	1	1	1			N/A
1A	11F	1	1	1	1			N/A
1A	11G	1	1	1	1			N/A
1A	12F	1	1	1	1			N/A
1A	12G	1	1	1	1			N/A
1A	13F	1	1	1	1			N/A
1A	13G	1	1	1	1			N/A
1B	23H	2	2	1	1			N/A
1B	23I	2	2	1	1			N/A
1B	23J	2	2	1	1			N/A
1B	23K	2	2	1	1			N/A
1B	22K	2	2	1	1			N/A
1B	24H	2	2	1	1			N/A
1B	24I	2	2	1	1			N/A
1B	24J	2	2	1	1			N/A
1B	24K	2	2	1	1			N/A
1D	21N	2	2	1	2			N/A
1D	21O	2	2	1	2			N/A
1D	21P	2	2	1	2			N/A
1C	29G	2	2	1	1			N/A
1C	29H	2	2	1	1			N/A
1C	30G	2	2	1	1			N/A
1C	30H	2	2	1	1			N/A

Table 6-3. Separation of Space for Stela Cave, Belize

Chamber	Unit	L1 R2	N1 S2	E1 W2	Light1	Dark2	Open1	Restr2
1	1	1	1	1	1			1
1	2	1	1	1	1			1
1	3	1	1	1	1			1
1	4	1	1	1	1			1
1	5	1	1	1	1			1
1	7	1	1	1	1			1
3	8	2	2	2	2			2
3	9	2	2	2	2			2
3	10	2	2	2	2			2
3	11	2	2	2	2			2

Table 6-4. Separation of Space for Cueva de El Duende, Guatemala

Provenience	L1 R2	N1 S2	E1 W2	Light1	Dark2	Open1	Restr2
CD2-0-3	N/A	1	1	1		1	
CD2-1	N/A	2	1	1		1	
CD2-3	N/A	2	1	1		1	
CD2-2	N/A	2	1	1		1	
CD1-1	N/A	1	2	2		2	
CD1-2	N/A	1	2	2		2	
CD1-3	N/A	1	2	2		2	
CD1-4	N/A	1	2	2		2	
CD3-1-1	N/A	1	2	2		2	

Table 6-5. Separation of Space for Cueva de Sangre, Guatemala

Provenience	L1 R2	N1 S2	E1 W2	Light1 Dark2	Open1 Restr2	Provenience	L1 R2	N1 S2	E1 W2	Light1 Dark2	Open1 Restr2
CS1-1-1	1	1	2	N/A	N/A	CS1-58-1	2	1	2	N/A	N/A
CS1-1-2	1	1	2	N/A	N/A	CS1-62-1	2	1	2	N/A	N/A
CS1-1-3	1	1	2	N/A	N/A	CS1-66-2	2	1	2	N/A	N/A
CS1-2-1	2	1	2	N/A	N/A	CS1-66-3	2	1	2	N/A	N/A
CS1-3-1	1	1	2	N/A	N/A	CS1-68-1	2	1	2	N/A	N/A
CS1-4-1	2	1	2	N/A	N/A	CS1-70-2	1	1	2	N/A	N/A
CS1-5-1	1	1	2	N/A	N/A	CS1-71-1	1	1	2	N/A	N/A
CS1-6-1	2	1	2	N/A	N/A	CS1-74-1	1	1	2	N/A	N/A
CS1-7-1	2	1	2	N/A	N/A	CS1-76-1	2	1	2	N/A	N/A
CS1-8-1	2	1	2	N/A	N/A	CS1-77-2	1	1	2	N/A	N/A
CS1-9-1	2	1	2	N/A	N/A	CS1-78-1	2	1	2	N/A	N/A
CS1-10-1	1	1	2	N/A	N/A	CS1-84-1	1	1	2	N/A	N/A
CS1-12-1	2	1	2	N/A	N/A	CS1-85-1	1	1	2	N/A	N/A
CS1-13-1	1	1	2	N/A	N/A	CS1-89-1	2	1	2	N/A	N/A
CS1-15-1	2	1	2	N/A	N/A	CS1-90-1	2	1	2	N/A	N/A
CS1-16-1	1	1	2	N/A	N/A	CS1-99-1	2	1	2	N/A	N/A
CS1-19-1	1	1	2	N/A	N/A	CS2-10-1		1	2	N/A	N/A
CS1-20-1	2	1	2	N/A	N/A	CS3-04-1		1	2	N/A	N/A
CS1-21-1	1	1	2	N/A	N/A	CS3-05-1		1	2	N/A	N/A
CS1-26-1	1	1	2	N/A	N/A	CS3-07-1		1	2	N/A	N/A
CS1-27-1	2	1	2	N/A	N/A	CS5-08-1		2	1	N/A	N/A
CS1-28-1	1	1	2	N/A	N/A	CS6-03-1		1	1	N/A	N/A
CS1-32-1	2	1	2	N/A	N/A	CS6-06-1		1	1	N/A	N/A
CS1-33-1	1	1	2	N/A	N/A	CS6-08-1		1	1	N/A	N/A
CS1-34-1	1	1	2	N/A	N/A	CS7-02-1		2	1	N/A	N/A
CS1-35-1	1	1	2	N/A	N/A	CS7-03-1		2	1	N/A	N/A
CS1-37-1	2	1	2	N/A	N/A	CS7-04-1		2	1	N/A	N/A
CS1-39-1	2	1	2	N/A	N/A	CS7-05-1		2	1	N/A	N/A
CS1-40-1	1	1	2	N/A	N/A	CS9-02-1		2	1	N/A	N/A
CS1-43-1	1	1	2	N/A	N/A	CS9-03-1		2	1	N/A	N/A
CS1-44-1	2	1	2	N/A	N/A	CS9-04-1		2	1	N/A	N/A
CS1-45-1	2	1	2	N/A	N/A	CS9-06-1		2	1	N/A	N/A
CS1-46-1	2	1	2	N/A	N/A	CS9-07-1		2	1	N/A	N/A
CS1-50-1	2	1	2	N/A	N/A	CS9-08-1		2	1	N/A	N/A
CS1-51-1	2	1	2	N/A	N/A	CS11-01-1		2	1	N/A	N/A
CS1-52-1	1	1	2	N/A	N/A	CS11-02-1		2	1	N/A	N/A
CS1-53-1	2	1	2	N/A	N/A	CS11-03-1		2	1	N/A	N/A
CS1-54-2	1	1	2	N/A	N/A	CS11-04-1		2	1	N/A	N/A
CS1-55-1	1	1	2	N/A	N/A	CS11-05-1		2	1	N/A	N/A
CS1-56-1	2	1	2	N/A	N/A	CS11-06-1		2	1	N/A	N/A
CS1-57-1	2	1	2	N/A	N/A						

Table 6-6. Separation of Space for Naj Tunich, Guatemala

Op	Lot	L1 R2	N1 S2	E1 W2	Light1 Dark2	Open1 Restr2
IV	1	1	1	1	2	N/A
IV	2	1	1	1	2	N/A
IV	3	1	1	2	2	N/A
IV	4	1	1	2	2	N/A
IV	5	1	1	2	2	N/A
IV	6	1	1	2	2	N/A
IV	7	1	1	2	2	N/A
IV	10	1	1	2	2	N/A
IV	11	1	1	1	2	N/A
IV	12	1	1	1	2	N/A
IV	13	1	1	1	2	N/A
IV	14	1	1	1	2	N/A
IV	15	2	2	1	1	N/A
IV	16	1	1	1	2	N/A
IV	17	2	2	1	1	N/A
IV	18	1	1	1	2	N/A
IV	21	1	1	1	2	N/A
IV	22	2	1	1	1	N/A
IV	24	2	2	1	1	N/A
IV	25	2	2	1	1	N/A
IV	26	2	2	1	1	N/A
IV	27	1	1	2	1	N/A
IV	28	1	1	2	1	N/A
IV	29	1	1	2	1	N/A
IV	30	2	2	1	1	N/A
IV	31	1	1	2	1	N/A
IV	34	1	1	1	2	N/A
IV	36	1	1	1	2	N/A
IV	37	1	1	1	2	N/A
IV	40	1	1	1	2	N/A
IV	41	1	1	1	2	N/A
IV	42	2	1	1	2	N/A
IV	43	2	1	1	2	N/A
IV	44	1	1	1	2	N/A
IV	45	1	1	1	2	N/A
IV	46	2	2	1	1	N/A
IV	47	2	2	1	1	N/A
IV	48	2	2	1	2	N/A
IV	49	2	2	1	2	N/A
IV	50	2	2	1	2	N/A
IV	51	1	1	1	2	N/A
IV	53	1	1	2	2	N/A
IV	54	1	1	2	2	N/A
IV	57	1	1	1	2	N/A

CHAPTER 7 INTERPRETATIONS

Introduction

This research project attempted to reconstruct the ancient Maya ritual use of caves through the analysis of the spatial distribution of faunal remains using both GIS and visual analysis. My study relies on some of the major tenets of cognitive archaeology, or the study of reconstructing and understanding the “ancient mind” (Flannery and Marcus 1996, 1998), including reconstructing the intentional placement of artifacts within the landscape using such technological advances as GIS. The use of landscapes and the distribution of sites and artifacts across these landscapes is an important part of understanding an ancient people’s use of their surroundings; however, there is more than just subsistence underlying these sometimes complex patterns. The landscape represents both the functional place for food and shelter, and a sacred landscape to the ancient Maya.

The sacred landscape of the ancient Maya is based on both the vertical, or layering of space, and the horizontal, or cardinal directionality, planes (Mathews and Garber 2004). The most relevant plane to be analyzed in the cave and this research project is the horizontal plane, which includes the quadripartite separation of space and directionality in the form of north, south, east, west, and the center (Garcia-Zambrano 1994; Mathews and Garber 2004; Moyes 2001, 2002, 2004) and also the sidedness of space between the right and left (Brown 2004; Coggins 1980; Palka 2002). Here I have attempted to reconstruct the ancient Maya mind in relation to the faunal materials in a ritual setting. The known ritual use of caves and the ethnographic, ethnohistoric, and iconographic information available about the symbolic meaning of a variety of animals (often spatially associated) allowed me to test various spatial models of the ancient Maya universe and symbolic meaning of animals within cave rituals.

GIS was used to help facilitate the analysis of the use of space within the cave along with a visual analysis of the site. Cokriging and Spatial Autocorrelation tools were used to define significant patterning or pattern loci of taxonomic groups in each cave. Spatial autocorrelation identifies the spatial distribution of taxonomic groups within the cave as being either dispersed, random, or clustered within the cave. Cokriging was used to identify the spatial patterning by analyzing the relationship between taxonomic groups and the five dichotomies for the separations of space. The patterns formed from cokriging identify the areas within the caves that higher concentration of these taxonomic groups should be identified within. Due to the small sample sizes and limited distribution of remains and areas of excavations the GIS spatial analysis tools were not always helpful in identifying patterns. Therefore, visual analysis of each site was also conducted on the taxonomic groups. Visual assessment was also used to determine patterning including the relationship between elements or body portions, sides of elements, and when applicable, the burning or charring of these elements under analysis.

Limitations to Spatial Pattern Analysis

Spatial analysis and computer-generated finding always have a minimum of samples needed based on the programs and systems used for analysis. It is always important in any scientific study to address these limitations early on and use them to help with the overall assessment of the site and those findings at these sites. There were some limitations in the spatial patterns analysis that need to be addressed for both the GIS and visual assessments in this research project. The limitations are addressed generally for all of the sites, and then specific site issues are discussed. The main problems that arose from both the GIS and visual analyses can be traced back to the reconstruction of the sites based on maps, placement of the excavation units, the small sample size of faunal remains from these sites, and the taphonomic influences, both natural and cultural, on these faunal remains.

Many of these sites and the excavation units within them were reconstructed from maps that were drawn to scale. However, there was some difficulty in placing these sites in georeferenced areas with known coordinates, which is a necessity when working with GIS. There were also some difficulties in redrawing and rescaling these maps; however, I was able to get the maps in ArcGIS to reflect the scales and orientations provided by researchers from these sites. Caves Branch Rockshelter and Stela Cave both had images of the sites that had been previously constructed and digitized by their respective researchers, Gabriel Wrobel (Wrobel and Tyler 2006; Wrobel 2008) and Cameron Griffith (Ishihara and Griffith 2004). Cueva de Sangre and Cueva de El Duende were both reconstructed from printed materials from the site and then digitized by myself (Brady 1997; Brady et al. 1997; Brady and Rodas 1992; Brady and Scott 1997; Minjares 2003). Operation IV at Naj Tunich was also taken from Brady's (1989) dissertation and digitized with all of the surface collection sites included in this reformatted map. The only problem encountered during the digitizing or prepping of these maps for GIS analysis was that the placement of excavation units and the use of scale were sometimes faulty because of the copies of the maps used. Therefore, it is safe to assume that these reconstructed maps and placement of excavation units are at the scale provided by the initial researchers.

The two GIS spatial analysis tools, Spatial Autocorrelation and Cokriging, needed specific sample sizes and distributions which hindered the ability to process these tools. Spatial autocorrelation required a sample size of over 30 samples to run effectively, although there were discrepancies in these results even with 30 samples. This discrepancy in effective outcomes included that most of the samples were random even when visually they seemed clustered in a specific area within the cave. The limitation with the cokriging program was that a sample of over ten areas with remains was needed. The use of ten units or surface collections still did not

produce accurate measurements from cokriging and these results were inaccurate when put against visual analysis. The sites that were unable to process cokriging because of limited distribution included Cueva de El Duende and Stela Cave, both of which only had eight units with faunal remains. Visual analysis helped in the identification of some patterns; however, there were also limitations in the size of the samples that dictated the observable results. Smaller samples were difficult to identify during this research study and the limited distribution of some units in specific spatial regions also skewed those findings. For example, Caves Branch Rockshelter included a very small dark region (n=3) of the site sample and a very high amount from the light region (n=21) which skewed some of the findings since there would always be a high preponderance of light over dark parts of the cave.

Excavation methods were different within each of the caves. There were those caves whose remains were collected from excavated units, including CBR, CD, and STC, while there were also sites with mainly surface collections and very few excavated areas including, CS and NT. These differences in collection methods can be seen in the differences in how both GIS and visual analysis were able to process. CS and NT contained the highest amount of samples within this study and these remains were well distributed for both GIS and visual analysis. There were however issues with the placement of these surface collections and the higher amount of remains being identified in some areas than in other areas, i.e. more surface collections in the light than the dark regions of the cave.

Each cave also had a different taphonomic impact that affected the visual and GIS analyses. These taphonomic influences include to movement of artifacts by both animals, water, and human movements within the cave. For example, CBR was a known ancient Maya cemetery and the soil at this site was a mixed grave fill, which means that the soil had been physically

churned and dug within over time as new burials were being interred at the site. At CBR, which is located next to a river, there is a large area of runoff and displacement of artifacts from the seasonal rains within the area. Cueva de Sangre and Cueva de El Duende both had a high amount of sedimentation from seasonal flooding during the rainy season that caused the movement of artifacts and animal remains. At both STC and CBR there were also evidence of looting that may have caused the destruction and displacement of animal remains within the site. The taphonomic movement and inclusion of animal remains may have skewed both the GIS and visual analysis findings. These impacts are discussed in the section below.

Taxonomic Trends

Trends that were identified for some species and taxonomic groups in terms of the spatial divisions tested in this thesis are highlighted and discussed in detail below based on the taxonomic groups used for analysis. Additional variables for each taxonomic group such as body portion and side distributions are considered. In each case, additional information on the habitats, habits, and symbolic importance of the animal group are used to consider the possible meaning of the distributions revealed. Within the caves analyzed for and included within this study the collection methods, excavations placements, and taphonomy are also all important in understanding the overall patterns and these are also discussed in the sections below. It is important to keep in mind that each cave is unique, and for this study many different shapes and types of caves were considered. Therefore, although the separations of space, or dichotomized relationships considered include the left versus right sides, north versus south, east versus west, light versus dark, and open versus restricted parts of the cave, the proportion of these spaces in each cave does vary as does the proportion of each space that was excavated.

Certain caves show interesting patterns for some species, but general patterning replicated in all caves was not identified. Reasons for the lack of generalized patterning and the

distributions or lack of certain species are discussed in detail below in terms of the possible taphonomic and sample size limitations

Crustaceans

Crustacean remains were expected to be well-distributed in cave sites that are near a river or body of water and those that might contain water seasonally or year round within the cave. This is because crabs, even the terrestrial crabs, require water to complete their life cycle since all species have a planktonic stage that involves larval metamorphic changes to the crustacean's body before adulthood is reached (Hickman 1967). Caves Branch Rockshelter is located adjacent to a river (Bonor 1998, 2002; Glassman and Bonor Villarejo 2005). The caves from Dos Pilas, Cueva de Sangre and Cueva de El Duende, are interconnected by an underground river system with the three other caves identified at this site (Minjares 2003:24). Naj Tunich does contain areas with pools of water that were both naturally and culturally constructed within the cave and may have served different ceremonies at the site (Brady 1989). Stela Cave has some seasonal flooding, but areas of year-round water are not identified (Ishihara and Griffith 2004).

All five of the cave sites contained crustacean remains, and only at CBR were a high proportion (n=65, 5.09%) of crustacean specimens identified (Table 7-3). This high prevalence of crustacean remains at CBR may be due to the close proximity of a river at the site, but there is otherwise no correlation between caves with crustaceans and proximity of water sources, suggesting that their presence may be intentional. Crabs might have been brought to the caves by predators (perhaps from smaller water sources or by flying predators), but the body portion analysis does not support this interpretation. In all caves, the predominant body portion was the claw in mainly complete forms and this may be consistent with human use. The claw is not better preserved or preferred by natural crab predators. Even in CBR, where the crabs might be a natural component, we see a predominance of crab claws. Therefore, we can assume that the

crabs were brought to the caves and used there by humans in most cases. There is no evidence for a predominance of right-sided over left-sided crab claws in these samples.

In two of the five caves the crustacean remains were found to be clustered (CBR, NT) (Tables 7-3, 7-17), in one cave no patterning was found (STC) (Table 7-5), and in the other two caves spatial autocorrelation was not possible (Tables 7-8, 7-12). At CBR, cokriging found significant clustering in Operation 1A associated with the left, north, and light regions of the cave, in the other four sites, cokriging was not possible for crustaceans because of the limited distribution of remains (Table 7-3).

Visual comparison of the remains showed that in three out of the five caves, there was a predominance of crustacean remains in the light over the dark regions of the cave. The lack of remains within the dark regions of the caves may be due to the size and larger number of excavation units in the light than in the dark regions of these caves. If considered as a proportion of number of remains found in each of these regions however, we see that there are over twice as many ($n=3.4$) per unit in the light region than those in the dark region ($n=1.5$) per unit. Therefore, the crabs are correlated with the light area of the cave. There is a predominance of left over right sides of the cave in three out of the four caves. There are also more remains located in the north (three out of five) and the east (four out of the five).

Water has been identified as a sacred part of caves (Ashmore 1989, 1991; Brady 1997; Brady and Ashmore 1999; Prufer and Kindon 2005; Stone 1995). Crustaceans are also known to live in water both within and surrounding many of these cave sites. No other researchers have identified that crustaceans are symbolically associated with water. A single source about the noises from animals within caves can be used to understand the role of crustaceans within the caves (Bruchez 2007). In 2007 (p.52), Margaret S. Bruchez suggested that the noises produced

by crustaceans within cave could be mistaken for larger animal species including crocodiles and jaguars by the ancient Maya. In summary then, crabs were found to be clustered in, or associated with, the north, east, and light areas of the caves in this sample. The clustering does not seem to have any links to the natural habits or habitats of the crabs or their predators, nor any explanation based on taphonomy or excavation practice.

Ray-Finned Fishes

Ray-finned fish remains were found within four out of the five cave sites. The distribution of ray-finned fish remains varied throughout all of the caves within this study. The largest sample of fish came from Cueva de El Duende (n=399) (Table 7-8) while only three other sites (CBR, STC, CS) contained a total of 19 fish remains (Tables 7-3, 7-5, 7-12). This disparity between sites is interesting considering that the site with the closest water source was CBR, and it had only 13 fish remains. From these very small sample sizes of fish remains, little can be identified in the patterning of their distribution. Cokringing was unable to process at all four sites with fish remains and spatial autocorrelation identified the pattern of fish remains as random at both CBR and CD. Cueva de El Duende did contain a majority of fish remains with the highest majority of remains being identified from the southern, eastern, light and open parts of the cave (Tables 7-10, 7-11, 7-12). However, this pattern may be due to the higher number of excavated units in these areas than in the other areas and also due to the separations of space that I identified. At the site of Cueva de Sangre, the small size and brittleness of fish remains may be a reason for these bones not being found. They were also not found in the large mud samples that were later deflocculated, which was water screened through a fine mesh that was 4 mm in size (Brady and Scott 1997).

Fish refuse and the caching of fish remains are important at many of the ceremonial centers and within burials and caches at elite centers (Beaubien 2004; Moholy-Nagy 2004). The Maya

located at inland sites have been associated with the “cult of the sea” and held marine fish and other animals as showing prestige among the ancient Maya (Pohl 1983). Fish and other marine fauna may have been used to represent water and this association is seen in the representation of faunal remains in layered caches (Kunen et al. 2001; Mathews and Garber 2004). Only one marine fish remain was identified in all of the caves, this is a cf. *Sparisoma* sp. (spotlight parrotfish) pharyngeal jaw from Caves Branch Rockshelter. Parrotfish are tropical fish located along shallow reef systems. CBR is located at an inland forested area. This indicates that the parrotfish, or this parrotfish pharyngeal jaw, had to have been imported from the coast to the site. Fish are also depicted as offerings within the Maya codices and they have been identified as offerings within the Year Bearer ceremonies (Thompson 1972; Bill et al. 2000; Taube 1988; Tozzer 1941) and Burner Cycles (Bricker 1991; Thompson 1972). Within the yearbearer ceremonies there have been fish remains identified with both the southern (Bill et al. 2000; Taube 1988; Tozzer 1941) and western (Thompson 1972) directions.

The fish remains were sparsely distributed at CBR, STC, and CS, but were identified in large concentrations at CD. The majority of the remains at CD were associated with the southern and eastern directions, and their placement within these parts of the cave may have been from the yearbearer ceremonies (Tables 7-6, 7-7). However, the lack of a large number of fish remains at all of the sites and there only being one marine specimen identified within these four collections may be an indication of either poor preservation or collection methods at these sites. Fish and marine fish in general may be more closely associated with rituals at above ground than in underground ancient Maya sites.

Amphibians

There were very few amphibian remains identified within the cave sites. Amphibians would be found naturally within the forested habitats of all five cave sites and some may even

have been inhabitants of these caves. Three out of the five sites (CBR, STC, CD) under study had amphibian remains and only a total of 17 specimens were identified. Due to the small sample size and limited distribution of remains at all three sites, both spatial autocorrelation and cokriging failed to process. Visual analysis did identify a majority of remains being located in the light and open regions of the cave which would be expected since these animals are known to live at the mouth of caves. Most of these remains (n=16) were identified from the order Anura (frogs and toads). Frogs and toads are associated with water and are found to live within and surround both caves and cenotes. From these close associations with entrances to the underworld and the fact that these animals live in watery environments they have been identified as having a relationship with Chac, the rain god (Pohl 1983). They have also been identified as guards to these entrances, caves and cenotes, into the underworld. Toads and frogs were sacredly associated with the underworld and may be the reason for the low number of remains within the cave sites. The lack of amphibian remains could also be due to the small size and low preservation of these animal remains within cave contexts.

Turtles

Turtles represent an important food source for the ancient Maya for both the elite and non-elite residents of many sites. Turtle foods may have also been used as offerings in the Maya codices as “tortoise breads” are found in many depictions throughout these sacred books (Bricker 1989). Turtle remains were identified at all five of the caves. Spatial autocorrelation was able to process at three out of the five sites and the distribution of these remains was identified as random (Tables 7-3, 7-5, 7-12). Cokriging was only able to process at two of these sites and the clusters identified at CBR (Table 7-3) were located around Operations 1A, 1C, and 1D and at CS (Table 7-12) they were concentrated at the mouth of the cave. During visual analysis of the sites there was a higher concentration of turtle remains associated with the eastern part of three out of

the five caves and the open over restricted parts in two out of the five caves. There was inconclusive evidence for the relationship between the northern versus southern and light versus dark. The depictions of turtles as offerings have been identified in the Maya codices and there is a reference to offering of tortoise bread to the eastern direction during the summer rainmaking ceremony in D.29b-30b (Bricker 1991; Thompson 1972).

All of the turtle remains were identified to be freshwater species which have been known to be utilized both for subsistence and utilitarian uses (Emery 1997). At the site of Caves Branch Rockshelter a large number of Kinosternidae (mud and musk turtles) and a few *Dermatemys mawii* remains were identified. The mud and musk turtles are believed to have served as a food source for the Maya (Emery 1997), but others have identifies them as non-food sources and only used for ritual events (Pohl 1983). However, the more desired species of food used by the Maya elite was the *Dermatemys mawii* (Emery 1997:132) which was lacking in large numbers at the all of the cave sites in this study.

There was an association with the type of turtle bones, carapace and plastron or turtle shell, recovered from all of the cave sites. The high amount of turtle shell remains could be due to two major factors, either the subsistence of turtles as a viable food resource and the method of cooking turtles in their shells that has been identified by other researchers (Hamblin 1984; Kozelsky 2005) or the use of turtle shell as drums during ceremonial events (Pohl 1983). Since none these remains were identified as being burnt, it would be safe to assume that these turtle shells may have been used or associated with ancient instruments. Turtles are also associated with ancient Maya mythology, with the birth of the maize god from a turtles back and the use of a turtle shell to represent the primordial world of the Maya. This association with turtles and the

creation of the Maya is an important part of their use in ceremonies and their close associations with water, earth, and also abundance (Kozelsky 2005; Pohl 1983).

Lizards

There was only a total of 12 lizard remains identified in three out of the five caves (CBR, STC, CD) analyzed in this study. Lizards are known inhabitants of forested areas and would also be expected to live within the opening of caves. Spatial autocorrelation was only able to process at CBR and identified the lizard distribution as random within the site (Table 7-3). Due to the low number of specimens and their limited distribution, cokriging failed to process at all three sites. The low number of lizard remains is interesting considering the strong association of iguanas with ritual offerings of the ancient Maya. Iguanas were offered as “breads” (Thompson 1972) and “tamales” (Taube 1988:238) throughout the Maya codices. The iguana offerings from the Maya codices have been shown to have a strong association with ritual events and offerings towards the western direction (Bricker 1991). Only one of the caves, CD, had an association between the western direction and the distribution of five lizard remains in this study (Table 7-7). The lack of strong associations with these remains and the western direction in these caves can be due to the preservation of these remains within the caves and also with their actual placement within the caves. Lizards are known forest inhabitants in the areas surrounding these cave sites. Most of the remains might actually be remnants of these animals as either cave dwellers or refuse from predator consumption. The Maya codices depict iguanas as being parts of breads or tamales. Cooking of these animals would help to quicken the degradation of these remains in a cave setting. The lack of iguana remains in caves may be more associated with the preparation of these materials as offerings than their normal preservation within the site.

Snakes

Snake remains were associated in four out of the five caves (CBR, STC, CD, CS), but with largely varying amounts of these specimens within these cave sites. Snakes are also inhabitants of caves and their surrounding areas. Spatial autocorrelation was only able to process the snake remains in two cave sites, and the distribution was considered random (Tables 7-3, 7-5). Cokriging was only able to process at CBR and the concentration of remains was identified around Operation 1D, the small cave at the site (Table 7-3). The majority of snake remains were located within the light region for three of the four caves with specimens. However, there was a large amount of snake remains found within the dark region of the small cave located at CBR, which is further interesting because these remains were also burned (Table 7-2).

Snake handling and the use of snakes in ritual has been identified for the *cuch* ritual and also in bloodletting ceremonies (Pohl 1983). Snakes are associated with fertility, which may be due to their behavior and the fact that snakes are seen shortly after it rains (Pohl 1981). The snake remains within the caves may actually be more of a representation of a natural distribution of these animals since they live in these habitats. All of the snake remains were from the axial part of the body including the vertebrae and ribs of these animals. This is an expected finding for these animals since snakes are mainly vertebrae, ribs, and the cranium. However, at many of these sites the snake remains were very similar in size and may actually represent a few intact snakes that died by natural causes.

Birds

Bird remains have been an important part of the deposition of Maya ritual behavior because more bird remains, excluding turkeys, are recovered in ritual deposits than in trash middens (Pohl 1983). There are many raptorial and predatory birds that can be identified as normal cave inhabitants, including owls and hawks. However, there are some examples of cave

faunal assemblages that contain those birds not normally located in areas around caves, for example the bird assemblage from Naj Tunich included Ardeidae (herons and bitterns family), Ramphastidae (toucans family), Psittacidae (parrots and cockatoos family), Columbidae (doves and pigeons), and *Meleagris gallopavo* (domesticated turkeys) which are not known inhabitants of caves (Brady 1989).

Although my analysis only identified birds to the general class of Aves, these remains were located in all of the cave sites, but in varying amounts. Spatial autocorrelation was able to process at three of the sites (CS, CBR, and NT), and the distribution of remains was identified as being randomly distributed at all of the sites. Cokriging processed at two sites, CBR had a higher concentration in Operation 1A (Table 7-3) and NT had a larger concentration around Lot 3 (Table 7-17). The majority of sites, three out of the five caves (CBR, STC, CD) contained a high amount of bird remains within the light region. However, there was little to no true patterning of remains in relation to directionality or sidedness. Mary Pohl (1983) identified the right side of the body as being associated with the rising sun and the left side of the body with the underworld. Using a small sample (n=14) of bird remains from Eduardo Quiroz Cave, Pohl (1983) identifies the larger number of left-sided bones (n=11) as being an example of selective sidedness for bird remains within cave sites. However, the idea that left-sided bird bones were cached within cave sites does not work well within most of the caves used in this study. A total of 71 bones were sided from all of the five cave sites, within these remains a total of 36 were left-sided and 35 were right-sided. This similarity in sidedness does not help to prove that there was a selection for specific sides of bird remains.

Opossums

The opossum remains were identified at all five of the cave sites in this analysis. Spatial autocorrelation was able to process at four out of the five sites, with three sites showing

clustering (Tables 7-3,7-12, 7-17) and one site having a random distribution (Table 7-5).

Cokriging was unable to process at any of the sites. The amount of these animals identified at all the sites varied, and the highest concentration were identified in Cueva de Sangre (n=62). The distribution of opossum remains does not adhere to any specific patterns. These remains are distributed throughout the caves in relation to sidedness and directionality. However, within three out of the five caves (CBR, STC, NT), opossum remains were located in the light region and mouth of these caves. This would be expected since opossums tend to live in forested areas and may have used the caves as a place of refuge. There are no specific findings of opossums in the archaeological record. However, there are depictions of the “Bacabs” or the “Opossum actors” in codices that are found in the relation to New Years and Uayeb rites (Thompson 1972). The depiction of these animals dressed in human clothing is one of the only depictions of these animals within the codices.

Armadillos

Armadillos are found throughout the Maya region and are known inhabitants of forested areas and agricultural field where they burrow their homes into. Armadillo remains were found in all five cave sites, but there were drastic differences in the amount of remains identified in those caves from Belize (CBR and STC) and those from Guatemala (CD, CS, and NT). The amounts of remains identified in the Belizean collections are 182 remains while only 11 remains were identified at the Guatemalan sites. The disparity in numbers of specimens between regions is unclear but an interesting pattern considering how large the differences are. Spatial autocorrelation was only able to process for the two caves with large sample sizes, and CBR (Table 7-3) had a random distribution while STC (Table 7-5) was somewhat clustered. Cokriging was only able to process at CBR and the highest concentrations were located around Operation 1A (Table 7-3).

The majority of remains were located in the light region; these remains were specifically located in three out of the five sites including both Belize sites. There was no real spatially distinct distribution of the armadillo remains in relation to the sidedness and directionality within these caves. Armadillos represent a known food source to the Maya and they are depicted with only a few in the hunting and trapping almanacs of the codices. The armadillo is associated with fertility throughout Mesoamerica (Pohl 1983). At the site of CBR, there is a large concentration of armadillo remains (n=102) and this may be related to large number of known armadillo burrows at the site. The armadillo would find the mixed grave fill soils from CBR as hospitable places to live. The movement of armadillos within archaeological sites has been shown to affect the distribution of artifacts and their movement through the soils may have caused some impacts on the archaeological record (Araujo and Marcelino 2003).

Bats

Bats represented a link to the underworld to the ancient Maya, an association that is easily understood because they are natural inhabitants of caves. Bat remains were identified at all five of the sites, but the amounts of these remains were low at four out of the five sites. These low numbers of remains are unexpected since these sites serve as home for many bat species in the Maya region. Spatial autocorrelation was identified the pattern as random at three out of the five (STC, CD, NT) sites that it was able to process (Tables 7-5, 7-8, 7-17). Cokriging failed to process at all five sites.

Cueva de El Duende was the only site to contain a high number of remains (n=632). The site with the lowest amount (n=1) was Caves Branch Rockshelter. The other sites only contained a few samples each including Stela Cave (n=13), Cueva de Sangre (n=12), and Naj Tunich (n=6). The small sample sizes did not help in producing any significant patterns. The sidedness of elements included more left-sided than right –sided elements at four of the five sites. The most

significant cave with a large number of left sides (n=7) with no right sides was Stela Cave (Table 7-5). The distribution of these remains was only located in Chamber 1 which was associated with the light and open regions of the cave. An unexpected result considering that the bats were known to live in the back part of the cave in Chamber 3. At Cueva de El Duende, the majority of remains over 99% were located in the open and light region as well (Table 7-7). The natural occurrence of bats in all of the cave sites makes their distribution seem more natural than cultural in origin.

Primates

Primates were closely associated with deer by the ancient Maya and were represented pictorially in the Maya codices with deer parts, including antlers. Deer were depicted with monkey attributes, including long tails (Pohl 1983). Monkeys were also associated with the arts and creation myths of the ancient Maya (Baker 1992). Primates from the Maya region include two monkey species, the howler monkeys (*Alouatta palliata* and *Alouatta pigra*) and the spider monkey (*Ateles geoffroyi*). There were only two monkey remains identified at one out of the five sites from this study. These two remains from Naj Tunich were in a single unit and could not be analyzed for any type of patterning (Table 7-17). The lack of primate remains in the cave sites mirror those at surface sites because monkey remains were identified rarely in the archaeological record. This may have something to do with the close association of humans and monkey. The ancient Maya identified the phylogenetic relationship between humans and monkeys, and this may be the reason they were not being used in cave ritual events.

Canids

The Canidae family includes coyotes, dogs, foxes, jackals, and wolves and within this larger group two main species of canids from the Maya region were identified including *Canis familiaris* (domestic dog) and *Urocyon cinereoargenteus* (gray fox). Canid remains were

identified in all five of the cave sites in this study. However, there were not many remains identified at three of these sites, CBR (n=3), STC (n=4), and NT (n=4). Since dogs are known to be ritually significant animals it would be expected that larger numbers of canid remains would be located in these caves. However, the canid remains from these ritually significant contexts were lacking in numbers to support their known ritual importance to the ancient Maya. Cokriging failed to process at any of these sites, and spatial autocorrelation was identified as being random at two of the five sites.

The domestic dog represents the only animal, besides the turkey, that was a domesticated species in Mesoamerica. Dogs, and in general all canids, are believed to be guides on the river that is in the underworld and they are also well known ritual offerings as both sacrifice and as burial offerings (Pohl 1983). The inclusion of the domestic dog at many of these sites represents a human placed species that was ritually interred in these areas. In contrast to the known inhabitants, such as the opossum, bat, and armadillo, the dog remains in these caves could only have been placed through human processes. At the site of Cueva de Sangre a large number of dog teeth were identified at the site, this is very similar to the large sample of dog teeth found at Actun Polbilche (Pendergast 1974). Dogs have also been identified as offerings in Yearbearer ceremonies in both the Maya codices, specifically in the Madrid Codex (pages 34 to 37) (Bill et al. 2000; Bricker 1989; Love 1986; Taube 1988; Vail 2004; Vail and Bricker 2004) and ethnographic accounts from Landa (Tozzer 1941). Dog as sacrificial offerings make the low number of canid remains in the caves even more significant.

Felids

Another important carnivore family located in some of the caves includes the felid or cat family. There were only two caves with identified cat remains. This is very significant because the largest cat in the Maya region, the jaguar, is a symbol of wealth and cultural distinction in the

Maya region and Mesoamerica in general. Jaguar pelts and paws were worn and used to show distinction among Maya hierarchy. Therefore the absence of their remains at these sites is an interesting occurrence. Large cat remains are usually found in association with burials that include pelts, paws, and also teeth. The pelts and paws may have also played a role in the accession ceremonies for kings that have been hypothesized to have occurred within the caves (Pohl 1983).

The medium- and large-sized cats of the Maya region are known inhabitants of caves, and have been traditionally identified with the setting sun, the underworld, and with water (Pohl 1983). The small number of feline remains (n=11) is interesting because it would be expected that a larger amount of ritually and elite-centric remains would be associated with these sites. Naj Tunich remains (n=3) include a radius, a humerus, and a metapodial, which may have all been associated with cat paws. The remains at Cueva de El Duende (n=8) were all cranial fragments from a single unit, another interesting finding since these remains may represent either a skull or multiple cat skulls (Table 7-8). With a larger sample more patterning might be identified, but due to the small sample size no distinct distribution patterns can be identified.

Raccoons

The Procyonidae includes raccoons, coatis, and kinkajous. These animals are known as a food source to the ancient Maya and symbolically represented the negative aspects of people including thievery and gluttony (Emery 1997). There were very small samples of remains (n=3 to 4) from three out of the five sites (CBR, STC, NT). These remains were located in different places within all the caves and no specific spatial relationship can be identified for the raccoon family. These remains may be from natural contexts since known predators of the raccoons lived in caves and also because no known ritual significance has been assigned to this family.

Tapirs

The largest mammal in the Maya region is the Baird's tapir (*Tapirus bairdii*). Due to the illusive and timid behavior of this animal, the tapir is rarely identified in the caves. In this study only one site, Naj Tunich has a sample of tapir remains. These remains were associated with the left side of the cave, the north, east, and dark regions of the cave (Tables 7-13, 7-14, 7-15, 7-16). The elements identified also varied, but the majority of metapodials and tarsals/carpals bone identified may be indications that the lower leg and lower arm bones may have been distributed at the site (Table 7-17). There are no known or described associations with the tapir in Maya ritual caches or within other cave sites.

Artiodactyls

The artiodactyls, or even-toed ungulates, represent some of the major food sources to the ancient Maya. The artiodactyls include the peccary and deer families. These two families are known to have played a major role in both subsistence and also in ritual. This large taxonomic grouping was identified at all five of the sites. It is not known if the ancient Maya identified the close taxonomic relationship of this large group but both the peccary and deer were analyzed separately and are discussed in detail below.

Peccaries

There are two major peccary species identified in the Maya region including the white-lipped peccary (*Tayassu pecari*) and the collared peccary (*Tayassu tajacu*). Due to the very similar nature of peccary remains, these two groups were not individually identified in this study. Peccaries are depicted in the Maya codices, but these depictions are rare and only found with the animal trapping almanacs. The most important element of the peccary was its cranium, and there are a majority of carved craniums that have been identified in the archaeological record. The most interesting being the distribution of peccary remains on the island of Cozumel, with the

postcranial remains identified only in Postclassic burials, while the skulls were found only in housemounds (Hamblin 1984; Pohl 1983).

Peccary remains were identified in four out of the five cave sites in this study. Spatial autocorrelation at Stela Cave and Naj Tunich identified the pattern of peccary remains as random (Table 7-5, 7-17). Only at Naj Tunich was cokriging able to process and at the site the highest concentration of remains was identified at Lots 1, 16, 24, and 57 (Table 7-17). All of the remains were identified in varying parts of the caves. However, there was an interesting trend in the elements identified at all of the sites. Within three of the sites the majority of remains included cranial and teeth remains, out of the fifteen remains identified twelve were cranial in origin. Naj Tunich included the largest sample from all of the sites (n=25), and at this site the majority of remains were limb elements (Table 7-17). This may be due to the use of peccary skulls at surface sites instead of within caves. By placing animal remains within cave site, the Maya would be taking a valuable product out of their ritual economy (Brady 2005). The rarity or sacredness of peccary skulls, many of which are carved, at surface sites may have been the limiting factor in their addition to ritual cave faunal assemblages.

Deer

There are two major species of deer identified and utilized by the Maya including the white-tailed deer (*Odocoileus virginianus*) and the brocket deer (*Mazama* sp.). In Pohl's (1983) groundbreaking analysis of ritual use and association of animal remains, deer were the first and most important animal species analyzed. Deer remains at archaeological sites in the Maya region usually represent the largest identified species in a collection. Deer served as a major source of protein to the Maya and were ritually significant offerings for the elite and gods of the ancient Maya. Deer also represented the sun and as a source of renewal. The Maya codices contain many different depictions of deer haunch offerings to both the gods and the ruling elites. Deer remains

represented the largest group of artiodactyls at all five cave sites. The numbers of deer remains were usually higher for white-tailed deer than brocket deer at all but one of the sites, Cueva de Sangre. Although this discrepancy is due to a large number of teeth, 31 out of the 35, remains identified to brocket deer at the site.

For deer remains at the cave sites, there were few patterns identified. Deer are associated with the sun, more specifically the rising sun. This association would place the directional importance of deer with the east and also with the sun at its apex, or the north. Close associations with the eastern and northern directions were identified in the codices for the New Years or Uayeb ceremonies and also with some of the burner cycle ceremonies (Bricker 1991, 1997; Thompson 1972). The only site to show a greater concentration of deer remains in the north (92.1%) and east (85.1%) than the south and west was at the site of Naj Tunich (Tables 7-10, 7-11). However, none of the other sites with the lower amounts of deer remains showed this same pattern. The use of deer haunches as ritual offerings would involve a larger number of deer remains being associated with these elements. A high amount of forelimbs and hindlimbs were identified within three sites containing the smaller-sized samples, CBR (7 out of 11 remains) (Table 7-3), STC (11 out of 16 remains) (Table 7-5) and at CD (15 out of the 18 remains) (Table 7-8). However, in the larger samples there were fewer numbers of limb and distal elements.

Rodents

Rodents are known inhabitants of caves and also known food sources for those animals that inhabit these caves. It would be expected that the second largest amount of remains, behind bats, identified within cave sites would be rodents. However, the amount of rodent remains varied throughout the five sites. The concentrations of rodent remains at the sites from largest to smallest include, Stela Cave (n=222), Cueva de Sangre (n=190), Caves Branch Rockshelter (n=30), Cueva de El Duende (n=21), and Naj Tunich (n=20). Spatial autocorrelation was able to

process at four out of the five sites and the patterns of remains were identified as random (Tables 7-3, 7-5, 7-12, 7-17). Cokriging was only able to process at two sites and at CBR these remains were concentrated around Operations 1B and 1C (Table 7-3), while at CS the highest concentration of remains were around CS6-8-1 and CS6-3-1 (Table 7-12).

The lack of rodent remains from some of these sites, including Naj Tunich and Cueva de El Duende, may be due to the collection methods. Rodents, like other small animals, are associated with otherworldliness and also the underworld (Pohl 1983). The patterns of distribution of remains varied throughout these sites and failed to produce a possible pattern for their spatial distribution. Small-sized rodents are usually identified as intrusive species in the zooarchaeological record at most sites; however, new ethnographic and ethnohistoric research has identified a possible trade of and utilization of these small protein sources.

Squirrels

Squirrel remains were only found at one site, Stela Cave, and in very limited numbers with a total of four specimens. However, there are strong ethnographic and epigraphic identifications of squirrels as ritual offerings. In Muluc years, squirrels were recorded as being offered in both Landa's *Relacion de las Cosas de Maya* (Tozzer 1941) and also within the yearbearer pages of the Madrid Codex (M.36) (Love 1986). Muluc years are associated with the eastern direction and these four remains were identified in the eastern part of the cave. However, it is difficult to assume the ritual significance of this small sample size. These remains were located in Chamber 1 of STC which falls within the open and light part of the cave (Table 7-4). The squirrel remains may actually represent remains from carnivore droppings or possibly the natural death of these animals within the cave.

Agoutis and pacas

The largest and most well-known food source from the rodent order includes the medium-sized rodents from the Agoutidae (pacas) and Dasyproctidae (agoutis) families. Agoutis and pacas were identified at all five of the cave sites in various amounts. Spatial autocorrelation identified the pattern of distribution as random at four out of the five sites it was able to process at (Tables 7-3, 7-5, 7-12, 7-17). Cokriging was able to process at three sites including CBR around Operation 1D (Table 7-3), at CS around lower regions of CS1 (Table 7-12), and at NT concentrated around Lot 57 (Table 7-17). These two families have not been identified to have specific ritual significance to the ancient Maya by previous research projects. There were no specific spatial patterns identified for their distribution within these caves because all aspects of the separations of space varied.

Cottontail rabbit

Finally, the last taxonomic group to be discussed is the cottontail rabbit. The rabbit has been identified as the second most consumed animal after deer (Emery 1997). Symbolically, the rabbit has been associated with fertility and vegetation because of its known preponderance to reproduce rapidly (Emery 1997). The rabbit, like the deer, is also associated with the ancient Maya sky. The moon is believed to be the profile of a rabbit in the sky (Emery 1997). The rabbit has also been pictorially represented as a scribe in the Maya codices. There were a few rabbit (n=7) remains identified within three of the five caves (CBR, STC, NT). Due to the small sample size spatial patterning for these remains could not be identified.

Summary

GIS and visual analysis were able to identify patterning for the following taxonomic groups, including the remains from crustaceans, turtles, peccary, deer, and squirrel remains. These patterns were formed using small sample sizes and should be taken as tentative

identifications for the intentional distribution of faunal remains within cave site. Animals have strong sacred associations with Maya rituals and in caves, these associations may be the reasoning for and lack of some taxonomic groups. A further discussion of these results is discussed in the next chapter.

Table 7-1. Separation of Space Summaries for Left versus Right Sides and North versus South Directions at Caves Branch Rockshelter, Belize.

Region of the cave (n=380)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
Left/North (n=157)	Crabs	65	33	21.0%	50.8%
	Fish	13	3	1.9%	23.1%
	Amphibia	5	2	1.3%	40.0%
	Turtles	42	14	8.9%	33.3%
	Iguana	6	3	1.9%	50.0%
	Snakes	37	6	3.8%	16.2%
	Birds	21	11	7.0%	52.4%
	Opossums	8	2	1.3%	25.0%
	Armadillos (w/ scutes)	102	50	31.8%	49.0%
	Armadillos (non-scutes)	31	21	13.4%	67.7%
	Bats	1	0	0.0%	0.0%
	Dogs	3	2	1.3%	66.7%
	Raccoons	4	2	1.3%	50.0%
	Artiodactyls	18	9	5.7%	50.0%
	Peccaries	3	1	0.6%	33.3%
	Deer	9	4	2.5%	44.4%
	Rodents	30	8	5.1%	26.7%
	Agoutis and pacas	24	12	7.6%	50.0%
	Rabbit	1	0	0.0%	0.0%
	Total:		380	157	100.0%
Right/South (n=223)	Crabs	65	32	14.3%	49.2%
	Fish	13	10	4.5%	76.9%
	Amphibia	5	3	1.3%	60.0%
	Turtles	42	28	12.6%	66.7%
	Iguana	6	3	1.3%	50.0%
	Snakes	37	31	13.9%	83.8%
	Birds	21	10	4.5%	47.6%
	Opossums	8	6	2.7%	75.0%
	Armadillos (w/ scutes)	102	52	23.3%	51.0%
	Armadillos (non-scutes)	31	10	4.5%	32.3%
	Bats	1	1	0.4%	100.0%
	Dogs	3	1	0.4%	33.3%
	Raccoons	4	2	0.9%	50.0%
	Artiodactyls	18	9	4.0%	50.0%
	Peccaries	3	2	0.9%	66.7%
	Deer	9	5	2.2%	55.6%
	Rodents	30	22	9.9%	73.3%
	Agoutis and pacas	24	12	5.4%	50.0%
	Rabbit	1	1	0.4%	100.0%
	Total:		380	223	

Table 7-2. Separation of Space Summaries for Light versus Dark and Open versus Restricted Regions at Caves Branch Rockshelter, Belize.

Region of the cave (n=380)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
Light/Open (n=309)	Crabs	65	62	20.1%	95.4%
	Fish	13	7	2.3%	53.8%
	Amphibia	5	5	1.6%	100.0%
	Turtles	42	36	11.7%	85.7%
	Iguana	6	5	1.6%	83.3%
	Snake	37	22	7.1%	59.5%
	Birds	21	21	6.8%	100.0%
	Opossums	8	6	1.9%	75.0%
	Armadillos (w/ scutes)	102	78	25.2%	76.5%
	Armadillos (non-scutes)	31	26	8.4%	83.9%
	Bats	1	1	0.3%	100.0%
	Dogs	3	3	1.0%	100.0%
	Raccoons	4	2	0.6%	50.0%
	Artiodactyls	18	16	5.2%	88.9%
	Peccaries	3	3	1.0%	100.0%
	Deer	9	7	2.3%	77.8%
	Rodents	30	26	8.4%	86.7%
	Agoutis and Pacas	24	18	5.8%	75.0%
	Rabbit	1	1	0.3%	100.0%
		Total:	380	309	100.0%
Dark/Restricted (n=71)	Crabs	65	3	4.2%	4.6%
	Fish	13	6	8.5%	46.2%
	Amphibia	5	0	0.0%	0.0%
	Turtles	42	6	8.5%	14.3%
	Iguana	6	1	1.4%	16.7%
	Snake	37	15	21.1%	40.5%
	Birds	21	0	0.0%	0.0%
	Opossums	8	2	2.8%	25.0%
	Armadillos (w/ scutes)	102	24	33.8%	23.5%
	Armadillos (non-scutes)	31	5	7.0%	16.1%
	Bats	1	0	0.0%	0.0%
	Dogs	3	0	0.0%	0.0%
	Raccoons	4	2	2.8%	50.0%
	Artiodactyls	18	2	2.8%	11.1%
	Peccaries	3	0	0.0%	0.0%
	Deer	9	2	2.8%	22.2%
	Rodents	30	4	5.6%	13.3%
	Agoutis and Pacas	24	6	8.5%	25.0%
	Rabbit	1	0	0.0%	0.0%
		Total:	380	71	100.0%

Table 7-3. Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Caves Branch Rockshelter, Belize.

Taxonomic Group	NISP (n=545)	% Taxa	% of Left sided elements	Body Portion comment	% NISP Burned	Spatial Autocorrelation	Cokriging
Crabs	65	17.1%	28/56 = 50%	98.5% claws	None	Clustered, not random chance	Op 1A cluster (Left/North/Light)
Fish	13	3.4%	1/1 = 100%	cranial 4, axial 4, UID 6	None	Slight clustering	No clusters
Amphibia	5	1.3%	2/3 = 66.7%	appendicular 4, axial 1	None	Didn't run	Didn't run
Turtles	42	11.1%	2/11 = 18.2%	92.8% carapace/plastron, 5, 11.9% axial, 1, 2.4% long bone	2/42, 4.8%	Random	Cluster between Op 1A, 1B, + 1D
Iguana	6	1.6%	1/4 = 25%	Appendicular 1, cranial 2, axial 3	None	Random	Didn't run
Snakes	37	9.7%	N/A	All vert	13/37, 35.1%	Not clustered, not dispersed	Op 1D cluster
Birds	21	5.5%	1/4 = 25%	App 14, axial 4, UID 3	1/21, 4.8%	Slight clustering	Op 1A cluster
Opossums	8	2.1%	2/7 = 28.6%	Cranial 4, axial 3, humerus 1	None	Clustered, not random chance	Didn't run
Armadillos	102	26.8%	See Below	Scutes 71, Read below	13/102, 12.8%, 10/ 102, 9.8% scute	Random, not clustered or dispersed	Higher probability for N/S, L/R, D/Light
Armadillos (non-scute)	31		4/11 = 36.3%	metapodial 15, vertebrae 6, radius 2, fibula 2, calcaneum 2, humerus 1, ulna 1, tibia 1, astragalus 1		Random, not clustered or dispersed	Higher probability for N/S,L/R, D/Light
Bats	1	0.3%	1/1 = 100%	1 innominate	None	Didn't run	Didn't run
Dogs	3	0.8%	1/2 = 50%	2 crania, 1 distal	None	Didn't run	Didn't run
Raccoons	4	1.1%	3/4 = 75%	2 ulnae, 2 tibiae	None	Didn't run	Didn't run
Artiodactyls	18	4.7%	4/8 = 50%	6 appendicular, 2 cranial, 1 axial	2/18, 11.1%	Random, neither dispersed nor clustered	Clustering in Op 1A and 1D
Peccaries	3	0.8%	2/3 = 66.7%	All teeth	1/3, 33.3%	Didn't run	Didn't run
Deer (9 wtd)	11	2.9%	4/8 = 50%	App 6, cranial 2, axial 1	None	Random	Didn't run
Rodents	30	7.9%	19/26 = 71%	App (19) cranial (11)	1/30, 3.3%	Random, not clustered nor dispersed	Clustering around 1B and 1C
Agoutis and pacas	24	6.3%	12/23 = 52.2%	Tooth (18), App (6)	4/24, 16.7%	Clustering, random chance	Clustering at 1D
Rabbit	1	0.3%	n/a	metatarsal	None	Didn't run	Didn't run

Table 7-4. Separation of Space Summaries for Left versus Right Sides, North versus South, East versus West Directions, Light versus Dark, and Open versus Restricted Regions at Stela Cave, Belize.

Region of the cave (n=498)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
Left/ North/East/ Light/Open (n=447)	Crabs	11	11	2.5%	100.0%
	Fish	4	3	0.7%	75.0%
	Amphibians	1	1	0.2%	100.0%
	Turtles	43	43	9.6%	100.0%
	Lizards	1	1	0.2%	100.0%
	Snakes	18	17	3.8%	94.4%
	Bird	39	39	8.7%	100.0%
	Opossums	13	13	2.9%	100.0%
	Armadillo	80	78	17.4%	97.5%
	Bats	13	13	2.9%	100.0%
	Dogs	4	3	0.7%	75.0%
	Racoons	3	3	0.7%	100.0%
	Artiodactyls	30	27	6.0%	90.0%
	Peccary	7	7	1.6%	100.0%
	Deer	16	15	3.4%	93.8%
	White-tailed deer	4	4	0.9%	100.0%
	Brocket deer	4	4	0.9%	100.0%
	Rodent	222	181	40.5%	81.5%
	Squirrel	4	4	0.9%	100.0%
	Agoutis and pacas	8	7	1.6%	87.5%
Rabbits	4	3	0.7%	75.0%	
	Total:	498	447	100.0%	
Right/South/West/Dark/Restricted (n=51)	Crabs	11	0	0.0%	0.0%
	Fish	4	1	2.0%	25.0%
	Amphibians	1	0	0.0%	0.0%
	Turtles	43	0	0.0%	0.0%
	Lizards	1	0	0.0%	0.0%
	Snakes	18	1	2.0%	5.6%
	Bird	39	0	0.0%	0.0%
	Opossums	13	0	0.0%	0.0%
	Armadillo	80	2	3.9%	2.5%
	Bats	13	0	0.0%	0.0%
	Dogs	4	1	2.0%	25.0%
	Racoons	3	0	0.0%	0.0%
	Artiodactyls	30	3	5.9%	10.0%
	Peccary	7	0	0.0%	0.0%
	Deer	16	1	2.0%	6.3%
	White-tailed deer	4	0	0.0%	0.0%
	Brocket deer	4	0	0.0%	0.0%
	Rodent	222	41	80.4%	18.5%
	Squirrel	4	0	0.0%	0.0%
	Agoutis and pacas	8	1	2.0%	12.5%
Rabbits	4	1	2.0%	25.0%	
	Total:	498	51	100.0%	

Table 7-5. Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Stela Cave, Belize.

Taxonomic Group	NISP (n=498)	% Taxa	% of Left sided elements	Body Portion comment	% NISP burned	Spatial Autocorrelation
Crabs	11	2.2%	3/9 = 33%	10, 91% claw, 1, 9% body frag	None	Random, neither clustered nor dispersed
Fish	4	0.8%	1/2 = 50%	2, 50% dentary, 1, 25% vert, 1, 25% UID	None	Didn't run
Amphibians	1	0.2%	1/1 = 100%	1, 100% humerus	None	Didn't run
Turtles	43	8.6%	10/20= 50%	42, 97.7% plastron/carapace, 1, 2.3% humerus	None	Dispersed, random chance
Lizards	1	0.2%	N/A	1, 100% mandible frag	None	Didn't run
Snakes	18	3.6%	N/A	18, 100% vertebrae	1 blackened	Clustering, random chance
Bird	39	7.8%	10/26 = 38.5%	27, 69.2% limb, 9, 23.1% axial, 3, 7.7% UID	None	Random, neither clustered nor dispersed
Opossums	13	2.6%	4/6 = 67%	7, 53.8% cranial, 6, 46.2% axial	None	Random, neither clustered nor dispersed
Armadillo	80	16.1%	9/15 = 60%	51, 63.8% scutes, 4 verts, 1 rib, 1 scapula, 2 humerus, 3 ulna, 7 metapodials, 1 inn. 1 patella, 4 tibia, 2 fibula, 1 astragal, 1 calcaneus	1 calcined (scute), 2 blackened (long bones)	Clustering, random chance.
Bats	13	2.6%	7/7 = 100%	10, 76.9% front limb, 3, 23.1% cranial	None	Random, neither clustered nor dispersed
Dogs	4	0.8%	1/3 = 33%	3 limb, 1 cranial	1 calcined gray	Didn't run
Racoons	3	0.6%	2/2 = 100%	1 cranial frag, 1 metapodial, 1 scapula	None	Didn't run
Artiodactyls	30	6.0%	8/19 = 42.1%	20, 66.7% limb, 9, 30% cranial, 1, 3.3% axial	5 blackened, 1 calcined gray, 3 calcined white	Random, neither clustered nor dispersed
Peccary	7	1.4%	2/5 = 40%	3 cranial, 2 teeth, 2 metapodials	3 blackened	Random, neither clustered nor dispersed
Deer	16	3.2%	4/11 = 36.4%	5, 31.3% cranium, 6, 37.5% hindlimb, 2, 12.5% front limb, 3, 18.8% metapod, 1, 6.3% scapula	2 blackened, 1 calcined gray, 1 calcined white	Random, neither clustered nor dispersed
White-tailed deer	4	0.8%	1/4 = 25%	2 astragalus, 1 metacarpal, 1 mandible	None	Didn't run
Brocket deer	4	0.8%	1/3 = 33.3%	1 ulna, 1 molar, 1mtt, 1mtp	1 calcined gray, 1 calcined white	Didn't run
Rodent	222	44.6%	114/213 = 53.5%	120, 54.1% hind limb, 67, 30.2% cranium, 22, 9.9% front limbs, 13, 5.8% axial	None	Random, neither clustered nor dispersed
Squirrel	4	0.8%	3/4 = 75%	2 femurs, 1 mandible, 1 tibia	None	Didn't run
Agoutis and pacas	8	1.6%	4/7 = 57.1%	5 (62.5%) teeth, 1 (12.5%) ulna, 1 (12.5%) tibia, 1 astragalus (12.5%),	None	Dispersed, random chance
Rabbits	4	0.8%	2/4 = 50%	3 femurs, 1 mandible	None	Didn't run

Table 7-6. Separation of Space Summaries for North versus South Directions at Cueva de El Duende, Guatemala.

Region of the cave (n=1270)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
North (n=611)	Crabs	1	0	0.0%	0.0%
	Fish	399	40	6.5%	10.0%
	Lepisosteidae (gars)	39	2	0.3%	5.1%
	Siluriformes (catfish)	8	4	0.7%	50.0%
	Amphibians	11	4	0.7%	36.4%
	Turtles	15	1	0.2%	6.7%
	Lizards	5	0	0.0%	0.0%
	Snakes	50	5	0.8%	10.0%
	Bird	37	5	0.8%	13.5%
	Opossums	29	11	1.8%	37.9%
	Armadillo	2	0	0.0%	0.0%
	Bats	632	509	83.3%	80.5%
	Dogs	22	2	0.3%	9.1%
	Cats	8	0	0.0%	0.0%
	Artiodactyls	30	16	2.6%	53.3%
	Deer	18	7	1.1%	38.9%
	White-tailed deer	15	6	1.0%	40.0%
	Brocket deer	1	0	0.0%	0.0%
	Rodent	21	16	2.6%	76.2%
	Agoutis and Pacas	8	2	0.3%	25.0%
	Total:	1270	611	100.0%	
South (n=659)	Crabs	1	1	0.2%	100.0%
	Fish	399	359	54.5%	90.0%
	Lepisosteidae (gars)	39	37	5.6%	94.9%
	Siluriformes (catfish)	8	4	0.6%	50.0%
	Amphibians	11	7	1.1%	63.6%
	Turtles	15	14	2.1%	93.3%
	Lizards	5	5	0.8%	100.0%
	Snakes	50	45	6.8%	90.0%
	Bird	37	32	4.9%	86.5%
	Opossums	29	18	2.7%	62.1%
	Armadillo	2	2	0.3%	100.0%
	Bats	632	123	18.7%	19.5%
	Dogs	22	20	3.0%	90.9%
	Cats	8	8	1.2%	100.0%
	Artiodactyls	30	14	2.1%	46.7%
	Deer	18	11	1.7%	61.1%
	White-tailed deer	15	9	1.4%	60.0%
	Brocket deer	1	1	0.2%	100.0%
	Rodent	21	5	0.8%	23.8%
	Agoutis and Pacas	8	6	0.9%	75.0%
	Total:	1270	659	100.0%	

Table 7-7. Separation of Space Summaries for East versus West Directions, Light versus Dark, and Open versus Restricted Regions at Cueva de El Duende, Guatemala.

Region of the cave (n=1270)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
East/ Light/Open (n=1182)	Crabs	1	1	0.1%	100.0%
	Fish	399	377	31.9%	94.5%
	Lepisosteidae (gars)	39	39	3.3%	100.0%
	Siluriformes (catfish)	8	4	0.3%	50.0%
	Amphibians	11	7	0.6%	63.6%
	Turtles	15	14	1.2%	93.3%
	Lizards	5	5	0.4%	100.0%
	Snakes	50	47	4.0%	94.0%
	Bird	37	32	2.7%	86.5%
	Opossums	29	18	1.5%	62.1%
	Armadillo	2	2	0.2%	100.0%
	Bats	632	626	53.0%	99.1%
	Dogs	22	20	1.7%	90.9%
	Cats	8	8	0.7%	100.0%
	Artiodactyls	30	14	1.2%	46.7%
	Deer	18	11	0.9%	61.1%
	White-tailed deer	15	9	0.8%	60.0%
	Brocket deer	1	1	0.1%	100.0%
	Rodent	21	5	0.4%	23.8%
	Agoutis and Pacas	8	6	0.5%	75.0%
	Total:	1270	1182	100.0%	
West/Dark/Restricted (n=88)	Crabs	1	0	0.0%	0.0%
	Fish	399	22	25.0%	5.5%
	Lepisosteidae (gars)	39	0	0.0%	0.0%
	Siluriformes (catfish)	8	4	4.5%	50.0%
	Amphibians	11	4	4.5%	36.4%
	Turtles	15	1	1.1%	6.7%
	Lizards	5	0	0.0%	0.0%
	Snakes	50	3	3.4%	6.0%
	Bird	37	5	5.7%	13.5%
	Opossums	29	11	12.5%	37.9%
	Armadillo	2	0	0.0%	0.0%
	Bats	632	6	6.8%	0.9%
	Dogs	22	2	2.3%	9.1%
	Cats	8	0	0.0%	0.0%
	Artiodactyls	30	16	18.2%	53.3%
	Deer	18	7	8.0%	38.9%
	White-tailed deer	15	6	6.8%	40.0%
	Brocket deer	1	0	0.0%	0.0%
	Rodent	21	16	18.2%	76.2%
	Agoutis and Pacas	8	2	2.3%	25.0%
	Total:	1270	88	100.0%	

Table 7-8. Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Cueva de El Duende, Guatemala.

Taxonomic Group	NISP (n=1270)	% Taxa	% of Left sided elements	Body Portion comment	% NISP burned	Spatial Autocorrelation
Crabs	1	0.1%	N/A	1 claw	None	Didn't run
Fish	399	31.4%	18/43= 41.9%	148, 37.1% UID, 15, 12.8% Cranial, 200, 50.1% Axial	None	Random, neither clustered nor dispersed
Lepisosteidae (gar)	39	3.1%	5/8 = 62.5%	25, 64.1% scales, 4, 10.3% vertebrae, 10, 25.6% cranial	None	Didn't run
Siluriformes (catfish)	8	0.6%	1/3 = 33%	3 cranial, 1 coracoid, 4 postcranial	None	Didn't run
Amphibians				1, 9.1% vertebra, 1, 9.1% maxilla, 3, 27.2% humerus, 4, 36.4% innominate, 2, 18.2% long bone	None	Didn't run
Notes: 10 Anura	11	0.9%	4/8 = 50%			
Turtles	15	1.2%	3/9 = 33%	12, 80% carapace, 1, 6.7% coracoids, 1, 6.7% humerus, 1, 6.7% innominate	None	Didn't run
Lizards	5	0.4%	2/3 = 66.7%	5, 100% dentary	None	Didn't run
Snakes	50	3.9%	N/A	38, 76% ribs, 12, 24% vertebrae	None	Didn't run
Bird	37	2.9%	13/25 = 52%	15, 40.5% hind limbs, 10, 27% front limbs, 6, 16.2% axial, 8.1% cranial, 3, 8.1% long bone fragments	None	Didn't run
Opossums	29	2.3%	14/26 = 53.8%	14, 48.3% cranial, 5, 17.2% axial, 5, 17.2% front limb, 5, 17.2% hind limb	None	Didn't run
Armadillo	2	0.2%	N/A	2, 100% scutes	None	Didn't run
Bats	632	49.8%	116/209 = 55.5%	309, 48.9% phalanx fragments, 224, 35.4% front limbs, 38, 6% axial, 33, 5.2% hind limb, 28, 4.4% cranial	None	Clustering, random chance.
Dogs	22	1.7%	10/21 = 47.6%	1, 4.5% cranial fragment, 8, 36.4% teeth, 1, 4.5% atlas vertebrae, 2, 9% innominates, 6, 27.2% front limbs, 4, 18.1% hind limbs	1 blackened	Random, neither clustered nor dispersed
Cats	8	0.6%	3/8 = 37.5%	8, 100% cranial fragments	None	Didn't run
Artiodactyls	30	2.4%	10/13 = 76.9%	2, 6.7% cranial, 5, 16.7% axial, 4, 13.3% front limb, 11, 36.7% hind limb, 8, 26.7% distal appendages	3 blackened	Random, neither clustered nor dispersed

Table 7-8. Continued

Taxonomic Group	NISP (n=1270)	% Taxa	% of Left sided elements	Body Portion comment	% NISP burned	Spatial Autocorrelation
Deer	18	1.4%	8/11 = 72.7%,	2, 11.1% cranial, 1, 5.6% axial, 4, 22.2% front limb, 9, 50% hind limb, 2, 11.1% distal appendages	2 blackened	Didn't run
White-tailed deer	15	1.2%	7/10 = 70%	2 cranial, 1 axial, 2 front limb, 8 hind limbs, 2 distal	2 blackened	Didn't run
Brocket deer	1	0.1%	N/A	1 metacarpal	None	Didn't run
Rodent	21	1.7%	8/15 = 53.3%	4, 19% cranial, 7, 33.3% axial, 1, 4.8% front limb, 9, 42.9% hind limb	None	Didn't run
Agoutis and Pacas	8	0.6%	2 of 8 = 25%	2, 25% humerus, 1, 12.5% ulna, 2, 25% femur, 3, 37.5% tibia	None	Didn't run

Table 7-9. Separation of Space Summaries for Left versus Right Sides at Cueva de Sangre, Guatemala.

Region of the cave (n=299)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
Left (n=118)	Crustaceans	8	0	0.0%	0.0%
	Fish	2	0	0.0%	0.0%
	Turtle	70	27	22.9%	38.6%
	Snake	3	1	0.8%	33.3%
	Bird	4	2	1.7%	50.0%
	Opossums	62	28	23.7%	45.2%
	Armadillo	3	3	2.5%	100.0%
	Bats	12	0	0.0%	0.0%
	Dogs	39	6	5.1%	15.4%
	Artiodactyls	67	11	9.3%	16.4%
	Peccary	5	5	4.2%	100.0%
	Deer	56	7	5.9%	12.5%
	White-tailed deer	19	10	8.5%	52.6%
	Brocket deer	35	0	0.0%	0.0%
	Rodent	190	18	15.3%	9.5%
	Agouti and pacas	87	22	18.6%	25.3%
	Total:	547	118	100.0%	
Right (n=181)	Crustaceans	8	8	4.4%	100.0%
	Fish	2	2	1.1%	100.0%
	Turtle	70	41	22.7%	58.6%
	Snake	3	2	1.1%	66.7%
	Bird	4	1	0.6%	25.0%
	Opossums	62	33	18.2%	53.2%
	Armadillo	3	0	0.0%	0.0%
	Bats	12	12	6.6%	100.0%
	Dogs	39	11	6.1%	28.2%
	Artiodactyls	67	15	8.3%	22.4%
	Peccary	5	0	0.0%	0.0%
	Deer	56	13	7.2%	23.2%
	White-tailed deer	19	7	3.9%	36.8%
	Brocket deer	35	1	0.6%	2.9%
	Rodent	190	4	2.2%	2.1%
	Agouti and pacas	87	52	28.7%	59.8%
	Total:	547	181	100.0%	

Table 7-10. Separation of Space Summaries for North versus South Directions at Cueva de Sangre, Guatemala.

Region of the cave (n=295)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
North (n=238)	Crabs	6	3	1.3%	50.0%
	Turtle	8	5	2.1%	62.5%
	Bird	26	22	9.2%	84.6%
	Domestic turkey	14	12	5.0%	85.7%
	Opossums	10	7	2.9%	70.0%
	Armadillo	6	2	0.8%	33.3%
	Bats	6	3	1.3%	50.0%
	Primates	2	2	0.8%	100.0%
	Dogs	4	4	1.7%	100.0%
	Cats	3	3	1.3%	100.0%
	Raccoons	3	3	1.3%	100.0%
	Baird's tapir	11	8	3.4%	72.7%
	Artiodactyls	163	142	59.7%	87.1%
	Peccary	25	17	7.1%	68.0%
	Deer	138	125	52.5%	90.6%
	White-tailed deer	114	105	44.1%	92.1%
	Brocket deer	16	16	6.7%	100.0%
	Rodent	20	17	7.1%	85.0%
	Agouti and paca	25	16	6.7%	64.0%
	Rabbit	2	1	0.4%	50.0%
	Total:	295	238	100.0%	
South (n=57)	Crabs	6	3	5.3%	50.0%
	Turtle	8	3	5.3%	37.5%
	Bird	26	4	7.0%	15.4%
	Domestic turkey	14	2	3.5%	14.3%
	Opossums	10	3	5.3%	30.0%
	Armadillo	6	4	7.0%	66.7%
	Bats	6	3	5.3%	50.0%
	Primates	2	0	0.0%	0.0%
	Dogs	4	0	0.0%	0.0%
	Cats	3	0	0.0%	0.0%
	Raccoons	3	0	0.0%	0.0%
	Baird's tapir	11	3	5.3%	27.3%
	Artiodactyls	163	21	36.8%	12.9%
	Peccary	25	8	14.0%	32.0%
	Deer	138	13	22.8%	9.4%
	White-tailed deer	114	9	15.8%	7.9%
	Brocket deer	16	0	0.0%	0.0%
	Rodent	20	3	5.3%	15.0%
	Agouti and paca	25	9	15.8%	36.0%
	Rabbit	2	1	1.8%	50.0%
	Total:	295	57	100.0%	

Table 7-11. Separation of Space Summaries for East versus West Directions at Cueva de Sangre, Guatemala.

Region of the cave (n= 547)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
East (n=244)	Crustaceans	8	0	0.0%	0.0%
	Fish	2	0	0.0%	0.0%
	Turtle	70	0	0.0%	0.0%
	Snake	3	0	0.0%	0.0%
	Bird	4	1	0.4%	25.0%
	Opossums	62	1	0.4%	1.6%
	Armadillo	3	1	0.4%	33.3%
	Bats	12	3	1.2%	25.0%
	Dogs	39	16	6.6%	41.0%
	Artiodactyls	67	41	16.8%	61.2%
	Peccary	5	3	1.2%	60.0%
	Deer	56	36	14.8%	64.3%
	White-tailed deer	19	2	0.8%	10.5%
	Brocket deer	35	34	13.9%	97.1%
	Rodent	190	168	68.9%	88.4%
	Agouti and pacas	87	13	5.3%	14.9%
	Total:		547	244	100.0%
West (n=303)	Crustaceans	8	8	2.6%	100.0%
	Fish	2	2	0.7%	100.0%
	Turtle	70	70	23.1%	100.0%
	Snake	3	3	1.0%	100.0%
	Bird	4	3	1.0%	75.0%
	Opossums	62	61	20.1%	98.4%
	Armadillo	3	2	0.7%	66.7%
	Bats	12	9	3.0%	75.0%
	Dogs	39	23	7.6%	59.0%
	Artiodactyls	67	26	8.6%	38.8%
	Peccary	5	2	0.7%	40.0%
	Deer	56	20	6.6%	35.7%
	White-tailed deer	19	17	5.6%	89.5%
	Brocket deer	35	1	0.3%	2.9%
	Rodent	190	22	7.3%	11.6%
	Agouti and pacas	87	74	24.4%	85.1%
	Total:		547	303	61.7%

Table 7-12. Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Cueva de Sangre, Guatemala.

Taxonomic Group	NISP (n=545)	% Taxa	% of Left sided elements	Body Portion comment	% NISP Burned	Spatial Autocorrelation	Cokriging
Crustaceans	8	1.5%	2/ 5 = 40%	8 claws	None	Didn't run	Didn't run
Fish	2	0.4%	N/A	1, 50% vertebrae, 1, 50% postcranial	None	Didn't run	Didn't run
Turtle	68	12.5%	6/ 11 = 54.5%	69, 98.6% carapace/plastron, 1, 1.4% vertebra	4/68 = 5.9% blackened	Random, neither clustered nor dispersed	R/L high conc near mouth of cave
Snake	3	0.6%	N/A	3 vertebrae	None	Didn't run	Didn't run
Bird	4	0.7%	1/2 = 50%	1 vertebrae, 1 humerus, 1 ulna, 1 UID	None	Didn't run	Didn't run
Opossums	62	11.4%	16/32 = 50%	28, 45.2% vertebrae, 5, 8.1% cranium, 11, 17.7% teeth, 8, 12.9% mandible, 1, 1.6% scapula, 5, 8.1% humerus, 2, 3.2% radius, 1, 1.6% ulna, 1, 1.6% astragalus	None	Clustering, 5-10% chance it was random	Didn't run
Armadillo	3	0.6%	N/A	2, 66.7% scutes, 1, 33.3% caudal vert	None	Didn't run	Didn't run
Bats	12	2.2%	3/5 = 60%	4, 33.3% humerus, 4, 33.3% ulnas, 1, 8.3% femurs, 3, 25% phalanx	None	Didn't run	Didn't run
Dogs	39	7.2%	17/32 = 53.1%	37, 94.8% teeth, 1, 2.6% cranium, 1, 2.6% baculum	None	Clustering, random chance	Didn't run
Artiodactyls	67	12.3%	25/51 = 49%	40, 59.7% cranial, 1, 1.5% axial, 6, 9% frontlimb, 7, 10.4% hindlimb, 13, 19.4% distal	None	Random, neither clustered nor dispersed	L/R, N/S, E/W high conc CS7-3-1 and CS11-1-1
Peccary	5	0.9%	1/3 = 33.3%	3, 60% teeth, 1, 20% mandible, 1, 20% metacarpal	None	Didn't run	Didn't run
Deer	56	10.3%	24/48 = 50%	36, 64.3% cranial, 1, 1.8% axial, 4, 7.1% frontlimb, 7, 12.5% hindlimb, 8, 14.3% distal	None	Clustering, random chance.	L/R, N/S, E/W high conc CS7-3-1 and CS11-1-1

Table 7-12 Continued.

Taxonomic Group	NISP (n=545)	% Taxa	% of Left sided elements	Body Portion comment	% NISP Burned	Spatial Autocorrelation	Cokriging
White-tailed deer	19	3.5%	4/11 = 36.4%	1, 5.3% cranial, 1, 5.3% axial, 4, 21.1% frontlimb, 6, 31.6% hindlimb, 7, 36.8% distal	None	Random, neither clustered nor dispersed	N/S, E/W high conc CS1, L/R high conc mouth of CS1
Brocket deer	35	6.4%	18/35 = 51.4%	34, 97.1% cranial, 1, 2.9% hindlimb	None	Random, neither clustered nor dispersed	Didn't run
Rodent	190	34.9%	79/124 = 63.7%	54, 28.4% cranial, 55, 28.9% axial, 28, 14.7% front limbs, 40, 21.1% hindlimbs, 13, 6.8% distal	None	Random, neither clustered nor dispersed	L/R, N/S, E/W high conc CS6-8-1 and CS6-3-1
Agouti and pacas	87	16.0%	39/80 = 48.8%	61, 70.1% cranial, 1, 1.1% innominate, 15, 17.2% frontlimb, 6, 6.9% hindlimb, 4, 4.6% distal	None	Random, neither clustered nor dispersed	L/R, N/S, E/W high conc lower region of CS1 (CS1-84-1)

Table 7-13. Separation of Space Summaries for Left versus Right Sides at Naj Tunich, Guatemala.

Region of the cave (n=295)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
Left (n=204)	Crabs	6	3	1.5%	50.0%
	Turtle	8	5	2.5%	62.5%
	Bird	26	19	9.3%	73.1%
	Domestic turkey	14	11	5.4%	78.6%
	Opossums	10	7	3.4%	70.0%
	Armadillo	6	2	1.0%	33.3%
	Bats	6	2	1.0%	33.3%
	Primates	2	2	1.0%	100.0%
	Dogs	4	4	2.0%	100.0%
	Cats	3	3	1.5%	100.0%
	Raccoons	3	3	1.5%	100.0%
	Baird's tapir	11	7	3.4%	63.6%
	Artiodactyls	163	115	56.4%	70.6%
	Peccary	25	17	8.3%	68.0%
	Deer	138	98	48.0%	71.0%
	White-tailed deer	114	82	40.2%	71.9%
	Brocket deer	16	13	6.4%	81.3%
	Rodent	20	17	8.3%	85.0%
	Agouti and paca	25	14	6.9%	56.0%
	Rabbit	2	1	0.5%	50.0%
	Total:	295	204	100.0%	
Right (n=91)	Crabs	6	3	3.3%	50.0%
	Turtle	8	3	3.3%	37.5%
	Bird	26	7	7.7%	26.9%
	Domestic turkey	14	3	3.3%	21.4%
	Opossums	10	3	3.3%	30.0%
	Armadillo	6	4	4.4%	66.7%
	Bats	6	4	4.4%	66.7%
	Primates	2	0	0.0%	0.0%
	Dogs	4	0	0.0%	0.0%
	Cats	3	0	0.0%	0.0%
	Raccoons	3	0	0.0%	0.0%
	Baird's tapir	11	4	4.4%	36.4%
	Artiodactyls	163	48	52.7%	29.4%
	Peccary	25	8	8.8%	32.0%
	Deer	138	40	44.0%	29.0%
	White-tailed deer	114	32	35.2%	28.1%
	Brocket deer	16	3	3.3%	18.8%
	Rodent	20	3	3.3%	15.0%
	Agouti and paca	25	11	12.1%	44.0%
	Rabbit	2	1	1.1%	50.0%
	Total:	295	91	100.0%	

Table 7-14. Separation of Space Summaries for North versus South Directions at Naj Tunich, Guatemala.

Region of the cave (n=295)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
North (n=238)	Crabs	6	3	1.3%	50.0%
	Turtle	8	5	2.1%	62.5%
	Bird	26	22	9.2%	84.6%
	Domestic turkey	14	12	5.0%	85.7%
	Opossums	10	7	2.9%	70.0%
	Armadillo	6	2	0.8%	33.3%
	Bats	6	3	1.3%	50.0%
	Primates	2	2	0.8%	100.0%
	Dogs	4	4	1.7%	100.0%
	Cats	3	3	1.3%	100.0%
	Raccoons	3	3	1.3%	100.0%
	Baird's tapir	11	8	3.4%	72.7%
	Artiodactyls	163	142	59.7%	87.1%
	Peccary	25	17	7.1%	68.0%
	Deer	138	125	52.5%	90.6%
	White-tailed deer	114	105	44.1%	92.1%
	Brocket deer	16	16	6.7%	100.0%
	Rodent	20	17	7.1%	85.0%
	Agouti and paca	25	16	6.7%	64.0%
	Rabbit	2	1	0.4%	50.0%
	Total:	295	238	100.0%	
South (n=57)	Crabs	6	3	5.3%	50.0%
	Turtle	8	3	5.3%	37.5%
	Bird	26	4	7.0%	15.4%
	Domestic turkey	14	2	3.5%	14.3%
	Opossums	10	3	5.3%	30.0%
	Armadillo	6	4	7.0%	66.7%
	Bats	6	3	5.3%	50.0%
	Primates	2	0	0.0%	0.0%
	Dogs	4	0	0.0%	0.0%
	Cats	3	0	0.0%	0.0%
	Raccoons	3	0	0.0%	0.0%
	Baird's tapir	11	3	5.3%	27.3%
	Artiodactyls	163	21	36.8%	12.9%
	Peccary	25	8	14.0%	32.0%
	Deer	138	13	22.8%	9.4%
	White-tailed deer	114	9	15.8%	7.9%
	Brocket deer	16	0	0.0%	0.0%
	Rodent	20	3	5.3%	15.0%
	Agouti and paca	25	9	15.8%	36.0%
	Rabbit	2	1	1.8%	50.0%
	Total:	295	57	100.0%	

Table 7-15. Separation of Space Summaries for East versus West Directions at Naj Tunich, Guatemala.

Region of the cave (n=295)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
East (n=237)	Crabs	6	6	2.5%	100.0%
	Turtle	8	8	3.4%	100.0%
	Bird	26	19	8.0%	73.1%
	Domestic turkey	14	7	3.0%	50.0%
	Opossums	10	9	3.8%	90.0%
	Armadillo	6	6	2.5%	100.0%
	Bats	6	6	2.5%	100.0%
	Primates	2	2	0.8%	100.0%
	Dogs	4	1	0.4%	25.0%
	Cats	3	2	0.8%	66.7%
	Raccoons	3	1	0.4%	33.3%
	Baird's tapir	11	10	4.2%	90.9%
	Artiodactyls	163	137	57.8%	84.0%
	Peccary	25	20	8.4%	80.0%
	Deer	138	117	49.4%	84.8%
	White-tailed deer	114	97	40.9%	85.1%
	Brocket deer	16	13	5.5%	81.3%
	Rodent	20	7	3.0%	35.0%
	Agouti and paca	25	22	9.3%	88.0%
	Rabbit	2	1	0.4%	50.0%
	Total:	295	237	100.0%	
West (n=58)	Crabs	6	0	0.0%	0.0%
	Turtle	8	0	0.0%	0.0%
	Bird	26	7	12.1%	26.9%
	Domestic turkey	14	7	12.1%	50.0%
	Opossums	10	1	1.7%	10.0%
	Armadillo	6	0	0.0%	0.0%
	Bats	6	0	0.0%	0.0%
	Primates	2	0	0.0%	0.0%
	Dogs	4	3	5.2%	75.0%
	Cats	3	1	1.7%	33.3%
	Raccoons	3	2	3.4%	66.7%
	Baird's tapir	11	1	1.7%	9.1%
	Artiodactyls	163	26	44.8%	16.0%
	Peccary	25	5	8.6%	20.0%
	Deer	138	21	36.2%	15.2%
	White-tailed deer	114	17	29.3%	14.9%
	Brocket deer	16	3	5.2%	18.8%
	Rodent	20	13	22.4%	65.0%
	Agouti and paca	25	3	5.2%	12.0%
	Rabbit	2	1	1.7%	50.0%
	Total:	295	58	100.0%	

Table 7-16. Separation of Space Summaries for Light versus Dark Regions at Naj Tunich, Guatemala.

Region of the cave (n=295)	Gentaxa	Total NISP	NISP per Region	% NISP per Region	% NISP per Total NISP
Light (n=58)	Crabs	6	0	0.0%	0.0%
	Turtle	8	0	0.0%	0.0%
	Bird	26	5	8.6%	19.2%
	Domestic turkey	14	2	3.4%	14.3%
	Opossums	10	0	0.0%	0.0%
	Armadillo	6	0	0.0%	0.0%
	Bats	6	3	5.2%	50.0%
	Primates	2	2	3.4%	100.0%
	Dogs	4	1	1.7%	25.0%
	Cats	3	0	0.0%	0.0%
	Raccoons	3	0	0.0%	0.0%
	Baird's tapir	11	3	5.2%	27.3%
	Artiodactyls	163	26	44.8%	16.0%
	Peccary	25	9	15.5%	36.0%
	Deer	138	17	29.3%	12.3%
	White-tailed deer	114	14	24.1%	12.3%
	Brocket deer	16	0	0.0%	0.0%
	Rodent	20	14	24.1%	70.0%
	Agouti and paca	25	3	5.2%	12.0%
	Rabbit	2	1	1.7%	50.0%
	Total:	295	58	100.0%	
Dark (n=237)	Crabs	6	6	2.5%	100.0%
	Turtle	8	8	3.4%	100.0%
	Bird	26	21	8.9%	80.8%
	Domestic turkey	14	12	5.1%	85.7%
	Opossums	10	10	4.2%	100.0%
	Armadillo	6	6	2.5%	100.0%
	Bats	6	3	1.3%	50.0%
	Primates	2	0	0.0%	0.0%
	Dogs	4	3	1.3%	75.0%
	Cats	3	3	1.3%	100.0%
	Raccoons	3	3	1.3%	100.0%
	Baird's tapir	11	8	3.4%	72.7%
	Artiodactyls	163	137	57.8%	84.0%
	Peccary	25	16	6.8%	64.0%
	Deer	138	121	51.1%	87.7%
	White-tailed deer	114	100	42.2%	87.7%
	Brocket deer	16	16	6.8%	100.0%
	Rodent	20	6	2.5%	30.0%
	Agouti and paca	25	22	9.3%	88.0%
	Rabbit	2	1	0.4%	50.0%
	Total:	295	237	100.0%	

Table 7-17. Summary of NISP, % Taxa, Left Sided Elements, Body portions, % NISP Burned, Spatial Auto Correlation and Cokriging at Naj Tunich, Guatemala.

Taxonomic Group	NISP (n=295)	% Taxa	% of Left sided elements	Body Portion comment	% NISP Burned	Spatial Autocorrelation	Cokriging
Crabs	6	2.0%	N/A	6, 100% claws	1/6, 16.7%	Clustering, random chance	Didn't run
Turtle	8	2.7%	N/A	6, 75% carapace, 2, 25% long bones	None	Didn't run	Didn't run
Bird	26	8.8%	5/15 = 33.3%	1 Cranial, 4 coracoid, 1 keel, 4 humerus, 2 radius, 4 femur, 4 tibiotarsus, 1 phalanx, 5 UID	3/26, 11.5%, blackened	Random, neither clustered nor dispersed	concentrated around IV 3
		4.7%	5/14 = 35.7%	3 coracoid, 2 humerus, 2 radius, 3 femur, 4 tibiotarsus	3/14, 21.4%, blackened	Random, neither clustered nor dispersed	Didn't run
Domestic turkey	14	3.4%	4/9 = 44.4%	1, 10% maxilla, 4, 40% mandible, 1, 10% molar, 2, 20% scapula, 2, 20% humerus	None	Clustering, random chance	Didn't run
Opossums	10	2.0%	3/5 = 60%	1, 16.7% cranium, 1, 16.7% humerus, 1, 16.7% ulna, 2, 33.3% femur, 1, 16.7% tibia	None		Didn't run
Armadillo	6	2.0%	2/4 = 50%	2, 33.3% cranium, 2, 33.3% radius, 1, 16.7% ulna, 1, 16.7% metapodial	None	Didn't run	Didn't run
Bats	6	0.7%	2/2 = 100%	humerus and tibia	1/2, 50% blackened	Didn't run	Didn't run
Primates	2	1.4%	2/2 = 100%	1, 25% premolar, 1, 25% radius, 1, 25% ulna, 1, 25% metapodial	None	Didn't run	Didn't run
Dogs	4	1.0%	1/3 = 33.3%	1, 33.3% radius, 1, 33.3% humerus, 1, 33.3% metapodial	None	Didn't run	Didn't run
Cats	3	1.0%	2/3 = 66.7%	1, 33.3% radius, 1, 33.3% scapula, 1, 33.3% femur	None	Didn't run	Didn't run
Raccoons	3	3.7%	2/2 = 100%	1, 9.1% atlas vertebra, 1, 9.1% coccyx, 1, 9.1% scapula, 1, 9.1% humerus, 2, 18.2% carpal/ tarsal, 3, 27.3% metapodial, 2, 18.2% long bone	1/11, 9.1% blackened	Random, neither clustered nor dispersed	Didn't run
Baird's tapir	11						

Table 7-17 Continued.

Taxonomic Group	NISP (n=295)	% Taxa	% of Left sided elements	Body Portion comment	% NISP Burned	Spatial Autocorrelation	Cokriging
		55.3%	60/118 = 50.8%	23, 14.1% cranial, 46, 28.2% axial, 9, 5.5% axial-pectoral, 4, 2.5% axial-pelvic, 33, 20.2% front limb, 41, 25.2% hind limb, 7, 4.3% distal	34/163, 20.9%		conc Lots 44 +18
Artiodactyls	163					Clustering, 5-10% chance it was random	
		8.5%	3/11 = 27.3%	cranial (n=5, 20%), axial (n=6, 24%), front limb (n=9, 36%), hind limb (n=4, 16%), metapodial (n=1, 4%)	2/25, 8%		conc Lots 1, 16, 24, + 57
Peccary	25					Random, neither clustered nor dispersed	
		46.8%	40/78 = 51.3%	18, 13% cranial, 42, 30% axial, 7, 5.1% pectoral, 4, 2.9% pelvic, 24, 17.4% front limb, 37, 26.8% hind limb, 6, 4.3% distal	32/138, 23.2%	Clustering, 5-10% chance it was random	conc Lots 44 + 16
Deer	138						
		38.6%	25/62 =	14, 12.3% cranial, 51, 44.7% axial, 19, 16.7% front limb, 27, 23.7% hind limb, 3, 2.6% distal	20/114, 17.5%	Clustering, random chance	conc Lots 16, 18, and 42
White-tailed deer	114					Random, neither clustered nor dispersed	Didn't run
		5.4%	3/11 = 27.3%	3, 18.8% cranial, 1, 6.3% axial pectoral, 2, 12.5% front limb, 7, 43.8% hind limb, 3, 18.8% distal	4/16, 25%		
Brocket deer	16						
		6.8%	6/17 = 35.3%	3, 15% mandible, 3, 15% cranium, 1, 5% innominate, 4, 20% humerus, 4, 20% femur, 5, 25% tibia	None	Random, neither clustered nor dispersed	Didn't run
Rodent	20						
		8.5%	6/14 = 42.9%	11, 44% cranial, 4, 16% axial, 4, 16% front limb, 6, 24% hind limb	2/25, 8%		L/R, N/S, E/W conc Lot 57 and 1, Light/Dark Lots 57, 1, 16, and 42
Agouti and paca	25					Random, neither clustered nor dispersed	
Rabbit	2	0.7%	0/2 = 0%	1 tibia, 1 humerus	None	Didn't run	Didn't run

CHAPTER 8 CONCLUSIONS

Trends

The spatial patterning of faunal remains in ancient Maya cave site was tested using both GIS and visual analysis of the remains. Working under the theoretical framework of cognitive archaeology, I attempted to correlate spatial distributions of animal remains in these ritual landscapes to models of the cognized Maya universe, and thereby understand more fully the ancient Maya mind. I hypothesized that the distribution of faunal remains in the caves was caused by the ritual use of specific regions of the caves for certain activities associated with the symbolic meaning of those ritual spaces in the cognized universe or symbolic landscape of the Maya. The distinct placement of faunal remains as part of cave rituals could possibly be traced back to repeated ritual behaviors. However, do to the small sample sizes and limited distribution of remains there were few links identified to the ritual placement of faunal remains within the caves.

The patterns that I identified by this analysis included the use of the north/east/light areas of the cave for crab deposition, possibly linked to the symbolic association of crabs and water within the caves. The large amount of unburned turtle shell remains within the site may be an indication of these remains being used as instruments or offerings of instruments within the caves. Peccary remains were also found to contain more limb than cranial elements in the cave sites. This may have been due to the fact that carvings of peccary skulls were highly valued at above ground elite residences. A higher concentration of deer limbs, or haunches, was identified at three out of the five sites and maybe an indication of ritual offerings of these very sacred parts of the body. Squirrel remains were only identified in one cave site. However, their placement

within the eastern part of the cave mirrors the codices and ethnographic accounts for squirrel offerings during the Muluc New Years ceremonies (Love 1986; Tozzer 1941).

No patterning was found for ray-finned fishes, amphibians, snakes, birds, opossums, armadillos, primates, tapir, raccoons, rodents, agoutis and pacas, and cottontail rabbits. Snakes, amphibians, raccoons, rodents, agouti and pacas, and cottontail rabbits may represent inhabitants of the caves or may have been not used by the ancient Maya for ritual offerings. Since the bird remains were identified to the class of Aves and not to individual families, patterning for those birds not normally living in caves could not be defined as Brady (1989) was able to accomplish within Naj Tunich. Opossums were located mainly in the light and open regions of the cave which is where they would naturally occur. Armadillos identified at the cave sites might represent natural inclusions, since armadillos are known inhabitants and burrowers of soils in or around the cave sites in this study. The low number of primates and tapirs also seem strange considering their high prevalence in the forested habitats of all of the caves.

Some expected species were missing, suggesting another form of patterning. There was a lack of lizard, or iguana, remains at all the cave sites which may be due to the use of iguana breads or tamales as offerings (Bricker 1991; Taube 1988; Thompson 1972). The cooking of these bones may have lessened their chance for preserving within the cave sites. Bat remains were only found at Cueva de El Duende in large quantities which would have been expected at all cave sites. The finding of 7 left sided remains at Stela Cave in the Chamber 1 is also a strange anomaly considering bats are known to live in Chamber 3, located in the dark and restricted part of the cave. The lack of canid remains at many of the cave sites is a surprising finding, since dogs are well known ritual offerings to the ancient Maya. There were also a low number of felid

remains, which would have been expected to be in larger numbers since caves have been identified at the main place for the accession rituals for Maya royalty (Brady 1989).

Limitations

The patterning revealed in this study was not easily quantified, nor was it statistically verifiable. There are four major reasons for the inability to clearly quantify or verify specific patterns for the distribution of animal remains within these five Maya cave sites.

The first limitation on the analysis of the faunal remains at these sites was the mixture of both a small sample size for most of the taxonomic groups and also the limited distribution of the excavation units across the cave surfaces. GIS was used to help model and analyze the patterns that may have formed from the spatial relationship of remains with these cave sites. However, the small samples for many of the taxonomic groups did not allow spatial autocorrelation to process the findings. There were issues with the results from those that could be processed since many of the samples were identified as random despite a visual assessment of patterning, suggesting that sample size was again impacting the GIS results. Cokriging was another GIS spatial analysis tool that could not be used at all in three sites and provided results only for rare groups for the other caves, again because of limited distributions at the other caves.

A more complete collection process and robust sampling strategy would have helped with the overall distribution of faunal remains; however, even these improvements may not have increased the number of faunal remains recovered from each site. In addition, many of the samples collected were from surface collections. This is because there were rarely deep contexts to excavate at many of these cave sites. The lack of stratigraphic samples does not allow for specific chronological samples to be analyzed and the remains might represent multiple occupation periods. This is problematic because ritual practice and beliefs were undoubtedly not stagnant over the entire 2000 years of Maya occupation and use of the region. All of the sites

date to part of the Preclassic period, but most of the artifacts, ceramics, were from the Early to Late Classic at the sites.

Finally, differential excavation and faunal material recovery methods caused variations between sites. At the site of Cueva de Sangre there were a few assemblages recovered by the deflocculation of 1 meter by 1 meter soil samples. These samples produced the largest amounts of faunal remains at the site of CS and most of the findings were from these large soil samples. The findings at Naj Tunich were from surface collections. The other sites, CBR, and STC were excavated using ¼” screens. For both CS and CD, I am unsure of the specific recovery methods used; although I would expect ¼” screening was used. Screening and collection methods would impact many of the small animal findings, including rodent and bat remains. The collection methods may be one of the reasons for the lack of bat remains at all of the sites except for CD.

The second limitations on the results from this study are due to the taphonomic processes that occur in cave sites. Some taphonomic processes that may have caused the movement of remains within the caves are seasonal flooding and runoff from these flooding events. The caves with seasonal flooding and run-off include Caves Branch Rockshelter, Cueva de El Duende, and Cueva de Sangre. Stela Cave was identified as being relatively dry; however, this site was excavated before the rainy season and may in fact be affected by run-off. There were also indications at CBR that taphonomic disturbances may have been caused by the burrowing of armadillos at the site (Wrobel and Taylor 2006). Research has found that artifacts can be highly impacted by the movement of armadillo burrowing (Araujo and Marcelino 2003). Other taphonomic disturbances identified at most of the sites, except for Cueva de Sangre and Naj Tunich was looting. There were looters pits identified in Caves Branch Rockshelter which were

found during the excavation of this site and areas of human-induced disturbances were found in Stela Cave and Cueva de El Duende.

Other taphonomic processes that may have affected the deposition of animal remains within these cave sites are the cultural filters of animal remains over time. The Maya may have used the caves for areas of sacrificial offerings; however, the consumption and subsequent deposition of these remains may have been outside of the cave. The offering of specific species within the caves may have occurred but their consumption in other areas would make these events untraceable in the archaeological record. Therefore, the patterning and use of specific animals with directional associations, sidedness, or light and dark regions of the cave could be lost in the faunal assemblages. The same can also be said of the cave inhabitants and the distribution of their remains which may have been more culturally than naturally dispersed. The types of offerings depicted in the Maya codices of faunal remains are usually in the form of animal breads or tamales. The cooking of the hard parts of faunal remains will breakdown or disintegrates after these remains are cooked.

The third source of bias in the analysis of the faunal remains from these five cave sites may be due to the different shapes of these caves. Caves Branch Rockshelter was a large rockshelter area with a small cave. The rockshelter contained a well known drip zone that may have caused runoff at the site. Cueva de Sangre was a 3.5 km multiple tunnel system that did not allow for easy separations of spaces within the cave. Naj Tunich was the largest cave in this study, and Operation IV was located at the mouth of this cave system, which would have left the site open to the elements and natural deposits of animal remains at the site. Stela Cave and Cueva de El Duende were both relatively small in size and contained large open chambers with smaller back chambers, therefore over representing materials from the light and open spaces. All of these

varying sized caves were split into different spatial categories based on the availability of space and the placement of excavation units at these sites.

The final difficulty with this analysis was the differential use of these cave sites. This analysis relies on the assumption that all the caves would have been used for the same ritual purposes and therefore that the spatial distributions would be consistent between caves. However, this was not likely the case and this study highlights the difficulty of comparing different areas even within a broad “ritual” subgroup. CBR is a rockshelter that served as an ancient Maya cemetery. The soil within this site was mixed grave fill and the site has been identified as a non-elite burial ground that may have been closely associated with a few mounds located in front of the rockshelter. Stela Cave contains a chamber with modified architectural material, including a possible stela or altar, and therefore may have served a function as a non-elite area for cave rituals. Cueva de Sangre and Cueva de El Duende are both located at the large site of Dos Pilas. These two caves had limited access and have been described as elite cave contexts. Finally, the site of Naj Tunich, the largest cave site known in the Maya region, has been identified as an elite pilgrimage site because of the multitude of cave painting and hieroglyphics at the site. As archaeologists we hope that the rituals and cognitive worldviews of ancient people are stable, but in reality, they are a dynamic part of a people and the changes in ritual behaviors are large scale and vary over time.

While the variations of sample size, excavation strategy, and recovery methods may have limited the ability of this analysis to discern specific patterning. The different uses and spatial layout between all of these caves may actually be the best indicators to understand the varied distribution of faunal remains at all of these sites. It may be that different caves were used in different ways and for different types of rituals, perhaps all associated with the Maya universe,

but likely all representing that universe in different ways. The role in determining the spatial distributions may be affected by such differences as the status of the group using the site, the time period during which it was used, and even the season of the year it was used.

Recommendations

This research project provided the framework for conducting a future study involving the spatial distribution of faunal and other artifactual materials in both cave settings and also surface sites. The use of zooarchaeology and GIS in combination allows for both the analysis of spatial patterns and production of georeferenced databases with information that can be added to as research continues in the Maya region. In a future study there are recommendations I have for preparing a project for the analysis of faunal remains and GIS. The inclusion of GIS at the onset of a research project would help in the digitizing of cave site maps and would allow for a more three-dimensional perspective. With that said, the use of a one meter by one grid system, like the one used at CBR, allows for a more precise collection method. Collection methodologies in cave sites should be expanded to take the spatial distribution of remains into account. The expansion of collection areas may also increase the amount of animal remains identified at the sites.

Summary

To the Maya, layering and directionality played an important part of their worldview. The layering of caches by the Maya may have represented their world and parts of their defined universe. The directional placement of buildings within sites, ceremonial events at specific directions, and the placement of these caches in specific directions all reinforced the ancient Maya world. The Maya worldview has been defined in relation to sidedness, directionality, and the use and access to space. Caves represented a microcosm for these worldviews and with their known associations with ritual behavior can serve as a model for understanding ancient Maya rituals. Animals and animal remains have always played a role in these rituals. Using GIS and

faunal remains in caves was attempted to identify and understand the ritual use of animal in relation to the relationships of sidedness, directionality, and access to space. Hopefully future research studies are able to incorporate and identify the pattern of faunal remains in cave so that we can further understand the ancient Maya mind.

LIST OF REFERENCES

- Anderson, Elyse
2009 *Exploring Maya Ritual Fauna: Caves and the Proposed Link with Contemporary Hunting Ceremonialism*. MA thesis. University of Florida.
- Anschuetz, Kurt F., Wilshusen, Richard H. and Cherie L. Scheick
2001 An Archaeology of Landscapes: Perspectives and Directions. *Journal of Archaeological Research*. 9(2):157-211.
- Araujo, Astolfo G. Mello and Jose´ Carlos Marcelino
2003 The Role of Armadillos in the Movement of Archaeological Materials: An Experimental Approach. *Geoarchaeology*. 18(4): 433–460.
- Arata, Sean T.
2008 *Isla Cilvituk: Finding Primary Contexts using GIS*. Anthropology Department. Las Cruces, New Mexico, New Mexico State University: 244.
- Ashmore, Wendy
1989 Construction and cosmology: Politics and ideology in lowland Maya settlement patterns. In *Word and Image in Maya Culture: Explorations in Language, Writing and Representation*, edited by Hanks, W. F., and Rice, D. S., pp. 272–286. University of Utah Press, Salt Lake City.
1991 Site-planning principles and concepts of directionality among the ancient Maya. *Latin American Antiquity* 2: 199–226.
2002 ‘Decisions and dispositions’: Socializing spatial archaeology. *American Anthropologist*. 104: 1172–1183.
- Ashmore, Wendy and Jeremy A. Sabloff
2002 Spatial orders in Maya civic plans. *Latin American Antiquity* 13: 201–215.
- Awe, Jaime J.
1998 The Western Belize Regional Cave Project: Objectives, Context, and Problem Orientation. In *The Western Belize Regional Cave Project: A Report of the 1997 Field Season*, edited by J. J. Awe, pp. 1-22, Department of Anthropology, Occasional Paper No. 1, University of New Hampshire, Durham.
- Awe, Jaime J., Sherry Gibbs, and Cameron Griffith
2005 Stelae and Megalithic Monuments in the Caves of Western Belize. In *In the Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by James E. Brady and Keith M. Prufer, pp. 223-248, University of Texas Press, Austin.
- Baker, Mary
1992 Capuchin Monkeys (*Cebus capucinus*) and the Ancient Maya. *Ancient Mesoamerica*. 3:219-228.
- Beaubien, Harriet F.

- 2004 Excavation and Recovery of a Funerary Offering of Marine Materials from Copan. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery. Institute of Archaeology, UCLA Press, Los Angeles.
- Belli, Francisco E.
1999 *The archaeology of complex societies in southeastern Pacific coastal Guatemala: a regional GIS approach*. Oxford: British Archaeological Reports.
- Bender, Barbara
2002 Landscape. *Encyclopedia of Social and Cultural Anthropology*, edited by A. Barnard and J. Spencer, pp. 323-324. New York: Routledge.
- Bill, Cassandra R., Hernández, Christine L. and Victoria R. Bricker
2000 The Relationship Between Early Colonial Maya New Year's Ceremonies and Some Almanacs in the *Madrid Codex*. *Ancient Mesoamerica*, 11:149–168.
- Binford, Lewis R.
1962 Archaeology is Anthropology. *American Antiquity*. 28(2):217-225.
- Bonor Villarejo, Juan Luis
1998 Caves Branch Caves: Archaeological Field Report. FAMSI website. 8 December 2008 <<http://www.famsi.org/reports/96044/>>.
2003 Caves Branch Caves, Distrito de El Cayo, Belice. Reporte Arqueológico de Campo. FAMSI website. 8 December 2008 <<http://www.famsi.org/reports/96044es/>>.
- Brady, James E.
1989 *Investigation of Maya Ritual Cave Use with Special Reference to Naj Tunich, Peten, Guatemala*. PhD Dissertation, Department of Anthropology. Los Angeles, University of California.
1990 Investigaciones en la Cueva de la Sangre y Otras Cuevas de la Región de Petexbatun. In: Demarest AA, Houston SD, editors. Proyecto Arqueológico Regional Petexbatun. Informe Preliminar #2, Segunda Temporada 1990. Nashville, TN: Vanderbilt University Press. p 438-490.
1991 Caves and Cosmovision at Utatlan. *California Anthropologist*. 18(1):1–10.
1997 Settlement Configuration and Cosmology: The Role of Caves at Dos Pilas. *American Anthropologist*, New Series, 99(3):602-618.
2000 Early Political Appropriation of the Sacred Landscape. In *The Sacred and the Profane: Architecture and Identity in the Maya Lowlands*, edited by Pierre Robert Colas, Kai Delvendahl, Marcus Kuhnert, Annette Schubart, pp. 129-136. Acta Mesoamericana 10.
2003 In My Hill, In My Valley: The Importance of Place in Ancient Maya Ritual. In *Mesas and Cosmology in Mesoamerica*, edited by Douglas Sharon, pp. 83-91. San Diego Museum Papers 42. San Diego Museum of Man, San Diego.
2005 The Impact of Ritual on Ancient Maya Economy. In *Stone Houses and Earth Lords: Maya Religion in the Cave Context*, K. M. Prufer and J. E. Brady, pp. 115-134. Boulder, University Press of Colorado.

- Brady, James E. and Wendy Ashmore
 1999 Mountains, Caves, Water: Ancient Maya ideational landscapes. In *Archaeologies of Landscapes: Contemporary Perspectives*, edited by Ashmore, W., and Knapp, A. B., pp. 124–148. Malden, Mass.: Blackwell Publishers.
- Brady, James E., Luin, Fernando, Wright, Lori, Foncea, Carol, and Sandra Villagran De Brady
 1992 Descubrimientos recientes en la Cueva de Sangre de Dos Pilas. In *Simposio de Investigaciones Arqueológicas en Guatemala (4 session, 1990)*. pp. 153-168. Ministerio de Cultura y Deportes; Instituto de Antropología y Etnología e Historia., Guatemala
- Brady, James E., Luin, Fernando, Foncea, Carol, Wright, Lori, and Sandra Villagran De Brady
 1990 Investigaciones en la Cueva de Sangre y otras cuevas de la región de Petexbatún. In *El Proyecto Arqueológico Regional Petexbatún: Informe Preliminar 2*. Edited by Arthur A. Demarest and Stephen D. Houston, eds. pp. 438-566. Instituto Nacional de Antropología e Historia de Guatemala, Guatemala
- Brady James E. and Keith M. Prufer
 2005a *In The Maw of the Earth Monster: Mesoamerican Ritual Cave Use*. The Linda Schele Series in Maya and Pre-Columbian Studies. University of Texas Press, Austin.
- 2005b Introduction: A History of Mesoamerican Cave Interpretations. In *In the Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by J. E. Brady and K. M. Prufer, pp. 1-17. Austin, University of Texas Press.
- Brady, James E. and Irma Rodas
 1992 Hallazgos recientes y nuevas interpretaciones de la Cueva de El Duende, Petén. En *V Simposio de Investigaciones Arqueológicas en Guatemala, 1991* (editado por J.P. Laporte, H. Escobedo y S. Brady), pp.169-176. Museo Nacional de Arqueología y Etnología, Guatemala.
- Brady, James E., Rodas, Irma, Wright, Lori, Emery, Katherine, Lopez, Nora Maria, Stiver, Laura, and Robert Chatham
 1991 Proyecto Arqueologico regional de Cueva Petetabatun. In *El Proyecto Arqueológico Regional Petexbatún: Informe Preliminar 3*. Edited by Arthur A. Demarest, Takeshi Inomata, Hector Escobedo, and Joel Palka, pp. 652-748. Instituto Nacional de Antropología e Historia de Guatemala, Guatemala
- Brady, James E. and Ann Scott
 1997 Excavation of Buried Cave Deposits: Implications for Interpretations. *Journal of Cave and Karst Studies*. 59(1): 15-21.
- Brady, James E., Scott, Ann Cobb, Allan Rodas, Irma Fogarty, John, and Monica Urquizu Sanchez
 1997 Glimpses of the Dark Side of the Petexbatun Project: The Petexbatun Regional Cave Survey. *Ancient Mesoamerica*. 8:353-364.
- Bricker, Victoria R.

- 1983 Directional Glyphs in Maya Inscriptions and Codices. *American Antiquity*. 48(2):347-353.
- 1991 Faunal Offerings in the Dresden Codex. In *Sixth Palenque Round Table, 1986*, edited by Merle Greene Robertson and Virginia M. Fields, pp. 285-292. University of Oklahoma Press, Norman.
- 1997 The Structure of Almanacs in the Madrid Codex. In *Papers on the Madrid Codex*, edited by Victoria R. Bricker and Gabrielle Vail, pp. 1-25. Middle American Research Institute, Pub. 64. Tulane University, New Orleans.

Brown, Linda A.

- 2000 From Discarded to Divination: Demarcating the Sacred through the Collection and Curation of Discarded Objects. *Latin American Antiquity*. 11(4): 319-334.
- 2004 Dangerous Places and Wild Spaces: Creating Meaning with Materials and Space at Contemporary Maya Shrines on El Duende Mountain. *Journal of Archaeological Method and Theory*. 11(1):31-58.
- 2005 Planting the Bones: Hunting Ceremonialism at Contemporary and Nineteenth-Century Shrines in the Guatemalan Highlands. *Latin American Antiquity* 16(2):131-146.

Brown, Linda A. and Kitty Emery

- 2008 Negotiations with the Animate Forest: Hunting shrines in the Guatemalan Highlands. *Journal of Archaeological Method and Theory*. 15:300-337.

Bruchez, Margaret Sabom

- 2007 Artifacts that speak for themselves: Sounds under afoot in Mesoamerica. *Journal of Anthropological Archaeology*. 26:47-64.

Chase, Diane Z., and Arlen F. Chase

- 1998 The Architectural Context of Caches, Burials, and Other Ritual Activities for the Classic Period Maya (as Reflected at Caracol, Belize). In *Function and meaning in classic Maya architecture: a symposium at Dumbarton Oaks, 7th and 8th October 1994*, edited by Stephen D. Houston, pp. 299-332. Washington, DC: Dumbarton Oaks Research Library and Collection

Coggins, Clemency C.

- 1980 The Shape of Time: Some Political Implications of a Four-Part Figure. *American Antiquity* 45(4):727-738.

Ebert, David

- 2004 Applications in archeological GIS, *Canadian Journal of Archaeology*, 28, 219-41.

Emery, Kitty F.

- 1997 *The Maya Collapse: A Zooarchaeological Investigation*. PhD dissertation, Anthropology, Cornell University. 656 pp.
- 2003 The Noble Beast: Status and Differential Access to Animals in the Maya World. *World Archaeology*. 34(3): 498-515.

- 2004a Maya Zooarchaeology: Historical Perspectives on Current Research Directions. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by F. Emery, pp. 1-12. Los Angeles, Cotsen Institute of Archaeology, University of Los Angeles.
- 2004b Maya Zooarchaeology: In Pursuit of Social Variability and Environmental Heterogeneity. In *Continuities and Changes in Maya Archaeology: Perspective at the millennium*, edited by C.W. Golden and G. Borgstede, pp. 309-333. New York: Routledge.
- 2004c Animals from the Maya Underworld: Reconstructing Elite Maya Ritual at the Cueva de los Quetzales, Guatemala. *Behaviour Behind Bones: The Zooarchaeology of Ritual, Religion, Status, and Identity*, edited by S. J. O'Day, W. Van Neer and A. Ervynck, pp. 101-113. Oxford, Oxbow Books.
- 2004d Tropical Zooarchaeology: An Introduction to the Themes and Issues. *Archaeofauna*.13: 7-10.
- 2004e Introduction to Maya Zooarchaeology, In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K.F. Emery, pp. xi-xiii. Los Angeles, CA: Institute of Archaeology, UCLA Press
- 2004f *Maya Zooarchaeology: New Directions in Method and Theory*. Edited volume. Cotsen Institute of Archaeology, Monograph 51. Los Angeles, CA.

Flannery, Kent V. and Joyce Marcus

- 1993 Cognitive Archaeology. *Cambridge Archaeological Journal*. 3(2):260-270.
- 1996 Cognitive archaeology. In *Contemporary Archaeology in Theory: A Reader*, edited by R.W. Preucel, I. Hodder, pp. 350-63. Oxford: Blackwell.
- 1998 Cognitive archaeology. In *Reader in Archaeological Theory: Post-processual and cognitive approaches*, edited by D.S. Whitley, pp. 35-48. New York: Routledge.

Fogelin, Lars

- 2007 The Archaeology of Religious Ritual. *Annual Review of Anthropology*. 36:55-71.

Garcia-Zambrano, Angel J.

- 1994 Early Colonial Evidence of Pre-Columbian Rituals of Foundation. In *Seventh Palenque Round Table, 1989*, edited by Merle Greene Robertson and Virginia M. Fields, pp. 217-227. The Pre-Columbian Art Research Institute, San Francisco.

Glassman, David M. and Juan Luis Bonor Villarejo

- 2005 Mortuary Practices of the Prehistoric Maya from Caves Branch Rock Shelter, Belize. *Stone Houses and Earth Lords: Maya Religion in the Cave Context*, edited by Keith M. Prufer and James E. Brady, pp. 285-296. University Press of Colorado, Boulder.

Grayson, Donald K.

- 1984 *Quantitative Zooarchaeology*. New York: Academic Press.

Griffith, Cameron and Christophe G. B. Helmke

- 2000 Preliminary Investigation and GIS Spatial Analysis in Actun Halal, Belize. In *The Western Belize Regional Cave Project: A Report of the 1999 Field Season*, edited by C. Griffith, R. Ishihara and J. J. Awe, pp. 99-114. Department of Anthropology, Occasional Paper No.3, Durham, New Hampshire, University of New Hampshire.

Halperin, Christina T.

2005 Social Power and Sacred Space at Actun Nak Beh, Belize. In *Stone Houses and Earth Lords: Maya Religion in the Cave Context*, edited by Keith M. Prufer and James E. Brady, pp. 71-90. University Press of Colorado, Boulder.

Hanks, William F.

1990 *Referential Practice: Language and Lived Space among the Maya*. University of Chicago Press: Chicago.

Healey, Paul F.

2007 The Anthropology of Mesoamerican Caves. *Reviews in Anthropology*. 36(3): 245-278.

Helmke, Christophe G.B., and Jaime J. Awe

1998 Preliminary Analysis of the Pictographs, Petroglyphs and Sculptures of Actun Uayazba Kab, Cayo District, Belize. In *The Western Belize Regional Cave Project: A Report of the 1997 Field Season*, pp.145-204, Department of Anthropology, Occasional Paper No.1, University of New Hampshire, Durham.

Heyden, Doris

1975 An Interpretation of the Cave underneath the Pyramid of the Sun in Teotihuacan, Mexico. *American Antiquity*. 40(2):131-147.

Hickman, Cleveland P.

1967 *Biology of the Invertebrates*. C.V. Mosby Company: St. Louis.

Ishihara, Reiko

2007 *Bridging the chasm between religion and politics: archaeological investigations of the grietas at the Late Classic Maya site of Aguateca, Peten, Guatemala*. Doctoral dissertation, Department of Anthropology, University of California, Riverside.

2008 Rising clouds, blowing winds: Late Classic Maya rain rituals in the Main Chasm, Aguateca, Guatemala. *World Archaeology*. 40:2:169-189.

Ishihara, Reiko and Cameron Griffith

2004 Archaeological Investigations and the Evaluation of Sacred Spaces Construction in Stela Cave, Cayo District, Belize. *The Belize Valley Archaeological Reconnaissance Project: A Report from the 2003 Field Season* (eds C. M. Audet and J. J. Awe) pp. 56-75.

Knapp, A. Bernard and Wendy Ashmore (eds)

1999 Archaeological Landscapes: Constructed, Conceptualized, Ideational. In *Archaeologies of Landscape: Contemporary Perspectives*, edited by W. Ashmore and A.B. Knapp, pp. 1-30. Malden, Massachusetts: Blackwell Publishers.

Kozelsky, Kristin Linda

2005 *Identifying social drama in the Maya region: Fauna from the Lagartero Basurero, Chiapas, Mexico*. unpublished MA Thesis (Anthropology), Florida State University, Tallahassee.

- Kunen, Julie L., Galindo, Mary Jo and Erin Chase
 2002 Pits and Bones: Identifying Maya ritual behavior in the archaeological record. *Ancient Mesoamerica*, 13:197–211.
- Kvamme, K. L.,
 1999 Recent directions and developments in Geographical Information Systems, *Journal of Archaeological Research*, 7:153–201.
- Marciniak, Arkadiusz
 1999 Faunal Materials and Interpretive Archaeology – Epistemology Reconsidered. *Journal of Archaeological Method and Theory*. 6(4): 293-320.
- Marín Arroyo, Ana Belen
 2009 Assessing What Lies beneath the Spatial Distribution of a Zooarchaeological Record: The use of GIS and spatial correlations at El Miron Cave (Spain). *Archaeometry*. 51(3):506-524.
- Mathews, Jennifer P. and James F. Garber
 2004 Models of Cosmic Order: Physical expression of sacred space among the ancient Maya. *Ancient Mesoamerica*. 15(1):49-59.
- McBee, Karen and Robert J. Baker
 1982 *Dasyus novemcinctus*. *Mammalian Species* 162:1-9.
- McNatt, Logan
 1996 Cave Archaeology of Belize. *Journal of Cave and Karst Studies* 58(2):81-99.
- Minjares, Amador, Jr.
 2003 Human Skeletal Remains from the Ancient Maya in the Caves of Dos Pilas, Guatemala. Masters Thesis. Texas A&M University
- Moholy-Nagy, Hattula
 2004 Vertebrates in Tikal Burials and Caches. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by F. Emery, pp. 193-205. Los Angeles, Cotsen Institute of Archaeology, University of Los Angeles.
- Moyes, Holley
 2001 *The Cave as a Cosmogram: The Use of GIS in an Intrasite Spatial Analysis of the Main Chamber of Actun Tunichil Muknal, A Maya Ceremonial Cave in Western Belize*, Master's Thesis, Florida Atlantic University.
 2002 The Use of GIS in the Spatial Analysis of an Archaeological Cave Site. *Journal of Cave and Karst Studies* 64(1):9-16.
 2005 Cluster Concentrations, Boundary Markers, and Ritual Pathways: A GIS Analysis of Artifact Cluster Patterns at Actun Tunichil Muknal, Belize. In *In The Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by J. E. Brady and K. M. Prufer, pp.

269-300. The Linda Schele Series in Maya and Pre-Columbian Studies. University of Texas Press, Austin.

Moyes, Holley and Jaime J. Awe

1998 Spatial Analysis of Artifacts in the Main Chamber of Actun Tunichil Muknal, Belize: Preliminary Results. In *The Western Belize Regional Cave Project: A Report of the 1997 Field Season*, edited by J. J. Awe., pp. 23-36. Department of Anthropology, Occasional Paper No. 1, University of New Hampshire, Durham.

Nardini, Alessandra and Frank Salvadori

2003 A GIS Platform Dedicated to the Production of Models of Distribution of Archaeo(zoo)logical Remains. *Archaeofauna*. 12:127-141.

Palka, Joel W.

2002 Left/Right Symbolism and the Body in Ancient Maya Iconography and Culture. *Latin American Antiquity*. 13(4):419-443.

Pendergast, David M.

1969 *The Prehistory of Actun Balam, British Honduras*. Art and Archaeology Occasional Paper No. 16. Royal Ontario Museum, Toronto.

1971 *Excavations at Eduardo Quiroz Cave, British Honduras (Belize)*. Art and Archaeology Occasional Paper No. 21. Royal Ontario Museum, Toronto.

1974 *Excavations at Actun Polbilche, Belize*. Royal Ontario Museum Monograph 1. Toronto.

Peterson, Polly Ann

2006 *Ancient Maya ritual cave use in the Sibun Valley, Belize*. Doctoral dissertation, Department of Archaeology, Boston University, Boston, Massachusetts.

Pohl, Mary D.

1981 Ritual Continuity and Transformation in Mesoamerica: Reconstructing the Ancient Maya Cuch Ritual. *American Antiquity*. 46(3): 513-529.

1983 Maya Ritual Faunas: Vertebrate Remains from Burials, Caches, Caves, and Cenotes in the Maya Lowlands. In *Civilization in the ancient Americas: essays in honor of Gordon R. Willey*, edited by R. M. Leventhal and A. L. Kolata, pp. 55-103. Albuquerque, N.M., University of New Mexico Press.

Preucel, Robert W.

2006 *Archaeological Semiotics*. Oxford: Blackwell Publishing.

Prufer Keith M. and James E. Brady

2005a Concluding Comments. In *In the Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by J. E. Brady and K. M. Prufer, pp. 403-411. Austin, University of Texas Press.

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

Pugh, Timothy W.

- 2001 Flood Reptiles, Serpents Temples, and the Quadripartite Universe: The Imago Mundi of Late Postclassic Mayapan. *Ancient Mesoamerica*. 12:247–258.
- 2005 Caves and Artificial Caves in Late Postclassic Maya Ceremonial Groups. In *Stone Houses and Earth Lords: Maya Religion in the Cave Context*, edited by Keith M. Prufer and James E. Brady, pp. 47-69. University Press of Colorado, Boulder.

Reitz Elizabeth J. and Elizabeth S. Wing

- 1999 [2008] *Zooarchaeology*. Cambridge: Cambridge University Press.

Renfrew, Colin

- 1993 Cognitive Archaeology: Some Thoughts on the Archaeology of Thought. *Cambridge Archaeological Journal*. 3(2):248-253.
- 1994 Towards a Cognitive Archaeology.' In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E. B.W. Zubrow pp. 3–12. Cambridge: Cambridge University Press.

Renfrew, C. and Ezra B.W. Zubrow (eds)

- 1994 *The Ancient Mind: Elements of Cognitive Archaeology*. Cambridge: Cambridge University Press.

Saturno, William A., Taube, Karl A., and David Stuart

- 2005 The Murals of San Bartolo, El Peten, Guatemala, Part 1: The North Wall. *Ancient America* 7:1-56.

Scott, Ann

- 1995 1993 Investigations in the Cueva de Sangre. In *El Proyecto Arqueológico Regional Petexbatún: Informe Preliminar 6*. Edited by Juan A. Valdés, Arthur A. Demarest and Hector Escobedo, eds. pp. 537-541. Instituto Nacional de Antropología e Historia de Guatemala, Guatemala.

Spenard, Jon

- 2006 *The Gift in the Cave for the Gift of the World: An Economic Approach to Ancient Maya Cave Ritual in the San Francisco Hill-Caves, Cancuen Region, Guatemala*. Unpublished Masters Thesis. Department of Anthropology, Florida State University, Tallahassee, Florida.

Stanchly, Norbert

- 2004 Picks and Stones May Break My Bones: Taphonomy and Maya Zooarchaeology. In *Maya Zooarchaeology: New Directions in Method and Theory*, edited by K. F. Emery, pp.35-43. Institute of Archaeology, UCLA Press, Los Angeles.

Stone, Andrea

- 1989 The Painted Walls of Xibalba: Maya Cave Painting as Evidence of Cave Ritual. In *Word and Image in Maya Culture: Explorations in Language, Writing and Representation*,

- edited by Hanks, W. F., and Rice, D. S., pp. 319-335. University of Utah Press, Salt Lake City.
- 1995 *Images from the Underworld: Naj Tunich and the tradition of Maya cave painting*. Austin: University of Texas Press.
- 1997 Regional Variation in Maya Cave Art. *Journal of Cave and Karst Studies*. 59(1):33-42.
- 2005 A Cognitive Approach to Artifact Distribution in Caves of the Maya Area. In *In The Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by J. E. Brady and K. M. Prufer, pp. 249-268. The Linda Schele Series in Maya and Pre-Columbian Studies. University of Texas Press, Austin.
- Taack, George H.
- 1973 *An Iconographic Study of Deer Hunting Scenes in Maya Painting: Codex Madrid and Vases from Calcehtok and Altun Ha*. Master's thesis, University of New Mexico, Albuquerque.
- Taube, Karl
- 1988 The Ancient Yucatec New Year Festival: The Liminal Period in Maya Ritual and Cosmology. Ph.D. diss., Yale University.
- Teeter, Wendy G.
- 2004 Conclusions: Suggesting Solutions to the Issues of Tropical Zooarchaeology. *Archaeofauna* 13: 199-202.
- Teeter, Wendy G. and Arlen F. Chase
- 2004 Adding Flesh to Bones: Using Zooarchaeology Research to Answer the Big-Picture Questions. *Archaeofauna* 13: 155-172.
- Thompson, J. Eric S.
- 1972 *A Commentary on the Dresden Codex: A Maya Hieroglyphic Book*. Memoirs of the American Philosophical Society, Vol. 93. Philadelphia.
- Tozzer, Alfred M.
- 1941 *Landa's Relación de las cosas de Yucatan*. Papers of the Peabody Museum of American Archaeology and Ethnology, Vol. 18. Harvard University, Cambridge.
- Trigger, Bruce G.
- 2006 *A History of Archaeological Thought*, 2nd edition. Cambridge: Cambridge University Press.
- Vail, Gabrielle
- 1997 The Deer-Trapping Almanacs in the Madrid Codex. In *Papers on the Madrid Codex*, edited by Victoria R. Bricker and Gabrielle Vail, pp. 73-110. Middle American Research Institute, Pub. 64. Tulane University, New Orleans.
- von Nagy, Christopher
- 1997 Some Comments on the Madrid Deer-Hunting Almanacs. In *Papers on the Madrid Codex*, edited by Victoria R. Bricker and Gabrielle Vail, pp. 27-71. Middle American Research Institute, Pub. 64. Tulane University, New Orleans.

Vogt, E. Z. and Stuart, D.

2005 Some notes on ritual caves among the ancient and modern Maya *In The Maw of the Earth Monster: Mesoamerican Ritual Cave Use*, edited by J. E. Brady and K. M. Prufer, pp. 155-85. The Linda Schele Series in Maya and Pre-Columbian Studies. University of Texas Press, Austin.

Wrobel, Gabriel D.

2008 Temporal Changes in the Mortuary Ritual Use of the Caves Branch Rockshelter, Belize.. FAMSI website. 8 December 2008
<<http://www.famsi.org/reports/07090/07090Wrobel01.pdf>>.

Wrobel, Gabriel D. and James C. Tyler

2006 Revisiting Caves Branch Rockshelter: Results of the 2005 Excavations. *The Belize Valley Archaeological Reconnaissance Project: A Report of the 2005 Field Season*, edited by Christophe G.B. Helmke & Jaime J. Awe, pp. 1-10. Institute of Archaeology, National Institute of Culture and History, Belmopan.

Zender, Marc

2006 Teasing the Turtle from its Shell: *AHK* and *MAHK* in Maya Writing. *The PARI Journal* 6(3):1-14.

Zubrow, Ezra B.W.

1994 Knowledge Representation and Archaeology: A Cognitive Example Using GIS. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E.B.W. Zubrow, pp. 107–18. Cambridge: Cambridge University Press.

BIOGRAPHICAL SKETCH

Erol Kavountzis is a native New Jerseyan who migrated south to attend the University of Florida to pursue a master's degree in anthropology. As a child visiting and living in Greece during his summers, Erol built up an appreciation for the ancient Greeks and the ocean. Although his appreciation for the ocean never changed, his interest in archaeological exploration did.

Erol graduated from Boston University (BU) in 2002 with a dual major in Archaeology and Biology with a Specialization in the Marine Sciences. During the spring of 2000, Erol went on his first archaeological excavation as a student in the Xibun Archaeological Research Project (XARP) through BU headed by Patricia McAnany and a great team of graduate students. After graduating from BU he decided to pursue a career in archaeology by working multiple jobs in Greece and Ukraine, and also within the United States, mainly in New Jersey, New York, and Pennsylvania. His interest in animal bone analysis allowed him many opportunities to work with domesticated animals within the Old World.

After a few years in the Cultural Resource Management field, Erol decided to return to graduate school to increase his knowledge in archaeology. He has spent the last few years working with Prof. Emery on multiple faunal collections from the Maya region. Erol also had a chance to work on excavations in Belize during the summer of 2007. The analysis of animal remains is an important part of his life and he hopes to one day continue his pursuit in understanding the deeper role that animals and humans both shape in the modern and ancient world.