Archaeology of Void Spaces

Cory Look

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Archaeology of Void Spaces

by
Cory Look

A dissertation submitted to the Graduate faculty in Anthropology in partial fulfillment of the requirements for the degree of Doctor of Philosophy,
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2017
Archaeology of Void Spaces

This manuscript has been read and accepted for the Graduate Faculty in Anthropology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

The overall goal of this research is to evaluate the efficacy of pXRF for the identification of ancient activity areas at Pre-Columbian sites in Antigua that range across time periods, geographic regions, site types with a variety of features, and various states of preservation. These findings have important implications for identifying and reconstructing places full of human activity but void of material remains. A synthesis for an archaeology of void spaces requires the construction of new ways of testing anthrosols, and identifying elemental patterns that can be used to connect people with their places and objects. This research begins with an exploration of rich middens in order to study void spaces. Midden archaeology has been a central focus in Caribbean research, and consists of an accumulation of discarded remnants from past human activities that can be tested against anthrosols.

The archaeological collections visited for this research project involved creating new databases to generate a comprehensive inventory of sites, materials excavated, and assemblages available for study. Of the more than 129 Pre-Columbian sites documented in Antigua, few sites have been thoroughly surveyed or excavated. Twelve Pre-Columbian sites, consisting of thirty-six excavated units were selected for study; all of which contained complete assemblages for comparison and soil samples for testing. These excavations consisted almost entirely of midden excavations, requiring new archaeological investigations to be carried out in spaces primarily void of material remains but within the village context. Over the course of three seasons excavations, shovel test pits, and soil augers were used to obtain a variety of anthrosols and archaeological assemblages in order to generate new datasets to study Pre-Columbian activity areas.

The selection of two primary case study sites were used for comparison: Indian Creek and Doigs. Findings from this research indicate that accounting for the variety of activity areas that make up a site can imbue a site with an identity of purpose and shed light on how different sites
may have served different purposes within a regional framework. Excavations at the site of Indian Creek identified a series of raised middens that enclosed an open space for approximately 1500 years. This research explores this open space, and questions the meaning of 'void' and 'empty' with respect to past human activities. While archaeologists recognize that areas void of material remains are certainly part of the larger site, the question remains, without an understand of these spaces; what aspects of past life are we possibly masking? The integration of anthrosols alongside archaeological excavations and spatial analysis indicate that the site of Indian Creek contained a ceremonial plaza that formed early on and was maintained until abandonment. The spatial distribution of material objects combined with anthrosol studies provided additional evidence of ritual deposits concentrated in one part of the plaza associated with a nearby creek-bed.

The second site, Doigs represents one of the last intact undisturbed Early Ceramic Age site of its kind in the Eastern Caribbean. Since its discovery in the 1970’s, Doig’s has been partially surveyed and excavated. The identification of residential activity areas including several potential structures, bead manufacturing loci, and cooking hearths were used to help test chemical signatures with archaeologically defined activity areas. Findings from this site illustrated the uniqueness of elemental patterns associated with activity areas, and also generated new questions regarding void spaces enriched with elemental patterns associated with concentrations of plant and vegetation debris.

It is the hope of this study to contribute to our general knowledge for the identification of ancient activity areas as well as the different places that give sites their identity. These assemblages of activity areas can provide Caribbeanists with an alternative approach to studying social organization at a village scale and generate new discussions regarding island wide-community relationships.
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Introduction

The dissertation is presented in ten chapters:

Chapter 1: Antiguan Archaeological Background and Development

The first chapter presents a discussion of the background and development of Pre-Columbian archaeology in Antigua providing the historical context for many of sites revisited and sampled for this research project.

Chapter 2: Archaeological Focus

The second chapter describes the archaeological datasets used to study anthrosols, including the categorization of different habitation loci from multi-elemental analysis and archaeological assemblages. The selection criteria for case study sites used in this research is also described.

Chapter 3: Theoretical Framework

This chapter presents the theoretical framework used for this dissertation. I discuss the necessity to reconsider our understanding of site, as well as construct a theoretical approach towards understanding the connection between ancient activity areas and place-making. Research questions and hypotheses are also presented here.

Chapter 4: Methods

An evaluation and rationale of different methods are discussed in chapter four. Instrumental analysis, particularly the limitations and practicality of using a portable x-ray flourescence (pXRF) instrument to study anthrosols is discussed. A rationale for the integration of rapid color change testing of phosphorus during the early planning phase of research is provided as well.

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Chapter 5: Establishing Baselines

This chapter provides datasets used to test causal links between material type and elemental pattern found in associated anthrosols. Elemental characterization of reference samples are presented which are used to identify elemental patterns necessary for the interpretation of chemical residues left behind from different categories of habitation loci.

Chapter 6: Data Analysis

The sixth chapter presents the findings from multi-elemental analysis of anthrosols collected from excavations, shovel test pits, and soil augering. Anthropogenic soil analysis is broken up into sites, in order to compare archaeological assemblages directly to elemental findings. Rapid color change testing of phosphorus (P-test) used during the planning phase of this research, was re-evaluated using pXRF analysis to construct quantitative ranges for each sauger.

Chapter 7: Archaeology

This chapter presents the archaeological analysis from different case study sites. Particular attention is paid to the site of Indian Creek. Archaeological assemblages available through Yale University's on-line materials database provided an opportunity to revisit, analyze, and spatially reference the distribution of special finds useful in identifying particular activity areas.

Chapter 8: Comparative Interpretation and Spatial Analysis

The eighth chapter presents new datasets generated from the integration of archaeological and elemental analysis using GIS software to spatially map models of habitation loci at Indian Creek. A discussion of void spaces and middens are drawn from ethnohistorical and ethnoarchaeological analogues for comparison to the emergence and maintenance of central plazas within a Pre-
Columbian context. Comparative analysis between the spatial proximity of special finds are compared to map models of habitation loci generating new insights into the variety of human activities practiced over space and time.

Chapter 9: Place-making in a Pre-Columbian Village

Activity loci are broken down into different types, generated from archaeological and elemental datasets generated from this research. By combining archaeologically defined activities, multielement analysis of anthrosols, and spatial analysis these different types rely on multiple threads of evidence to better characterize these spaces.

Chapter 10: Conclusions

This chapter summarizes the key findings from this research project and discusses how these findings fit into Antigua's Pre-Columbian history and what this means for the broader Caribbean. Additional findings summarize the significance and applications of how this research can be applied to cultural heritage management for the island of Antigua.
Chapter 1. Antiguan Archaeological Background and Development

Introduction

An overview for the development of Archaeological research in the Caribbean is necessary, as these interpretations are often a reflection of changing researcher preferences, traditions, and practices. This dissertation will focus on site level interpretations and then expand outwards, comparing how these new finds relate within an inter-site scale on Antigua. The data generated will be used for the broader discussion regarding the broader Caribbean.

Therefore, a brief description of local archaeological development will also be provided for further context.

1.1 Caribbean Archaeological Context

Researching the history of the Caribbean has grown increasingly more complicated over the past few decades resulting from new theoretical approaches and technological innovations; while at the same time development projects have exposed and threatened cultural heritage sites and Pre-Columbian histories throughout the region. With tourism accounting for the majority of Caribbean GDP, mounting pressure to develop historical landscapes have threatened numerous heritage sites requiring local archaeologists to seek new methods for rapid assessment and recovery. The island of Antigua is no stranger to these challenges, beginning with the island’s initiative in the 1960’s to embrace the growing tourism industry through resort development. The island contained 3 hotels in 1953, and expanded to 33 hotels by 1973 (Henry 1985:123-125). By 1971, the Antiguan Archaeological Society was tasked with the
responsibility to document and record archaeological sites throughout the islands of Antigua and Barbuda.

The first systemized efforts to record and catalogue sites originated in the 1960’s by the Antigua Archaeological Society (AAS) and local archaeologist Desmond Nicholson, whose work is now carried on and maintained by the Museum of Antigua and Barbuda in St. John’s and the Dockyard Museum in English Harbour. These early efforts relied on community members to record and note the general locations of artifacts stemming from surface deposits. Over 85 Pre-Columbian aceramic and ceramic age sites were documented during this time (Davis 1993; Murphy 1999). The first evidence of Pre-Columbian settlements in Antigua was the site of Indian Creek, discovered by a member of the AAS Ogden Starr, using a water map created for the Mill Reef Club by water diviner Kenneth Roberts (Olsen 1974) in the winter of 1955-56. Members of the AAS invited Caribbean archaeologist Dr. Irving Rouse, of Yale University to help train and guide members of the AAS in excavation and recording techniques to begin exploration of the site. Dr. Rouse began synthesizing a chronological history of Pre-Columbian settlements throughout the Caribbean using primarily a taxonomic approach to identify changes in material culture as markers of changing cultural epochs. By 1973, this approach shaped the first systematic excavation conducted at Indian Creek through a collaboration between Dr. Rouse and members of the AAS using matching funds from the AAS and the National Science Foundation. Excavations at Indian Creek were used to establish ceramic chronologies for the island of Antigua, and fix them to a comprehensive radiocarbon sequencing strategy. By coupling his theory of modes within a temporal framework, Rouse generated an early model for Pre-Columbian development in the Caribbean and establish a methodological approach towards
ceramics that are still employed today (Rouse 1974; Davis 1988). Excavations at Indian Creek by Rouse and the University of Yale focused on bulk ceramic recovery, often discarding faunal and organic remains, scrubbing them from the archaeological record at this site. Early collections housed at the Museum of Antigua and Barbuda were made up predominately of special artifact finds from a variety of Pre-Columbian sites on both islands, with few to no faunal assemblages available to revisit. Dr. Rouse’s early work and influence on the island meant that the majority of archaeological sites were investigated through the excavations of middens in order to add, revise, and study culture history through the framework of object analysis.

Figure 1: Map of the Caribbean
1.2 Earliest Peopling

While the earliest settlers in Antigua are not the central focus of this research, their persistent use of coastal territories would have left behind inherited landscapes that continued into the ceramic age. One place in particular, Long Island, a small island located off the northeast coast of Antigua was heavily utilized during the Archaic period and continued well into the Ceramic period during Pre-Columbian times. The concentration and distribution of Long Island flint helped archaeologist identify the earliest peopling of Antigua (Davis 1993, 2000). The Archaic period is characterized by concentrated deposits of lithics, expansive shell mounds, and an absence of ceramics. The abundance of Archaic Age sites are undoubtedly connected to an abundance of local flint originating from the offshore island of Long Island in the northeast, and the rich marine ecosystem (Davis 1982, 1993, 2000). These sites contain no ceramics and predate the arrival of Saladoid migrants by over three thousand years. Radiocarbon dates of shell middens provide a date of 3,775 B.P. uncalibrated (Davis 1982; Nodine 1990; Murphy 1999). This coincides with the earliest peopling of the Greater Antilles starting with Cuba in Canimar Abajo dating between 6460 ± 140 B.P. (UNAM-0715) and 4,700 ± 70 B.P. (UBAR 171) (Martínez López et al. 2007) while in the Lesser Antilles, Banwari Trace in Trinidad suggests dates as early as 7,180 ± 80 B.P. (IVIC-888) and 5,650 ± 100 B.P. (IVIC-783) (Harris 1976). Similar archaeological sites throughout the Caribbean with rich shell mounds and lithic debitage suggest that early Archaic age peopling took place between 5500 to 4500 B.P. (Pagan-Jimenez 2013). Unfortunately, many of these sites are situated along the coast and have experienced significant disturbances due to coastal erosion, hurricane activity, and coastal development.
1.3 New Archaeology in Antigua

During the 1990’s Dr. Reg Murphy, Director of Heritage Resources for the National Parks of Antigua and Barbuda and Secretary General for the National Commission UNESCO Antigua and Barbuda, led a series of active research collaborations that have resulted in research collections housed in Antigua’s Archaeological Research Centre. Through Dr. Murphy’s guidance, a new wave of researchers began collaborating on a series of dissertation projects.
looking at settlement patterns, diet, disease, lapidary activities, and stone tool making (De Mille et al. 1999; Turney 2001; Gent & de Mille 2003; Gent 2004; De Mille et al. 2008). These researchers generated complete collections from a variety of Archaic and Ceramic age sites consisting of artifacts, eco-facts, and soil samples. Unlike the Yale excavations, which are primarily housed at Yale University, all collections excavated under Dr. Murphy’s guidance are housed in Antigua. While materials have been loaned out for analysis through active partnerships with a variety of academic institutions, these materials now require legal authorization due in large part to recent legislation passed in Antigua. These collections have contributed immensely to this research, particularly, as some of these sites have been irrevocably lost and destroyed.

1.4 Ceramic Age

A total of fifty-eight ceramic age sites have been recognized in Antigua, with only eight sites associated with the early Ceramic Age (400 B.C. - A.D. 400) Saladoid component (Murphy 2004). This cultural designation is associated with distinct changes in settlement patterns and their association with ceramics sharing similar forms and design of the people from the Saladero region along the Orinoco river systems (Rouse & Cruxent 1963). As opposed to the earliest Archaic Age coastal settlements, early Saladoid settlements were concentrated around natural resources such as fresh water and accessible marine life (Haviser 1997; Curet 2005). These settlement patterns may be incomplete, as the only early Ceramic Age settlement along the waterfront Winthorpe’s West has almost entirely eroded out to sea. Therefore, any settlement pattern models must account for the potential loss due to erosion and on-going climatic impacts.
Four sites Indian Creek, Royall’s, Elliot’s and Wallings are at least one kilometer inland, while the sites of Doig’s, Cades and Falmouth Church are described as lying within the coastal plains (Murphy 2004). It has been argued that some sites situated along rivers, creeks, and watercourses are partly coastal due to their access to open seas and marine resources. Only one site, Indian Creek, matches this description and coincidentally represents the earliest radiocarbon sequences for early ceramic age Saladoid settlements in Antigua with Oxcal dates of BC 197 to 214 AD (I-7855, 2 sigma, 95% probability) and BC 106 to 324 AD (I-7981, 2 sigma, 95% probability).

1.4.1 Early Ceramic Age

The early Saladoid settlers of the Caribbean are described as fishing-gatherers who practiced a form of horticulture cultivating manioc and other root crops adapted to dry sandy clay soils (Pagan-Jimenez 2013). At the site of Maisabel in Puerto Rico, starch grain evidence suggests the presence of both arrowroot and maize associated with the early Saladoid traditions (Pagán Jiménez 2011). At the site of Tibes in Puerto Rico, C4/CAM isotopic results suggest that C4 plants like maize played a significant part in their diet (Curet & Stringer 2010), however C4 concentrations can be complicated due to the biogenic pathways inherent in island populations relying heavily on a marine diet (Little & Schoeninger 1995). Heavy marine diet can result in increased C4 signatures from marine animals feeding on coastal wetland vegetation, generating C4 signals that maybe unrelated to terrestrial food-ways. However, bioarchaeological analysis of 126 burials at Tibes does support that plant diets did translate into dental caries for 21 percent of the cemetery population studied (Pestle 2010). What this evidence suggests, is that plants played a significant role in the Pre-Columbian diet; and that Saladoid villages would have
consisted of designated spaces that were largely void of artifacts and objects. These void spaces
would have been places of intense use and activity resulting in the heavy modification of soils
and landforms. These spaces would have also required continued maintenance and the co-
production of ecological knowledge consisting of rainfall patterns, drought sensitivities, and soil
conditions. Archaeological investigations from two early Saladoid sites in Antigua, Doigs and
Indian Creek, uncovered void spaces well within the village limits. These spaces have the
potential to add to and supplement our body of knowledge regarding the use of space as well as
place-making in Pre-Columbian communities.

These sites are part of the wider cultural shift observed throughout the Caribbean with new
settlers from the Orinoco region. Particular ceramic styles from the region around modern day
Saladero were found in early sites throughout the Caribbean, and is designated the Cedrosan
Saladoid to distinguish between the mainland and Caribbean context. Characteristics of early
Cedrosan Saladoid ceramics have proven to be a valuable temporal indicator based on their
uniqueness across ceramic change in the Caribbean. Characteristics such as thin, fine tempered,
and well fired techniques (Rouse & Cruxent 1963; Berard 2013) to diagnostic decorative features
such as painted white-on-red (wor), zone incised crosshatching (zic), adornos, and red painted
plain ware have been consistently associated with early settlements across the Lesser Antilles
and Puerto Rico (Rouse & Cruxent 1963; Rouse 1974; Murphy 1999, 2004). The high level of
technical and social investment in the fabrication of these materials have been equated to social
and symbolic values (Roe 1989; Giraud & Bérard 2003; Waldron 2010; Berard 2013) which
were maintained throughout this early phase. While ceramic production has been extensively
studied throughout the Caribbean, further research is needed to understand the spaces used by
potters to make their ceramics. One question raised is whether the uniformity represented in early Cedrosan Saladoid ceramics is represented by uniformity in the many spaces of a village? How did spaces used by early potters change when ceramic forms changed to highly variable, less standardized, and expedient forms of ceramics? There is a lack of evidence in Antigua of ceramic production, and while hearths have been observed at numerous sites, concentrated clay fragments from firing have not. This maybe the result of periodic clearing and sweeping of space, as the buildup of broken pots from accidental firing mishaps would eventually make the space difficult to manage. While hearths can act to enrich the surrounding soils, periodic sweeping could have a deleterious effect by removing ground cover leading to threats of erosion and soil loss.

1.4.2 Middle Ceramic Age

The middle/late Cedrosan Saladoid (A.D. 400 - A.D. 600/850) is largely recognized by changes in settlement patterns, village layouts, and ceramic traditions increasingly more unique to the Caribbean (Boomert 2000; Berard 2013). Evidence of slash and burn techniques increased from the Early Cedrosan to Middle/Late Cedrosan sites, like Maisabel (Siegel et al. 2005). Evidence of decreasing charcoal production have been associated with the increase in these land-clearing practices. No large-scale horizons of burnt ash or charcoal associated with slash and burn have been found at Ceramic age sites in Antigua; however the central focus on midden excavations leaves room to explore land-use activities in areas dissociated from middens. While Middle/late Cedrosan village sites throughout the Caribbean are often associated with an increase in site size (Heckenberger & J Petersen 1995; Siegel 1996), this assertion is still largely based on the extent of midden deposits and structural remains. Land-use activities, particularly the
aforementioned void spaces outside of artifact concentrations may push the complexity of settlement patterns. This has particular relevance, as increasing site size in the Caribbean has been associated with increasing social stratification and the emergence of Chiefly societies (Crock & Petersen 2004). Changes in the archaeological record have been observed within settlements as well; the emergence of the circular form using middens to shape village boundaries and specialized activity areas (Curet 2005) have also been associated with this period. These changes highlight the need to study place-making within habitation loci, particularly the spaces of habitual activities that are often a reflection of societal rules, work place boundaries, and territorialities (Bourdieu 1980; Foucault & Miskowiec 1986). The concentric middens surrounding the site of Indian Creek provide an excellent opportunity to study both place-making and the emergence of archaeologically distinguishable habitation loci.

General trends throughout the Lesser Antilles have found that late ceramic age settlements (A.D. 600/850 - A.D. 1200/1300) increased in both number and size, with decreasing concentrations of exotic materials often associated with active trade and exchange networks (Knippenberg 2007; Lenik 2012). This is in contrast to Antigua, where settlement size defined by artifact concentrations and structural boundaries were found to shrink from more than 600 meters (Saladoid) to often less than 400 meters (Post-Saladoid) in diameter (Murphy 2004). These changes, as particularly observed in Puerto Rico and Anguilla to the east contrast heavily with Antigua as the increasing settlement size has been used to infer changing political structure and emerging elites (Curet 1996; Crock & Petersen 2004). Increased ceramic concentrations associated with larger settlements are also associated with a general decrease in stylistic diversity. While volcanic tempering, imported as either raw material or within finished ceramics,
have been found throughout much of pre-history (Fitzpatrick et al. 2008), ceramics in the late ceramic age have been found to contain less volcanic tempering and more localized resources such as crushed shells, or in the instance of the late period site of Indian Town Trail from Barbuda, re-used crushed tempered pottery as a temper for new ceramics (Donahue et al. 1990). The influence of discarded remains presents a remarkable challenge for archaeologists. New methods and techniques are needed to begin exploring Pre-Columbian activities that may have resulted in site disturbances such as the extraction and excavation of older ceramic fragments. The presence of decorated pieces, while artistically influential, may have lost its symbolic meaning to these late ceramic age potters.

### 1.4.3 Late Ceramic Age

The Post-Saladoid series (A.D. 1200/1300 - A.D. 1492) is one of the most challenging and least understood phases in the Lesser Antilles (Murphy 2004). For Antigua, ceramic traditions incur only minor changes, however due to the lack of reliable radiocarbon dates and few cross-dated archaeological assemblages to compare, these assertions must be taken as largely tentative. While a decrease in the use of decoration in ceramics have been observed in Antigua (Rouse & Morse 1995; Rouse et al. 1995; Whitehead 1995), ceramic traditions of the Early Saladoid were carried through into the thirteenth century (Rouse 1976; Murphy 1995). This stands in large contrast to the emergence of the Taino/Chican series in the Greater Antilles influencing ceramic traditions in parts of the north eastern Lesser Antilles such as Saba and Anguilla. The same can be said about islands south of Antigua, where Suazoid ceramic traditions developed (Allaire 1997). Both the Suazoid styles and the Taino/Chican ceramic traditions are absent on the island of Antigua with "...the Saladoid and Mamoran Troumassoid pottery [having] considerable
persistence in Antigua” (Murphy 2004). These findings raise questions regarding Antigua’s role in maintaining and preserving aspects of Saladoid ceramic traditions. Further research is needed to explore the changing role sites and settlements may have served communities living in Antigua. By focusing on the lived-in spaces where particular habitation loci took place, it may be possible to understand what activities played a role in place-making and generated a diversity of different kinds of settlements. These persistent places are the over-arching focal point of this research, and a discussion of the theoretical structure used for this argument is provided in the following chapter.
Chart 1: Geologic map of Antigua. Adapted from Martin Kaye (1956)
Chart 2: Calibrated Radiocarbon dates from Pre-Columbian Antiguan Sites (2 Sigma). List of dates and references can be found in Appendix C.

1.5 Geological Context

1.5.1 Natural Forces

The island of Antigua lies in the northeastern region of the Lesser Antilles in the Atlantic Ocean. Mean seasonal temperatures range between 73.5 and 83.5 degrees Fahrenheit with relative humidity of 70%-80% throughout the year. The northeast Trade Winds are at their peak between January and May while the greatest amount of rainfall and is followed by a heavy rainy
season between August to November, accounting for half of the year’s rainfall. The dry season can be extreme during the months of February, March, and April often requiring irrigation each season. The majority of rainfall is associated with the Shekerley Mountains in the southwest, with the highest peak of 1,319 feet associated with Mount Obama, formerly Boggy Peak.

1.5.2 Geology

Antigua consists of three geologically distinct regions that run north-west to south-east: (1) The south-west region is made of volcanic bedrock with dormant eruption centers made of eroded pyroclastic flows and ashfalls, (2) the central plains consists of volcanic sediments, and (3) the northeast consists of the limestone Antigua Formation of the island (Chart 1). The parent material associated with each site is the primary natural factor associated with the formation and shaping of soils in that region.

1.5.3 Cultural Forces

Most of the island was engaged in intensive agriculture during the sugar revolution that encompassed much of the Caribbean and the Americas. The passing of the Plantation Act of 1673 resulted in extensive land clearing preparing the land for sugar cultivation. This resulted in the re-shaping of much Antigua’s landscape (Dyde 2003). While much of the original vegetation prior to colonial occupation has been cleared, forests in the south-western hills have slowly regenerated (Hill 1966). Little is known regarding the impacts Pre-Columbian communities had on Antiguan landscapes, however there is evidence that these early peoples brought and introduced foreign plants and animals to the island (Harris 1965).

Natural and cultural forces have acted together to increase the threat and occurrence of
erosion through land clearing coupled with extreme drought and subsequent heavy rains. While factors such as topography, hydrology, land cover, and geomorphology play significant roles in shaping soil conditions, recent surveys have identified present and past land-use as the single most important factor in determining the likelihood of erosion (OAS/USAID 2001).

### 1.6 Site and Soil Background

The sites of Doigs and Indian Creek provide the central focus of this research, however a synthesis of the many places created within Pre-Columbian villages requires comparative and controlled context associated with known assemblages and archaeologically relevant activity areas necessary for constructing a meaningful understanding of the what kinds of behaviors are detectable using anthrosols. One particular activity area, middens, are associated with concentrated assemblages that can be used to study the process of diagenesis and elemental patterning. As discussed earlier in this chapter, midden assemblages are also quite ubiquitous throughout Pre-Columbian context in the Caribbean, and have been heavily studied. While objects found in middens are often dissociated from their place of use, soil studies, particularly the identification of elevated phosphorus, have proven to be indicative of midden deposits (Eidt 1977; Lilios 1992; Parnell 2002; Holliday 2004). Therefore, while food processing may take place elsewhere, refuse that is not consumed still consists of organic remains that can enrich the surrounding soil matrix in refuse heads. These factors provide a valuable comparison between the concentration of material remains and their associated elemental signatures measured in anthrosols.

The selection of additional sites is described in the following section discussing both
natural and cultural forces shaping our capacity to interpret Pre-Columbian activities in Antigua. Five natural forces have been recognized as primarily shaping soil formation in Antigua: parent material, climate, topography, vegetation, and time (Hill 1966). This research builds on these earlier findings and focuses on how past peoples interacted with their spaces to construct, maintain, alter, enrich, and possibly destroy spaces within village settlements. While natural forces play the predominate role in comparing anthrosols across different sites, the integration of the following sites is meant to explore whether the general patterns of elemental signatures resulting from past anthropogenic activities are detectable despite these natural forces. The effect of parent material, such as the limestone region in the north-eastern section of the island, can act to mask elemental enrichment resulting from past human activities. Limestone regions, which are made up of different forms of calcium carbonate (CaCO3), can act to mask calcium enrichment from shell midden deposits. This is particularly important, as soils throughout a site are not homogenous, making interpretations heavily reliant on combining archaeological investigations with elemental mapping of soils. The presence of aluminum and silicon are the byproduct of clay deposits made up of aluminosilicates, which comprise almost the entirety of both elements found. Therefore, while this research chooses to examine P, Ca, K, Fe, Al, Ti, and Si; only P, K, Fe, and Ti are reliably used for the interpretation of anthropogenic activities with Ca reliably used in volcanic regions and therefore tested in limestone regions to see if elemental loading is still discernable. Al, Si, and sometimes Ca are therefore being examined to compare sites across contrasting geomorphological substrates. This is particularly useful in studying the effects of erosion and hydrological processes that can act to move and concentrate elemental components of soils.
1.6.1 Bioturbation

Bioturbation is the process in which soils and sediments are disturbed by the activities of plants and animals. These processes can result in the modification of sediments (diagenesis) as well as the displacement of organic and material objects from their original stratigraphic position affecting the archaeological record (Armour-Chelu 1994; Grave & Kealhofer 1999; Canti 2003). There are few tools to test the extent of bioturbation, often relying on the experience of the archaeologists to identify material remains that appear chronologically dissociated or without any clear explanation to what these disturbances are. Often during excavations, depressions and areas of changing compaction present themselves, often leaving the researcher to discern whether these are the by-product of human activities (i.e. former postholes, small storage pits) or the by-product of bioturbation (i.e. root extensions, crab holes). In some instances when ceramics are present, total ceramic counts have been compared with total ceramic weights generating a sherd/gm average, often indicative of the extent of trampling, ploughing, and other destructive processes have had on the material remains (Blackman 2000; Balek 2002; Berard 2013). In these situations, bioturbation could potentially be ruled out. However, with respect to Pre-Columbian postholes, especially the ones where wooden posts were removed leaving behind a small depression, are difficult to distinguish between those small depressions caused naturally. It should also be re-emphasized that the appropriate methodological approach would be to expand the excavation to explore the spatial context of these depressions; however this is often time consuming and unrealistic, particularly when excavation middens of over 150 centimeters. One of the soil types analyzed for this research come from similar depressions, particularly those found with burnt wooden posts and those without, to compare their elemental characteristics and
assess whether or not this is an appropriate application for addressing this problem.

1.6.2 Volcanic Region
1.6.2.1 Doigs

The site of Doig’s (PA-015) is located in a small alluvial valley, slightly inland of Rendezvous Bay in the south central section of Antigua, and is surrounded by volcanic hills. Doig’s was settled within the basal volcanic region sitting on volcanic bedrock. The soils are part of the Dickensons Sandy Clay Loam series with reddish-brown colors resulting largely from the andesite and basalt parent material. The soil is fairly stony developed over alluvial and colluvial deposits. Soil surveys describe the structure to be moderate sub-angular and blocky, and is considerably strong and hard in areas that are dry. These conditions were observed during excavations at Doigs, where small hand picks and pickaxes were sometimes necessary to breakthrough certain levels. The area associated with the Pre-Columbian occupation overlaps an abandoned modern day farm which was also formerly used for sugar-cane production during colonial periods.

This site represents one of the most comprehensive archaeological investigations of Pre-Columbian settlements in Antigua (de Mille & Turney 2002; Fuess 1996, Gent 2004, and Cluney 2005) and is also sorely lacking publications synthesizing the settlement’s history. Starting with Martin Fuess’s work in November of 1992, a series of transects conducting surface collection and 28 circular shovel proves were used to delimit the site covering an area of 440 meters north-south by 300 meters east-west. Excavation was limited to a single 1x1 meter unit due to a landowner dispute ceasing excavations. Fuess obtained two unpublished radiocarbon dates with ranges between cal AD 110 to 405 (Beta-82000) with an intercept of radiocarbon age of cal AD
250 (2 sigma, 95% probability) and cal AD 595 to 800 (Beta-93702) with an intercept of radiocarbon age of cal AD 685 (2 sigma, 95% probability), both from the same unit. The University of Calgary followed up this preliminary work conducting archaeological investigations along the flat alluvial plain within the site employing a combination of block excavations, shovel test pits, and geophysical analysis that resulted in the identification of middens, structural features, and potential lapidary and lithic processing spaces. Geophysical survey was used to predict the potential location of structures. Two separate areas were excavated based on geophysical results revealing two sets of postholes from different regions of the settlement. These structures were not excavated and left intact for future research (Gent 2004). Ceramic analysis places the site in the early Saladoid and early late Saladoid ceramic phase aligning with the radiocarbon timeline (Berard 2013). Due to the numerous archaeologically defined activity areas at Doigs, associated soil samples from each context were used to help generate an elemental baseline pattern of anthrosols.

1.6.2.1.a Indian Creek

The site of Indian Creek is found in the southeastern section of Antigua along the volcanic region surrounded by volcanic hills. These soils are part of the Indian Creek Loam series, developed over coarse tuffaceous agglomerates which play the dominant role in contributing to the dark brown or purplish coloration. Erosion is common and has led to gullying and exposure of parent materials in multiple areas around the site. A dried creek bed stretches along the eastern edge of the site and flows through a series of winding inlets surrounded by mangroves eventually emptying out into the open sea.
Radiocarbon dating of midden deposits suggest that the site was settled continuously for approximately 1500 years. The site documents changes from the early Saladoid ceramic traditions all the way until the late and possibly post Saladoid ceramic traditions. All prior excavations have focused entirely on midden deposits, which were used to help construct a ceramic chronology for the island of Antigua. While early excavations focused on midden deposits, a more robust archaeological investigation is needed in order to address some of the poor sampling strategy earlier excavations conducted (Rouse 1974). While the site is described as consisting of concentric rings of middens, there has been no systematic or in-depth studies of the space bounded by these middens which has been hypothesized as being part of the primary living area for Saladoid settlers (Rouse 1974, Siegel 2006). This site forms a critical component of this research, as data generated from both new and previous archaeological investigations are coupled with elemental patterns studied from other sites to help synthesize new discussions on how different spaces within the site may have been used.

1.6.2.1.b Claremont Amerindian (MA5)

The site of Claremont is currently located in a pineapple farm along an alluvial plains and vallyes in the southwestern part of Antigua surrounded by volcanic hills. The soils are part of the the Blubber Valley Sandy Loam series deriving from the tuffs and agglomerates of the southwest hills (Hill 1966). The soils are purplish in color and developed over stoney and gravelly deposits up to 60 feet deep in some places. The site of Claremont is part of the wider valley system where stones are less frequent and contain good soils for agriculture. The texture is loamy with moderate crumb or sub-angular blocky structure with rapid drainage. These soils are generally low in phosphorus and potash.
The soils of this region are generally comparable to the site of Doig’s. Analysis of ceramics from surface collection suggest that the site consists of both an early Saladoid and late Saladoid tradition (Fuess 1994). No extensive excavations have been conducted as much of the land associated with Pre-Columbian occupation is actively farmed year round. One test unit was excavated within a midden as part of Martin Fuess’s dissertation research.

### 1.6.3 Limestone Region

#### 1.6.3.1 Winthorpe's West (GE-06)

Winthorpes West (GE-06) is a Pre-Columbian site situated along the northeast coast of the island. In July of 1996 and 1997, an intensive surface and subsurface survey was conducted along Winthorpe’s Bay ending at Withorpe’s West (Murphy 1999). Proceeding excavations and analysis were conducted during Dr. Reg Murphy’s dissertation research. Findings from his investigations suggest that shifting settlements were episodically scattered along this coastal region. While the site is situated along the Antiguan Formation consisting of exposed marl and limestone bedrock, subsequent excavations identified evidence of an older sandy beach ridge associated with Pre-Columbian occupation. The site sits on the Langsfords Clay series which is part of the undulating limestone region in the northeast, described as containing a top soil of about twelve inches deep, with humus stained layers of marl to white or buff parent materials. This series forms deeper and darker colored phases and are highly calcareous (>10% CaCO3) and high pH (Hill 1966). Radiocarbon dates suggest that GE-06 was settled between cal AD 555 and cal AD 1390 (based on 2 sigma, 95% probability; Murphy 1999) and are associated with all ceramic cultural phases from Saladoid, Mill Reef and Mamora Bay. The material remains consisted of assemblages made up primarily of domestic refuse with practical and functional
ceramic forms (Murphy 1999: 190).

1.6.3.2 Royall's

The site of Royall’s (JO-011) is also part of Dr. Reg Murphy’s dissertation research, and some of the key findings and background are presented here for context. Royall’s is situated approximately one kilometer inland along the northwestern section of the Undulating Limestone Region. The soils are part of the Fitches Clay series and is described as consisting of unconsolidated Friars Hill marls on broad terrace-like slopes of the steep limestone region (Hill 1966). The top soils are approximately 12 inches deep with humus stained layer of marl to the white or buff parent material. These soils are highly calcareous (>10% CaCO3) with an associated high pH.

Dr. Murphy’s research, taking place during July and August of 1998, found evidence of plow zone activity affecting the first ten centimeters of cultural deposits associated with the nearby Royall’s Plantation. No further intrusion or disturbance was observed. A road-cut exposed layers of dark humus and cultural deposits averaging 80 cm. Six soil samples were taken from one of the excavated units to test for the pH of the soil. The results were reported as falling within the alkaline range and was described as being similar to Elliot’s (Murphy 1999: 138). Assemblages represented evidence of domestic activity with ceramic cultural phases centering along the early Saladoid Complex. Two radiocarbon dates suggest that the site was settled sometime between cal AD 250 to 630 (2 sigma, 95% probability; Murphy 1999) and is comparable to Doig’s, another similar single ceramic cultural phase settlement. While the site of Royall’s is situated in the limestone formation of the island, Doig’s is set slightly inland along the southern coastline within the volcanic region and represents an important geological contrast
Coconut Hall (PE-015) is a large waterfront settlement situated on low-lying limestone bedrock within the alluvial plains and valleys region. The site sits along the northeastern coast of Antigua with soils associated with the Hodges Clay Loam series which are very black with high humic content most likely the result of uplifted swamp deposits (Hill 1966). These soils have strongly developed angular blocky structure and are saline and calcareous with relatively poor drainage due to the underlying dense clay. Cotton and vegetables are grown in the Coconut Hall region, where salinity is decreased in sections.

Coconut Hall consists of small, dense, and localized midden deposits rich in shell refuse (Fuess 1994) with further evidence of maize residues on stone and shell tools (Murphy 1999). Ceramic assemblages are associated with the post-Saladoid cultural sphere and has experienced significant disturbances due to bulldozing activity in the northern portion of the site (Healy 1995). Sections of the southern site are still largely intact, although covered in thick thorny vegetation.

1.6.3.4 Blackman's Point (GE-4)

The site of Blackman’s Point is located in the undulating limestone region in the north central part of Antigua. The site is located on a mix of Wetherills Clay Loam and Fitches Clay soil series which are described as occurring on unconsolidated Friars Hill marls with shallow stony soils. These soils are deeper and darker in color with twelve-inch-deep top soil. The soils are highly calcareous (>10% CaCO3) and have a high pH (Hill 1966).

The site contains both pre-ceramic (Nicholson 1976; Nodine 1988) and ceramic age
occupations layers (Fuess 1994). Three excavated 1x1 meter units were conducted outside of a bulldozed area with two yielding shallow deposits and one unit containing six strata at approximately 150 cm deep. Soils from this unit are of interest due to the two distinct cultural phases present within the test unit; with the earliest occurring at the deepest strata with ceramic age deposits sitting in the upper strata. Ceramic traditions were consistent with post-Saladoid period assemblages.

1.6.3.5 Betty's Hope

Betty’s Hope is a colonial plantation located along the undulating limestone region in the center of the island. The soils are associated with the Fitches Clay series which occurs over unconsolidated Friars Hill marls with top toils of twelve inches deep. The soils are deeper and darker in color and are highly calcareous (>10% CaCO3) with a high pH (Hill 1966). Drawing from ethno-archaeological studies linking soil inputs and human activities, an off-site control site was selected for comparison of historical versus pre-historic elemental loading. The selection of Betty’s Hope Sugar Plantation as an off-site control was based on the site’s previously studied use and spatial organization (Fox et al. 2013, Goodwin 1994), ongoing archaeological excavations and collaborations, rich historical archives, maps, and documents describing the site’s layout in good detail. This control helped test the historic impact of agricultural land-use on anthrosols, in particular dynamic denudation and equifinality (Johnson 2002).

1.6.3.6 Galleon Bay

The site of Galleon Bay (JO-007) is situated along a sandy beach within English Harbour in the south of the island. Volcanic hills surround the rear of the site which is part of a modern resort in
Antigua. While the Pre-Columbian context appears largely associated with the changing sandy coastline, soils surrounding the site are part of the Shirley Loam series and are developed over the sandy faces of tuffs and agglomerates (Martin-Kay 1959). The soil is strong brown to reddish brown possibly related to drainage, although the parent material plays a large part based on the rounded iron-stained boulders (Hill 1966).

Recent excavations have shown that Pre-Columbian occupation layers were cut into during colonial times in order to bury their deceased. This site represents a unique opportunity, similar to Blackman’s, to study different occupation layers that are superimposed upon one another. Analysis of both the human remains and Pre-Columbian assemblages is currently underway at both Brooklyn College, City University of New York and Farmingdale College, State University of New York.

1.7 Use of Anthrosols in the Caribbean

The use of soil analysis in describing Pre-Columbian activity areas are extremely limited. Soil and landscape approaches were combined to study intra-site activity/habitation loci at the civic-ceremonial center at Tibes in Puerto Rico combining the physical properties of soil types and the integration of phosphorus mapping to identify cultural features, non-feature site areas, and off-site localities (Scudder 2001). This study provided one of the clearest examples of soil chemistry being used to distinguish a variety of chemically unique localities within a settlement. These findings have particular bearing on this research, as the two cultural components span the Saladoid (ca. 300 BC to AD 600) and Elenan/Ostionan Ostionoid (ca. AD 600 to 1200) phases encompassing long-term post-depositional processes with considerable human disturbances occurring at the time of construction. Slvia Scudder’s research at Tibes provided evidence of large scale land modification such as stripping of top soil and leveling of the site for subsequent
construction. By integrating archaeological excavations, shovel test pits, and soil chemistry their team found distinct quantities of phosphorus between middens, floor layers, and off-site boundaries. These findings address some of the focal points of this research, particularly the study and analysis of void spaces. In this regards, soil is used to compliment pre-existing archaeological investigations and is used to generate a dialectical approach where sampling strategies and interpretations are constantly being shaped between the presence/absence of objects and the elemental signatures present within the associated soils.

At the Pre-Columbian site of Tutu in the Virgin Islands anthrosols were used alongside human bone samples to help reconstruct diet (Farnum, Glascock, Sandford, & Gerritsen, 1995). While their research wasn’t focused around identifying different kinds of habitation loci, their analysis demonstrates how bone diagenesis can enrich soil chemistry and result in unique chemical signatures. This is particularly useful in emphasizing the importance of establishing chemical baselines for soil chemistry of known anthropogenic context for comparison of different activities that may result in similar chemical outcomes. We should consider how the diagenesis of human bones arising from cemeteries compare with the soil enrichment resulting from the diagenesis of bones arising from food or ritual related activities. This research takes this into consideration by constructing a set of baselines, through the analysis and isolation of particular objects such as fish, mammal, and human bones, shells, coral, lithics, and ceramics to ascertain their potential affect in contributing to elemental enrichment and patterning with anthrosols.

One of the most valuable applications of anthrosols applied archaeologically, is the use of phosphorus to help distinguish between site and off-site boundaries. These applications are particularly valuable in the Caribbean, where rapid development projects continuously threaten the destruction of cultural heritage sites. Spot tests, a method created by Robert Eidt in 1977, provided rapid qualitative values for available phosphorus. This method is cheap, easy to do, and can be used as an in-field assessment to identify areas of concentrated anthropogenic
activities, primarily middens. This method was employed in Antigua, due to a large-scale
development threatening Doigs one of the earliest ceramic age settlements on the island (Look
site of Trants in Montserrat mapping and collecting surface deposits along with randomly spaced
test pits (50 m intervals). The site is approximately 62,250 square meters and dates to between
480 B.C. - A.D. 410 (Heckenberger & J Petersen, 1995). During the early phase of their
research Petersen found that high concentrations of phosphorus consistently matched elevated
surface and subsurface cultural debris. Levels for phosphorus fell within 650-2,736 mg kg-1 for
residential values recorded in other regional studies. From two middens, phosphorus values
peaked at levels equivalent to residential activities of the type found in Middle East tells or
urbanized zones (Petersen and Watters 1995). It is currently recognized that local geologic
makeup can account for these similarities, and it is better to apply these methods on a site scale.
One example, was the use of phosphorus to help determine whether the stones arranged in a
circular form around the site of Trans was indeed part of the Pre-Columbian site or rather a
modern disturbance. Soil samples from areas both inside and outside these stone features were
collected, with elevated phosphorus levels found along the inside of the stone feature and absent
outside this stone feature.

While these applications demonstrate the potential for integrating anthrosols within
archaeological investigations, there is a gap in literature regarding a comprehensive approach
integrating archaeological investigations with multi-element analysis of anthrosols at the site
level in the Caribbean. By allowing for a more dialectical approach between anthrosols and
material culture, the presence/absence of objects and elemental baselines can be used to shape in-
field interpretations, identify emerging trends, and save time and money during archaeological
field seasons.
1.7.1 Soils Collected for This Study

Soils were sampled directly from excavated units, shovel test pits, hand-held soil augers, and previously excavated assemblages. This diverse sampling strategy assured that soils could be collected from different stages of planning, survey, and excavation how soils can contribute at these different stages.
Chapter 2. Archaeological Focus

This research takes a case studies approach towards the study of anthrosols as archives. One of the major challenges towards applying soil studies within an archaeologic context, are the problems of equifinality, or identifying the discrete process-response relationship between a soil process and the resultant soil property (Walkington 2010/125; Davidson & Carter 1998). The lack of a clear causal link between the phenomenon and the context regarding these soil studies arises from the fact that different suites of processes can produce the same final form. As diagnostic properties do not necessarily develop in all soils equally or if at all and can be destroyed by subsequent post depositional processes, identifying causal links between anthrosols and phenomena such as settlements, boundaries, and burials require the comparative analysis between archaeological investigations and multi-element analysis of anthrosols, GIS software to map and identify activity loci, and integration of ethnohistorical and ethnoarchaeological analogues.

2.1 An Exploration of Middens and Central Plazas

The challenge in describing central spaces and plazas within a Pre-Columbian Caribbean context in the Lesser Antilles have often been the lack of structural features (Siegel 1996) and/or material remains (Alegria 1983; Curet & Stringer 2010) used to characterize the kinds of activities taking place in these spaces. The interpretation of spaces clean of refuse and structural features rely on their spatial configuration with respect to middens and structural features; despite the lack of physical evidence linking these spaces with particular activity areas. The identifica-
tion of central plazas require the integration of ethnohistorical and ethnoarchaeological research concerning central plazas to identify the dynamic processes accounting for unique elemental patterning. The commitment to maintain central plazas free of debris and overgrowth of weeds (Siegel & Roe 1986), can have a direct impact on soil enrichment or soil depletion (Wells 2004; Roos & Nolan 2012). The interpretation of these void spaces makes use of elemental findings from neighboring middens. Multi-elemental analysis of anthrosols used to identify the abundance of different categories of refuse (i.e. bone, shell, lithic, ceramic, and ash) and the spatial analysis of archaeological assemblages can help further characterize middens from trash heaps to evidence of ritual economy, tool production, or kitchen refuse despite similar geomorphic conditions (Wells 2004, Parnell et al. 2001). Different geomorphic conditions, climatic changes, and natural processes can influence elemental concentrations despite anthropogenic activities; therefore, the objective of studying anthrosols is to recognize ancient activity loci relies not on the absolute concentrations of elements, but rather the intra-site comparisons between different activity loci (Bethell & Mate 1989; Hutson & Terry 2006; Holliday & Gartner 2007; Wells 2010).

2.2 Site Context, and Sampling

2.2.1 Sites Sampled

This study encompasses multiple Pre-Columbian sites located across the island of Antigua. A series of sites were selected due to the island’s diversity in soil types and the range of settlement forms. Other factors considered were the hydrology patterns surrounding sites, topography, and land-cover as each plays a distinct role in pedogenesis. Thirteen sites were sampled that range from archaic to the historic plantation period. The coupling of archaeological
investigations with the study of anthrosols will explore the kinds of sites these places represent. Archaeological investigations of two Pre-Columbian sites, Doig's and Indian Creek, consisted of large scale excavations providing insight on village space. Previous Indian Creek excavations identified a large circular midden enclosing a central village space (Rouse & Morse 1999). The analysis of archaeological investigations, multi-element analysis of anthrosols, and ethnohistorical and ethnoarchaeological comparison were used to synthesize different habitation loci at Indian Creek (Chapter 8). Excavations and geomagnetic surveys helped identify a number of potential habitation loci at the Pre-Columbian site of Doig's. Multi-element analysis of associated anthrosols were compared to these archaeologically defined habitation loci (Chapter 9).

2.2.2 Activity Loci Test Site

As previously discussed, Doig’s (PA-015) is a single-phase occupation site that was selected to help establish an elemental baseline for selected anthrosols and habitation loci. The extensive archaeological research completed at the time of this study (Gent & de Mille 2003; Fuess 1995; Gent 2004; and Cluney 2005) provided a wealth of archaeologically defined activity areas that could be tested against elemental patterning extracted from pXRF analysis. In many ways, this research works to both test the uniqueness of chemical signatures for activity areas as well as test the reliability of these interpretations as many Pre-Columbian sites have been impacted by modern land-use. The site of Elliot's described below will expand on this discussion and illustrate how its findings will contribute to each site analyzed.
2.2.3 Building Baselines: Comparative Sites

A series of additional sites were sampled for comparative analysis based on natural and cultural diversity of settlements. These sites consisted of test units and shovel test pits from Winthropes (GE-006), Royall’s (JO-011) (Murphy 1999), Blackman's (GE-004), Claremont (MA-005), Coconut Hall (PE-015) (Healy et al. 1995), and Galleon Bay (JO-007). Each site selected had assemblages and available soils associated with feature specific (i.e. middens, burials, and structural) context. Additional soils were extracted during the first phase of survey. These sites provided soil samples varying in parent material, hydrology, and micro-climates.

2.2.4 Habitation Loci Synthesis: Middens and Void Spaces

While the aforementioned sites provided the necessary baselines for elemental pattern analysis, these baselines and findings were applied to the village space of Indian Creek. Material remains excavated by Yale were revisited for this research, and were analyzed to compare elemental findings with the spatial distribution of special finds and overall assemblages. As Yale did not collect soil samples during their excavations, additional test units, shovel test pits, and soil augering were necessary to obtain representative samples from associated midden context. No systematic or in-depth studies of the central space enclosed by these surrounding midden mounds were conducted (Rouse 1974; Siegel 2005). Excavated units and shovel test pits were conducted in this bound space to compare archaeological findings with associated elemental findings.
2.2.5 Impacts of Intensive Ploughing

The site of Elliot's has been characterized as a Saladoid village with a rich ceramic tradition. This site has experienced heavy disturbance due to modern farming practices that includes intensive ploughing. Aerial images and ground surveys have suggested that these activities have resulted in the gradual exposure of sterile soils. Despite minimal excavations conducted on site (Murphy 1999), preliminary analysis by Murphy has strongly indicated that this site was involved in intensive pottery development and stylistic experimentation. Studies using experimental archaeology of heavily plowed areas have shown that while the superpositions of artifacts and soils maybe destroyed, their horizontal positions are better preserved (Ammerman 1985; Navazo & Díez 2008; Lewarch & O'Brien 1981). Therefore, this site provided an important opportunity and case study to compare multi-element analysis of soils and a heavily disturbed context.

2.2.6 Historical Impact: Betty's Hope Sugar Plantation (off-site)

Drawing from ethnoarchaeological studies linking soil inputs and human activities, an off-site control site was selected for comparison of colonial versus Pre-Columbian elemental loading. The selection of Betty’s Hope Sugar Plantation as an off-site control was based on the site’s previously studied use and spatial organization (Fox 2014; Pratt 2015), ongoing archaeological excavations and collaborations, rich historical archives, and site maps. This control helped test the historic impact of agricultural land-use on anthrosols, in particular dynamic denudation and equifinality (Walkington 2010) that may result in obscuring Pre-Columbian activity loci.
2.3 Unit of Analysis: Habitation loci

This research cannot account for or address the immense diversity of human activities and individual practices. Therefore the unit of analysis is categorized into different *habitation loci* limited to those identifiable through archaeological investigations. The use of pXRF measurements of reference samples (i.e. bone, shell, ceramics, and lithics) and analysis of middens and associated soils generated baselines for elemental patterning and characterization. These elemental patterns were mapped horizontally to delimit particular areas of habitation activity. As limited archaeological soil studies have been conducted in the Caribbean, a range of ethnohistorical and ethnoarchaeological case studies from primarily Central and South America were used to compare findings and interpretations of ancient activity areas defined by anthrosols. General categories explored during the course of this research were architectural features, middens, hearths, central spaces, void spaces, consumption/cooking areas, site boundaries, burials, and ritual deposits. A comprehensive comparison between activity areas and anthrosols are presented in Chapter 9.

2.3.1 Research Variables and Limitations

2.3.1.1 Pedology

While comparative studies across different soil types are crucial in evaluating their use in studying past human activities; anthropogenic processes combined with changes to the rates of soil processes (Davidson & Carter 1998; Walkington 2010), such as accelerated soil erosion on hill slopes, requires several different control variables and will be discussed below.
2.3.1.2 Systematic On and Off-site Sampling

Obtaining off-site reference soil samples assumes that Pre-Columbian peoples did not modify or alter their surrounding environments; and that these spaces could be identified for referencing. Neither of which is possible, therefore off-site sampling was defined as areas outside of visible archaeological deposits and dissociated from nearby resources that maybe part of a larger site catchment (Vita-Finzi & Higgs 1982). The use of rapid Ptests (phosphorus color change ring tests) were part of the first phase of analysis used to identify areas of concentrated refuse and potentially delimit the extent of sites.

2.4 Temporal Dynamics

Dating of activity areas relied heavily on associating anthrosols with the appropriate strata using a combination of radiocarbon dating and relative chronologies established through the seriation of Pre-Columbian ceramics in Antigua (Rouse 1974; Rouse & Morse 1999; Davis 1988; Murphy 1999). While this method can be applied directly to middens, certain habitation loci such as central plazas and void spaces can prove difficult to date. This method of research focuses primarily on middle to long-term human activity areas that are detectable through anthrosols and were maintained and persisted over deep periods of time. The use of multi-element analysis of anthrosols was used with archaeological investigations to explore the persistence of these spaces and connect them to both radiocarbon dating of material remains present throughout middens and relative ceramic dating based on local calibrations.

Dating soils directly through radiocarbon dating is a technique with severe limitations in archaeological contexts due to a range of factors; such as the various roles soils play within the
global carbon cycle; dangers of post-burial contamination; and the rate of soil forming intervals (Walkington 2010/129). While the isolation of time dependent soil properties, such as the degree of weathering (Stafford 2004; Schuldenrein 1995; Schuldenrein et al. 2004) and clay accumulation (Chartres 1980) have been used for relative dating of soil sequences, these methods were not tested at the time of this dissertation.
Chapter 3. Theoretical Framework

3.1 Introduction

This chapter discusses the theoretical frameworks that were used to help define research questions, identify appropriate methods for investigation, and synthesize an approach towards studying void spaces. The study of void spaces is by no means a recent phenomenon (Wells 2004; Parnell et al. 2002a; Hjulström & Isaksson 2009; Milek 2012) with an abundance of literature applying the study of anthrosols towards spaces void of material remains including plazas, house floors, and specialized activity areas. However, the integration of anthrosols have often been applied to well defined boundaries such as structural features, plazas, and midden mounds, which are used to help give these spaces additional meaning. Ephemeral spaces, which lack objects or clear associations with archaeological features, have proven to be problematic to define or interpret. Void spaces are not just present in every Pre-Columbian village throughout the Caribbean but can manifest as pathways, play areas, garden plots, and plazas in almost any archaeological site.

This research builds on a number of key theoretical frameworks, primarily rooted in landscape archaeology, and seeks to apply them to lived-in spaces at a site scale. It is within this sphere that this research hopes to make its primary contribution; through an exploration of how places void of objects and architectural features can also be meaningful places of intense activities. This archaeology of void spaces adds to the aforementioned body of literature on anthrosol studies, by first creating site specific elemental baselines constructed from known objects and faunal remains as well as the elemental patterns associated with a variety of archaeological assemblages. In short, constructing a conceptual framework for spaces void of
material remains, is imbedded in a thorough exploration of material remains and anthrosols associated with rich archaeological deposits.

The following sections incorporate a number of theoretical approaches that were used to construct an archaeological framework for the study of void spaces. The section **Ontology of site** discusses how changing definitions for archaeological sites have influenced investigations, particularly the epistemological challenges of identifying and distinguishing between site and off-site. This has significant ramifications for interpreting the spatial analysis of archaeological assemblages in this research as well as cultural resource management of 'invisible' places. **Production of Place and Space** engages in the examination of spatiality and place-making literature from recent landscape studies and discusses how these concepts can be applied or modified to explore at the site scale. A discussion of space as a generative force was used to study the relationships people, place, and things have with areas inside village space. **From Human Activities to Site Formation: Integrating Anthrosols** describes the challenges of applying soil studies and elemental modeling as a means of getting at the natural and cultural dimensions of lived-in spaces. This section also discusses how literature on the study of activity areas using anthrosols was used to construct a research framework for the study of void spaces. Finally the discussion of **Persistent Place Theory** was vital to help characterize the kinds of places often being identified for this research. This section draws significantly on archaeological landscape literature, but proposes new ways that these concepts can be applied at smaller scales, particularly the variety of persistent places within sites. Place-making requires endurance and oftentimes commitment, which is reflective of the rules and taboos of a society. These persistent places that remain or are preserved, in spite of other changes to settlement patterns, ceramic
styles, and trade networks provides additional lenses to view Pre-Columbian histories that may not always align.

3.2 The Ontology of Site

Archaeologists have been engaged in the ontological discourse of sites, particularly how we choose to define sites and how these choices affect how we understand social organization through the arrangement of settlements, villages, and camps (Dunnell 1992; Ingold 1993; Souvatzi & Hadji 2013). While no archaeologist would reject that sites exist, there remains a lack of consensus regarding what constitutes a site, what are its boundaries, and what makes a site unique or exceptional enough (UNESCO World Heritage) to conserve and protect? Within a Caribbean island context, these discussions have particular bearing for those islands which have been continuously modified and lived-in for over 4000 years. Entire Caribbean landscapes can be littered with Pre-Columbian and Colonial objects ranging from a few scattered pieces of flint or ceramics to over a meter of deeply stratified midden remains. Therefore, we cannot assume that objects when found by archaeologists were in their original position. Cultural and environmental disturbances act to complicate and mobilize material remains, which can result in ambiguous interpretations (Schiffer 1987; Skibo & Schiffer 1987; Beck & Hill 2004).

For archaeologists the “concentration of artifacts” (Holmes 1897) have long been implicitly tied to the identification of sites and the relative abundance of material remains used to delimit its boundaries. This focus on artifact concentrations played a large role in shaping Pre-Columbian culture history throughout the Caribbean focusing excavations on sites with concentrated surface remains, resulting in a “telephone booth” style of archaeological excavation
and interpretation that eventually became heavily criticized for its inadequate sampling size, attention to environmental resources, and surrounding landscapes (Curet & Oliver 1998a; Petersen et al. 1999; Keegan 2009b).

Early culture historians viewed sites as neutral spaces that were in sense, empty containers, waiting to be filled with artifacts and objects. This de-emphasized the lived in spaces where daily activities took place and treated space as passive. Instead, artifacts, architecture, and things were treated as active variables used to distinguish change through time (Blake 2002; Lesure & Blake 2002). A greater emphasis on interpreting assemblages within a temporal framework grew from the early geological analogue of fossilized assemblages representing distinct historical epochs (Childe 1962). In the Caribbean, these distinctions were used to identify migration patterns, cultural identities, and trade or exchange (Rouse 1974; Rouse 1999; Roget 1975).

The New Archaeology (Willey et al. 1958; Binford 1964) was critical of artifacts being used as geologic analogues, as argued in Binford’s Pompeii Premise (1981), regarding that artifacts are not frozen in time like the site of Pompeii. Used objects rarely stay in the same position as its last user intended, and an object’s spatial context doesn’t necessarily mirror where they were used nor the architectural places they were associated with. Only when the assemblage was accounted for could different areas of ancient occupation or activities be identified (Hole & Heizer 1973). In the prehistoric focus, the emergence of settlement archaeology helped mediate between processual and spatial archaeology by exploring the settlement as a unit of analysis to compare settlement patterns and social organization (Parsons 1972; Trigger 1967). While the focus shifted to the assemblages, sites and settlement
archaeology continued to place a heavy emphasis on the “concentration of artifacts” to identify and give meaning to these spaces.

By the 1970’s research, such as in Oaxaca Valley by Kent Flannery (Flannery & Sabloff 1976), marked a significant transition by linking spatial and social into a meaningful framework creating socially defined units of analysis such as villages, households, and specialized activity areas. This socialized spatial context explored activity patterns within social units such as villages and between social units such as households. This change in classifications helped shift the meaning of sites and settlements from being empty spaces holding clusters of artifacts to places of action and activity resulting from the daily lives of past peoples. Empirically, these social units of analysis have generated a more synthetic archaeology of place such as “habitation loci” or residential components made up of several features related to domestic activities including storage, shelters, and refuse pile (Bethell & Máté 1989; LaMotta & Schiffer 1999). Defining how a site exists to particular groups of people, were necessary in defining what is part of the site and what is off-site. This will be further elucidated in the following section, Production of Place and Space.

Post-processualism brought a greater emphasis on socialized spatial archaeology (Hodder & Cambridge 1982; McGuire & Schiffer 1983; Renfrew & Cherry 1986; Ashmore & Sabloff 2002). One particular development was the emphasis on understanding how communities transform physical spaces into meaningful places (Hirsch 1995; Ashmore and Knapp 1999) treating space as a generative force on its own. These transformations form a centralized role in framing this research particularly the lived in spaces.
3.3 Production of Space and Place

The theoretical development and fleshing out of space as an area of "transdisciplinary" research was heavily influenced by the works of Henri Lefebvre and Michel Foucault during the 1960’s and 1970’s (Foucault 1986; Lefebvre 1991). Their work emphasized how an exploration of the histories of spaces could also reveal histories of powers. Archaeologists influenced by Foucault’s work began analyzing space as a generative force alongside temporality (Blake 2002, 2004; Whitridge 2004; Souvatzi & Hadji 2013). By introducing a subjective into space, it becomes apparent that we do not live in a “kind of void, inside of which we could place individuals and things… (rather) we live inside a set of relations…” (Foucault 1984). Space can be “charged, mediated, negotiated, and claimed by different social groups with diverse and often conflicting interests” (Souvatzi & Hadji 2013). By identifying these spaces, we can begin exploring their effect on how these past communities accepted, sparked, and resisted change. These kinds of relationships can contribute to why certain places were continuously re-used throughout or persisted throughout time (Schlanger 1992). These places are not restricted to sites or features of a landscape; they can take the form of flood plains, arable lands, flint deposits, creeks, and clay quarries. It has been suggested that place is “not defined by sheer size, but rather the qualities assigned to it by human action” (Souvatzi & Hadji 2013).

This has particular relevance for the Caribbean, as often the concept of central plazas or ceremonial spaces are often inferred by their lack of artifacts and spatial proximity to its surrounding features. If ceremonial spaces acted as gathering spaces for settlements and possibly neighboring villages, then these particular places may have also helped spark economic and political changes. Findings from the island of Puerto Rico at the ceremonial center of Tibes
suggests that the diversity in architecture from square to star shaped plazas were constructed sometime after many of these structures were put into place (Curet & Oliver 1998b; Curet & Stringer 2010; Torres et al. 2014). While evidence suggests that these spaces were occupied primarily as residential settlements, later phases suggest that smaller households remained possibly to help maintain the space. Unfortunately, these spaces are predominately void of artifacts and evidence of how these spaces were used. This presents a distinct gap within our historical narrative of Tibes and other ceremonial plazas and spaces explored throughout the Caribbean (Alegria 1983; Wilson 2007; Ramos 2010; Torres 2010). Drawing from ethnographic records can be dubious, as concepts of colonial plazas were often projected onto Pre-Columbian spaces. Regardless, these accounts may only capture the end of a space’s narrative and may not be reflective of the on-going changes that these spaces may have helped generate.

The site of Indian Creek, on the island of Antigua represents a much more problematic challenge in that it has been described as having a central plaza but does not contain the distinctive architectural stone features found in Puerto Rico. The social spatial context of discarded objects can be used to characterize the user’s last connection to these objects; particularly “primary refuse” or objects laid down by the user at the moment of abandonment and “secondary refuse” deposits not original to their location. As central plazas are often characterized by their lack of artifacts and objects, a renewed focus of these void spaces requires a re-evaluation of methodologies, and the integration of new and emerging techniques.
3.4 From Human Activities to Site Formation: Integrating Anthrosols

Identifying the places of past human activities, particularly the lived-in and managed spaces, can play a central role in understanding the meaning of a site as well as a site’s history or rather the discrete and non-discrete processes that lead to site formation. While site formation studies are not new (Renfrew 1976; Binford 1979; Schiffer & Herndon… 1985; Schiffer 1987), renewed interest in the study of activity loci represented by soil chemistry and anthrosol studies have generated new insights into the cultural dimensions that influence environmental changes (Butzer 1982; Beck 2007; Goldberg & Macphail 2008). Anthropogenic activities can act to enrich or deplete soils in particular patterns; combining anthrosol studies with ethnoarchaeology and experimental geoarchaeology, it has been shown that certain habitation loci are detectable using multi-element soil analysis (Shahack-Gross et al. 2003; Wilson et al. 2006; King 2008).

Therefore, the integration of anthrosol studies provides a unique tool to explore lived-in spaces including those where no artifacts or architecture maybe associated with. Archaeological investigations are vital not just in the spaces rich in material remains but also void spaces. These investigations provide a valuable critique on the role of equifinality, where a duplicity of past human activities can produce similar results (Johnson 1977; Johnson et al. 2007).

Coincidentally, by testing the consistency of soil signatures with archaeologically defined activity loci such as hearths, shelters, storage features, and other constructions; elemental patterning can be used to check interpretations (Shahack-Gross et al. 2003; Wilson et al. 2006). Local geologic variations, climatic conditions, and natural processes can have direct impact on soil chemistry. These processes can vary dramatically across a single site; therefore it is not the
total elemental concentration that is used to identify past human activities, but rather comparisons of elemental patterns between activity loci from within a site. For example, hearths produce a pattern whereby dramatic increases to phosphorus, calcium, iron, and potassium are observed in ash deposits and can be recognized by comparison to other activity loci. This general loading of elements resulting from the burning of wood ash is recognizable as a general pattern; and can be applied across temporal and geographic regions as long as local processes are accounted for. Therefore, the first step in interpreting void spaces is the construction of regionalized elemental models for spaces rich in material remains. This integration of geosciences into archaeological investigations can help generate linkages between the people who lived in the settlement and the objects left behind in a settlement. It is the intention of this research to explore how void spaces can also be places of intense human activities.

3.5 Identifying Persistent Places

The discussion of activity areas contributing to the development of place illustrates the relationship objects have between space and time. The scale at which archaeology operates at is rarely capable of identifying places of single short term events; rather archaeological investigations often result in identifying places of long-term patterns that accumulate from short-term events. Crucial to identifying these places are the various aspects of time within the archaeological record. Originating within the Annales School (Bailey 1981; 1983; 1987) the principles of time perspectivism, or how observations made at different temporal scales make different processes apparent, highlight how scale can affect a spaces meaning (Holdaway & Wandsnider 2008). How we give meaning to places that were repeatedly used and made use of is discussed through the concept of persistent places (Schlanger 1992; Barton et al. 1995;
3.5.1 Landscape Approach

Measuring persistence across landscapes can be challenging due to the emphasis on small assemblages and scattered surface deposits. Recently developments in landscape studies have contributed greatly to our understanding of off-site space (Dunnell 1992; Schlanger 1992; Wells et al. 2004; Cooper 2007). Often during landscape surveys, surface deposits are recorded and mapped. While clustered surface deposits may represent a singular event, it is the “nature of surface deposits that have accumulated over relatively long periods of time at a landscape scale” (Matthew 2008) that generate a more comprehensive understanding of the long-term use of these spaces. The use of GIS mapping of isolated finds across immense landscapes have allowed archaeologists to establish both a general time-frame and analyze assemblages associated with long-term use of particular places. The unique capacity for GIS software to incorporate qualitative and quantitative data across different scales, makes it invaluable to archaeologists looking to infer meaning to landscapes. This is particularly important when attempting to define intensity through spatial dispersion and temporal persistence; where material remains and relative and absolute chronologies are quantified spatially. In the spirit of the Annales School, taking a longue duree approach to studying the transition from foraging to farming in the Mediterranean Spain, persistence modeling was used to identify how different peoples from the Paleolithic, Mesolithic, and Neolithic had particular connections to different kinds of places (Barton et al. 2004). Within a Caribbean context, the longue duree perspective brought a renewed way of seeing the Caribbean sea; particularly as a timeless sea that unites different islands rather than separating them (Mol 2006; Cooper 2007; Hofman et al. 2010). By framing
artifact accumulation and spatial patterning within a temporal framework; persistent place theory can help generate insight into how spaces are made into places.

The difficulty lies in the high uncertainty regarding the classification of objects scattered across landscapes. This was pointed out during the survey of the Middle Gila River Valley of Central Arizona, where three-quarter of the sites recorded could not be categorized (Wells et al. 2004). As previously mentioned, both natural and cultural processes can act to bury and relocate objects over the course of time creating additional complications. The application and integration of geosciences can be used to test their spatial integrity and potentially uncover deposits not observable as surface deposits.

While an argument could be made that all materials were once surface deposits (Lewarch & O'Brien 1981); it is nonetheless vital that site formation processes must be accounted for if any interpretation is to be made from these materials. One case study, the Pre-Columbian site of Elliot's, was studied to understand the impact of overlapping colonial sugar farming and modern agricultural ploughing has had on the spatial integrity of surface deposits in plough zones.

3.5.2 Identifying Persistent Settlements

Settlements may begin as persistent places in the landscape that are visited frequently; but are not permanent. Temporary camps maybe setup in order to “scout” an appropriate location or to begin construction of village structures and homes. This process of becoming a village raises the question of when does a site become viewed as permanent or settled? Understanding the relative permanence and social context of a settlement requires a multi-scaler approach encompassing landscapes, site, and activity areas. This section focuses on archaeological materials often utilized to identify permanent settlements.
The use of midden deposits are often used to help distinguish between short-term, seasonal, and permanent settlements (Dunnell 1992; Barton et al. 2004; Wells et al. 2004). The combination of quantity, diversity of assemblage, and timeframe can help infer the nature of the deposits under investigation. While middens are particularly useful for establishing the relative timeframe and permanence of the site, they also represent relationships with their surrounding landscapes such as hillsides, creeks, flood plains, and other aspects of the site (Anschuetz et al. 2001). By comparing persistent places off-site with primary village occupations; a better sense of place can further characterize what kinds of settlements are present such as villages, ceremonial centers, or marketplaces. At the same time, middens can sometimes infer persistent places that maybe unobservable in the archaeological record; such as reef systems housing an assortment of fish or mollusks. Studies connecting midden deposits with their surrounding environments can infer seasonal versus year round occupations through a reconstruction of seasonality using faunal remains as well (Killingley 1981; Kennett & Voorhies 1996; Classen 1999).

Excavations of structural remains in the Pre-Columbian Caribbean have provided key evidence in contextualizing the social nature of settlements. Unfortunately, the nature of political powers, lack of funding, and the scope of site-level excavations have limited the number of villages excavated within the Caribbean. The poor preservation of wood and other Pre-Columbian building materials have resulted in few structural plans and village layouts (Curet 1992). Some of the most comprehensive excavations of Pre-Columbian settlements in the Caribbean are The Golden Rock site in St. Eustatius (Versteeg & Schinkel 1992), the Tutu village site in St. Thomas (Righter 2002), the Tanki Flip site in Aruba (Versteeg & Rostain 1997),
Maisabel in Puerto Rico (Siegel 1989, 1992), and El Cabo in Dominican Republic (Samson 2010). While the majority of these sites are later period, they nonetheless provide important insight into the nature of households and persistent areas of residential activities. The Golden Rock Site of St. Eustatius represents one of the first comprehensive publications, whose findings shed valuable insight into shaping the sampling strategies of this research. The focus of their excavations were on spaces away from midden mounds. Their excavations uncovered a series of domestic, work or activity, and storage structures. The site’s spatial configuration, particularly the spatial separation between middens and structures provides an opportunity to explore whether these spaces were maintained as suggestive from the overall circular form apparent at the village scale (Siegel 1992). Investigations at El Cabo shed direct insight into the nature of persistent households, particularly their “House Trajectories” (Samson 2010, 2013). The plan of El Cabo shows that houses were periodically rebuilt, or renewed in the same space. This has symbolic and territorial implications, suggesting that places of home were maintained and were passed on from generation to generation.

These findings have shed light on the areas of domestic activities, however further research is needed to explore additional void spaces. While archaeologists generally seek out loci that are particularly concentrated in artifacts or structural features and interpret these loci accordingly; this strategy which is particularly suited for studying large tracts of land provide an incomplete view of the interactions between humans and the spaces around them. There is a need to systematically collect data in spaces where material remains are rare or non-existent (Foley 1981; Dunnell 1992; Zvelebil et al. 1992; Ebert et al. 1996). It is under this scope that this research seeks to make use of anthrosols to compare void space elemental patterns with
elemental midden signatures, archaeologically defined activity areas, and ethnoarchaeological case studies. These findings are coupled with archaeological investigations to test the fluidity and resistance of Pre-Columbian spaces.

### 3.5.3 Production of Place within a Site

The identification of persistent places at the activity scale has the potential to identify other forms of fluid and resistant places. These kinds of socialized spatial dynamics can help to identify the kinds of social structures governing everyday activities (Bourdieu 1980). Pierre Bourdieu proposed that when people act and demonstrate agency, they are acting out daily rituals and activities that are part of the everyday norm also known as habitus. These daily rituals and activities, such as food preparation and cooking, can transform physical spaces into meaningful places (Ashmore & Knapp 1999). Configuration, access, and interaction with houses, central plazas, and middens can reflect the social norms, governing laws, and taboos that may have guided each community. As new insights are generated into how spaces are used within a village context, the integration of the subjective (Tilley 1994; Thomas et al. 2008; Tilley & Bennett 2008) can result in redefining the spatial characteristics of our units of analysis. Recent studies of the late Classic Maya farmsteads of Chan Noohol in Belize have shown how the Maya concept of house may have involved a complex auger of domestic and work spaces that may have extended beyond the confines of structural walls (Robin 2002). Physical places often require a commitment and motivation to maintain over long periods of environmental and climatic changes. The maintenance of place for even one life-time demands dynamic risk management strategies (Barton et al. 2004; Torres et al. 2014). The removal of top soil for leveling of a ceremonial plaza at Tibes in Puerto Rico (Curet & Stringer 2010) would have
caused immediate challenges for the management of erosion. Even today, the National Parks managing Tibes requires weekly maintenance for overgrowth of the surrounding ceremonial spaces and annual weeding to keep stones from being pushed over by weeds. Architectural features and stone alignments appear to help redirect flood waters, and act as retaining features to slow down erosion from nearby hillsides.

Recent studies have illustrated how landscape approaches integrating GIS software, analysis of archaeological assemblages, documentation of site-formation processes, and the integration of multi-element analysis of anthrosols can provide a more comprehensive understanding of past human activities that took place over repeated and often extended periods of time (Wells 2004; Fulton et al. 2013; LeCount et al. 2016). These studies have addressed some of the concerns over phenomenological approaches (Fleming 2006), by integrating traditional heuristic argument-grounded approaches with archaeological investigations. The identification of specialized assemblages and their spatial association with adjacent void spaces were often assumed to be the area of activity. As previously discussed, void space proximity does not guarantee an association. Additional focus is needed to identify the dynamic social context that interconnects and infuses significance to material objects. Studying sites as places of trade and exchange may consist of finer scaled places of transportation, travel networks, and markets. Places for flint knapping maybe associated with travel activities and can be classified as canoe making tools, or products for trade and exchange. While both areas are recognizable as activity areas of flint knapping, their social and cultural context helps define whether they are a tool or a product imbuing a different set of values for the same object. By identifying the spatial separation of persistent human activities, the application of multi-element analysis of anthrosols
have been used to distinguish places of food production, storage, and consumption based on the
accretional elemental buildup in soils caused by each event (Manzanilla 1996; Hutson & Terry
2006; Beck 2007). This is particularly valuable in spaces that lack direct artifact associations.

While middens have been previously discussed at the activity area level, additional
studies have highlighted important considerations when analyzing their spatial configuration;
particularly the study of re-use and recycling of artifacts. The potential role of surface visibility
of artifacts should be considered as a possible connection to their placement within villages as
well as their role in influencing generational potters. This has direct relevance for the production
of Pre-Columbian ceramics in the Lesser Antilles, with older ceramics being ground up as
tempering for late period production (Donahue et al. 1990; Descantes et al. 2009).

The theoretical developments brought up in this chapter help illustrate the complex set of
data and methods necessary to reconstruct and identify the places of human activity. It is the
focus of this research to use anthrosols to first validate interpretations presented by artifactual
evidence, and to use varying midden assemblages to help identify past human activities through
unique elemental signatures.

3.6 Research Questions

How can an archaeology of void spaces represent places full of human activity? The use of
anthrosols, archaeological investigations, and spatial analysis are used to study spaces within a
site that are void of any artifacts and faunal remains. Sites that are lived-in for centuries will
undoubtedly go through reconfigurations and organizational changes, however some spaces
appear to remain void of artifacts throughout the site's history. Can these places be identified,
and can the integration of multi-element analysis provide meaningful evidence of intensive human activities?

Multiple studies suggest that the use of multi-element analysis of anthrosols can help distinguish between different kinds of activity spaces, however the majority of studies have relied first on archaeologically defined activity areas to compare soils with rather than test elemental baselines from objects commonly found in middens and test how they influence elemental signatures associated with a variety of activity areas. To what extent do material remains contribute to unique elemental patterns necessary to distinguish between different ancient activity areas?

How does the integration of anthrosols contribute to our understanding of site? Does a site's largely neutral spaces become meaningful through the addition of artifacts and faunal remains? A great deal of Pre-Columbian archaeology in the Caribbean has been tied to material culture, which in many ways has also become representative of the cultures themselves. How can the use of anthrosols be used to expand our understanding between the relationship of people, place, and things?

Cultural heritage sites have become increasingly threatened due to economic development and environmental impacts. However, political and economic decision making has superseded climate impacts as the primary threat to these sites. While artifacts and structural remains have acted as primary lines of evidence for delimiting sites, areas void of artifacts and structures may prove to be rich with human activity and should be part of the preservation process. Can new techniques established in this research provide a substantive approach to help archaeologists in the Caribbean to identify, protect, and possibly recover cultural heritage that is threatened for
numerous reasons?

3.7 Research Instrument & Design

This research makes use of rapid spot tests for phosphorus (Eidt 1977; Eidt & University of Wisconsin 1984) to shape the first phase of research, particularly the identification of sharp boundaries between high and low phosphorus concentrations. The primary focus of this research is to build on these preliminary findings and evaluate the efficacy of pXRF for studying anthrosols used to identify ancient activity. The first phase of research rapid spot tests for phosphorus, consisted of qualitative measurements that were originally introduced by Robert Eidt during the 1970's, and has since been applied to numerous archaeological investigations throughout the world (Eidt & University of Wisconsin 1984; Lillios 1992; Bjelajac 1996; Thurston 2001; Parnell et al. 2002b; Holliday 2004). The second phase, and primary focus of this research, was the use of a portable X-ray florescence analysis, developed by Bruker Scientific. The author worked closely with the developers of portable XRF (pXRF) technologies, providing an important opportunity to modify and tailor methods to the research questions being studied. The modified pXRF methods designed with Dr. Bruce Kaiser were transferred to Brooklyn College’s Brooklyn Archaeological Research Center under the directorship of Dr. Arthur Bankoff and the Environmental Sciences Analytical Center under the directorship of Dr. Joshua Cheng. Exploratory data analysis and geostatistics allowed for recorded soil chemistry to be spatially mapped throughout the site during both phases of research.
3.7.1 Description of Portable X-ray Fluorescence Analysis

X-ray fluorescence or XRF is a process where electrons are displaced from their atomic orbital positions, creating instability forcing outer electrons to fill in these vacancies, which releases energy (fluoresces) that is characteristic of that element. In order to detect these characteristic energy dispersals, X-ray fluorescence involves a detector that registers this energy and categorizes it by element. The initial step in XRF analysis is the emitting of an x-ray beam containing enough energy to excite the inner orbital shells of the atom forcing the displacement of the electron(s). This occurs once the x-ray beam energy is greater than the binding energy that keeps the electrons in their orbits. Electrons fixed at specific energies determine which orbits they inhabit. The spacing between these orbital shells is unique to the atoms of each element, so that an atom of phosphorus (P) has a different spacing between the electron shells in contrast to potassium (K). Once electrons are knocked out of the orbit, electrons fill these vacancies with electrons from higher orbits, this process is known as fluorescence. Electrons further from the nucleus have higher binding energy, therefore when electrons are ejected close to the nucleus, electrons from the higher energy drop into these vacant orbits with a net loss of energy. The energy lost is equal to the energy difference between the two electron shells which is also defined by their distance and is unique to each element. By calculating the energy lost, we can identify specific elements due to their unique fluorescence characteristics.

3.7.2 X-Ray Fluorescence Limitations for Anthrosols

X-ray fluorescence analysis results in the quantification of total elements, but does not identify compounds these elements are associated with. This creates certain limitations
regarding the analysis of anthrosols, particularly the inability to distinguish between elemental enrichment resulting from anthropogenic input and elemental signatures due to the parent material. The use of p-XRF to study anthrosols does require an assumption that there is homogeneity across sites, despite however, that soils are moved to make buildings, plazas, etc. Since soils are not homogenous and can vary drastically across a single site, it is vital to consider the site’s geological parent materials as well as the impacts of erosion, runoff, and human activities (Macphail et al. 1990; FitzPatrick 1993; Samouëlian et al. 2005). Accounting for these factors aide interpretations, but some ambiguity remains, as will be discussed further in the findings and discussion chapters.

In sites like Winthorpe’s West, Royall’s, and Blackman’s Point which are geologically rich in calcium carbonate (Hill 1966), is expected that calcium readings are going to be considerably high. However, findings from this research suggest that midden counts and elemental readings including calcium continue to correlate despite calcium carbonate rich parent material. A fuller discussion regarding how this compares to volcanic regions is found in Chapter 8: Comparative Interpretation and Comparative Analysis. This may not be the case outside of middens, where exposure to wind, rain, and erosion can act to redistribute elemental concentrations. Therefore, elemental analysis should not be the sole means for interpretation but rather integrated into existing archaeological research frameworks that can be used to generate a more complete understanding of the spaces people lived in and the places they created.

The heterogeneity of soils emphasizes the importance of using multi-element analysis, particularly the integration of phosphorus as a baseline. Phosphorus forms stable compounds across a variety of soil conditions including alkaline and acidic soils making it relatively resistant
to erosion and hydrologic affects. Anthropogenic activities, such as midden dumps and food preparation areas can result in increased phosphorus levels in comparison to neighboring spaces. Other elements, such as calcium and/or potassium, related to middens or food preparation can therefore be compared to phosphorus measurements to study their applicability in identifying activity loci. It should be re-emphasized that the parent material may contribute to high phosphorus readings. Other methods, such as mass spectrometry, are better suited at distinguishing between available phosphorus, often connected to anthropogenic inputs, and stable phosphorus (associated with parent material); however these methods require intensive sample preparation and a full instrumental laboratory to conduct these analysis. This research focuses on the portability and field applicability of recent x-ray fluorescence analyzers that have been developed with archaeologists and have been modified to generate resolutions in-line with laboratory XRF analyzers.

3.7.3 Sampling Selection and Locational Analysis

The penetrating depth of the beam is largely dependent on the material being analyzed. The manner in which XRF analyzers direct their beams, the analysis is limited to the surface. Therefore, the homogeneity or heterogeneity of the material must be considered. Lithics can contain inclusions that may differ drastically in its elemental composition, meaning that the locational analysis of the item being analyzed is critical. For materials like ceramics, surface applications such as glazes, slips, and paints can differ elementally from the body. It is common for materials like this to be scraped off and isolated while being analyzed. For soils, multiple samples are necessary both spatially and contextually, along with repeated readings and agitation between repeated readings.
As the goal is to test the replicability of findings across different cases, soil samples collected varied in age, associated context, and geologic strata. This design is restricted to activities with measurable elemental patterns archived within soils. However, differences between elemental patterns linked to similar activities using multiple case studies may contribute to our insight of previously undetected activities.

Soil samples analyzed for this dissertation were sourced from archaeological excavations, shovel test pitting, landscape survey with a handheld Oakfield soil auger, and soils housed in Antigua’s Archaeological Research Center containing samples from past excavations. Elemental analysis occurred concurrent with the two phases of research described in section 4.1.

### 3.7.4 Rapid Spot Color Tests for Phosphorus

The spot color tests for phosphorus were originally evaluated from approximately 100 Pre-Columbian soil samples from the sites of Indian Town Trail and Seaview in Barbuda as well as an additional 150 soil samples collected using an Oakfield hand-held auger. These samples were tested using the spot color change test for phosphorus, thanks in large part to Dr. Tina Thurston (SUNY Buffalo) who provided guidance and advice in applying this strategy to Pre-Columbian Caribbean contexts. Spot color tests were used to shape more intensive soil sampling for the study of anthrosols.

Spot color testing (Rapid Ptest) is a qualitative measure designed to assess available phosphorus for archaeological prospection, with an emphasis on midden identification. Under this technique additional elements are not tested, with only phosphorus measurements comprising the primary bulk of proxy data. The spot tests employed a five-point scale (0-5)
wherein 0 = absence of P, 1 = mild presence of P, 2 = low-moderate presence of P, 3 = moderate presence of P, 4 = moderate-high presence of P, and 5 = high presence of P. These values were eventually measured using pXRF to generate a statistical range of phosphorus for each number.

### 3.7.5 Multi-Element Pattern Analysis

Multi-element pattern analysis identifies and measures specific elements, which are then characterized through their spatial patterning. Elemental baselines for objects commonly found in Pre-Columbian middens were tested against elemental patterns measured from anthrosols associated with archaeologically defined activity areas. These findings were used to identify unique chemical patterns that could then be tested across a variety of Pre-Columbian sites the the use of spatial analysis and GIS mapping of elemental patterns.

A Bruker Tracer IV pXRF Analyzer was used in the field due to its rugged and portable design. An Olympus DC-4000 Environmental Handheld XRF Analyzer was used during the early stages of this research, but was abandoned due to it's limited range and resolution for studying anthrosols. USGS standards were used to detect each instrument's limitations for studying P, Ca, and K. The Olympus did not detect P baseline values, which resulted in this instrument's exclusion from this study. Both instruments do not measure Carbon, Oxygen, Hydrogen, as well as inert gases.

### 3.7.6 Ethnoarchaeological and Ethnohistorical Comparisons

The use of ethnoarchaeological and ethnohistoric comparisons have played a vital role in multi-element soil analysis used to define the extant of human activity as well as the
interpretation of village organization and community planning. By testing the consistency of soil signatures with archaeologically defined activity loci across different regions and time periods, elemental patterning can become an increasingly effective tool for archaeologists. A number of ethnoarchaeological studies of farms have integrated extensive land-use accounts, oral histories, and archival records documenting the spatiotemporal locations of domestic, work, ritual, and overlapping spaces (Wilson et al. 2006; Shahack-Gross et al. 2003; Shahack-Gross et al. 2003). These studies suggest that despite the variability of elemental concentrations observed in similar human activities, there is often a detectable pattern that is consistent for different activity loci. These findings suggest that the variability in total concentrations are due to natural and cultural pedologic processes, and interpretation should be based on the patterning with concentrations calibrated for local conditions.

For this dissertation, the plantation site of Betty’s Hope in Antigua was selected as an off-site ethnoarchaeological control. Research and excavations have been conducted by Dr. Georgia Fox and Chico State University since 2009, providing a wealth of historical records, land-use maps, archaeological assemblages, and soil samples to help different habitation loci. This off-site control was selected to test the impact of historical land-use and the process of equifinality for elemental pattern analysis (Johnson 1977; Johnson et al. 2007).
Chapter 4. Methods

4.0.1 Introduction

This chapter describes the research methods and materials considered for collecting and analyzing the pedological, archaeological, and spatial data required to address the research questions of this dissertation. The purpose of this study was to compare and evaluate the relationship between anthrosols and their capacity to act as archives using two different approaches for analysis, **Rapid phosphorus Testing** (**Rapid Ptest**) and a full laboratory specified **portable X-ray Fluorescent Analyzer** (**pXRF**). While there is a growing body of literature favoring multi-element soil analysis over any singular elemental component (Linderholm & Lundberg 1994; Holliday 2004; Wilson et al. 2006); phosphorus analysis within an archaeological context remains well understood and has continued to play an important role in describing anthrosols and human activities (Hutson & Terry 2006; Thurston 2001; Lillios 1992). There is, however, a growing concern of phosphorus analysis being incorrectly used by archaeologists to infer findings that would otherwise be incomplete without accounting for additional trace and main component soil elements (Linderholm 2010; Holliday 2004). The selection of elements: P, Ca, K, Fe, Al, Ti, and Si were studied for this dissertation as their deposition can be linked through enthnoarchaeological studies linking them to specific human activities (Middleton & Price 1996; Manzanilla 1996; Wells 2004; Beck 2007).

This dissertation employs two approaches in studying anthrosols, Rapid Ptest, which studies the qualitative distribution of phosphorus and is limited to identifying both middens and the extent of human activity, and pXRF analysis which provides quantitative measurements of phosphorus as well as measurements and identification of trace and main component elements...
used to study anthrosols. Despite the limited interpretive scope of Rapid Ptesting, these methods provided a rough approximation of village shape that could be compared to previously studied Saladoid village configurations (Gent 2004; Drewett & Oliver 1997; Bartone et al. 1997; Righter & Lundberg 1991; Righter 2002). Rapid Ptests helped guide subsequent sampling strategies and placement of shovel test pits, and excavation units. The integration of pXRF analysis within field excavations and soil sampling were used to confirm certain context layers (i.e. hearths) and help distinguish between changes in strata. However, full multi-element analysis of anthrosols required additional post-processing that took place outside of the field where proper soil preparation and statistical analysis could be applied. The dataset used for this dissertation is comprised of anthropogenic soil samples collected from Pre-Columbian sites on Antigua, West Indies. This chapter consists of descriptions for data collection, instrumentation, and analysis procedures.

4.1 Data Collection Procedures

4.1.1 Survey Documentation

After sufficient soil samples were obtained using the Oakfield soil auger, a photographic record was kept of both the ground-cover and survey visibility. These photos were taken with a Nikon Coolpix AW100 which has an embedded GPS receiver and automatically geotags each photo, including the cardinal direction the camera is facing. The resolution for each image taken was at 16mp, and all videos were recorded at 1080p. These files were uploaded into a GIS database using Arcphoto to create a spatially referenced photo log of site conditions for the National Parks. A handheld Garmin Oregon 550 GPS was used to help navigate and record a
unique spatial ID for each auger. Using the soil auger as the center, a surface collection of 5 meters was conducted at each location.

Phosphorus measurements were then conducted in the field and projected onto our field survey database. The rapid feedback in the field provided valuable insight as to whether additional surveys were necessary and what areas required additional focus. This became particularly important in areas where thick ground cover or simply a lack of surface deposits were recorded. Areas showing no surface deposits but high phosphorus concentrations helped identify areas that are often not sampled during excavation strategies.

4.1.2 Rapid Color Ring Test for Phosphorus (Rapid Ptest)

All soil augers were taken to the Antigua Archaeological Research Station to be catalogued and further analyzed. Testing took place on chemistry grade color change filtration paper. Each plate was cut to approximately 6” x 11”, and given a specific plate ID. The plate was then divided into 30 separate spaces, each given its own individual soil ID. An eighth teaspoon of soil was then placed onto each square. Each soil sample was treated with an extraction phase, color change phase, and stop bath.

4.1.2.1 Extraction Phase

The methodology for extraction follows the Caribbean “modified” version of Dr. Tina Thurston’s (2001) field phosphorus analysis used to identify evidence for human activity. The most common acid extractions comprise of hydrochloric, nitric, perchloric, sulfuric, and citric acids. While the comparisons for all acids produce the same general trends, the measured concentrations for phosphorus vary accordingly to molar concentration and type of acid, thus rendering different extraction methods incomparable (Holliday & Gartner 2007). The
combination used for this study combines HCl and Citric Acid. While 2N HCl extracts 10 times as much P as 2% citric acid, citric acid is much better at extracting anthropogenic P. The extraction method used for this analysis makes use of both acids, thus providing ample separation for Available P and Active P.

4.1.2.2 Color Change Phase and Stop Bath

After the extraction of Available P and Active P, an acidic solution of ammonium molybdate is added to initiate a color change reaction. In this process, phosphorus are assigned a qualitative value equatable to the intensity of color change. In order to preserve the color change intensity, each plate was then immersed in a stop bath consisting of sodium citrate and sodium bicarbonate after 2.5 minutes.

4.1.2.3 Documenting Rapid Ptest Values

Additional qualitative measurements such as color change time and ring formation was recorded during in-lab analysis. Video and photographic records were kept during the spot testing of each soil sample with the use of a photo scale. Video was utilized in order to more accurately describe the color change time, and photographs before and after immersion within the stop bath were conducted in order to document the vibrant color intensity prior to the muting affects of the stop bath. Digital photographs provided an additional internal control during qualitative augering. All photos were taken indoors, using the same artificial light source. Flash was not used. Any additional color correction was conducted using Photoshop, in order to calibrate colors using the photo-scale. The color change descriptions are consistent with Thurston (2001), Woods (1977), and Bjelajac (1996). These measures provided an internal control towards variable qualitative measurements. In particular, the tendency to over-value
minute variations when numerous low readings were recorded.
Picture 1: Oakfield auger showing how stratigraphic changes were identified and recovered.

Picture 2: Rapid phosphorus Test prior to stopbath preserving color change. ECB stands for Elliot's augering samples, plate B
4.1.3 Elemental Pattern Analysis - XRF

An analysis of anthrosols provided information about elemental loading and patterning with regard to human activities originating from Pre-Columbian sites. These anthrosols revealed factors that helped shape their subsequent input, intensity, and occurrence levels in particular. While the use of X-Ray Fluorescence within an archaeological setting has been primarily used to study lithic (Milic 2014; Nazaroff et al. 2010) and ceramic sourcing (Hofman et al. 2008; Padilla et al. 2006, recent studies have shown how pXRF kits can be important tools for elemental identification, in particular as an in the field tool (Oonk et al. 2009b; Oonk et al. 2009a; Frahm et al. 2014). As pXRF kits are extremely durable, portable and can be brought out onto site and survey, and are largely non-destructive. Recent innovations have resulted in full laboratory specification pXRF instruments, which are increasingly more sensitive and with increased quantitative accuracy (Shugar & Mass 2012). It is vital to distinguish between these more accurate instruments and pXRF instruments.

4.1.4 Selection of XRF Instrumentation

Recent literature (Speakman 2012) have begun heavily critiquing the use of portable XRF instruments used for archaeological applications such as stone tools (Frahm 2012), ceramics, and metallurgic sourcing. Speakman & Shackley (Shackley 2012) conducted comparative analysis of commercially available pXRF instruments on the market, and have found them to be lacking in sensitivities, competent software, and user defined calibrations. These instruments were originally designed to be user friendly for novices working outside of lab environments predominately in the mining and metals industry. They have recently been marketed to archaeologists who do not recognize that these instruments are simply not applicable for
archaeological studies. Additional concerns have been raised regarding the lack of appropriate software packages used by novice researchers. The majority of these user-friendly software packages identify elements using single peak recognition which poorly characterizes elemental distributions and often results in high user-error and misleading datasets. Multiple light peaks, not single light peaks characterize elements. Often, interpretations from these datasets are impossible due to the lack of control samples used to calibrate instrumental findings. Studies which do not use calibrations such as standard samples provided by USGS (United States Geological Society) and NIST (National Institute of Standards Technology) are incomparable. Some researchers (Frahm et al. 2014) have argued that internal results are still useable and should not be discarded. While this is often true of internal interpretations; the lack of comparable datasets translates into research that remains isolated and unavailable for comparison by outside institutions.

In order to address these pitfalls, there are some pXRF manufactures who have been working with geoarchaeologists in developing instruments which are both sensitive and still maintain field portability. One such instrument, the Bruker Tracer III/IV Analyzer developed by Bruker Scientific and Dr. Speakman, was selected for this study adopting methods appropriate methods for anthropogenic soil analysis (Speakman 2012). USGS standards were used prior to each sample run as described below and identification was made manually by comparing known spectral patterns with spectral results rather than relying on auto-identification features found within the software. This analysis of raw spectrum data was conducted with the assistance of Dr. Bruce Kaiser, Ph.D. of Bruker Instrument who spent time in Antigua visiting the site and helping with sample analysis.
A loan was arranged with Bruker Scientific to continue analyzing samples at Brooklyn College. An Olympus DC-4000 XRF Analyzer, located in Brooklyn College’s Environmental Sciences Analytical Center was initially used to compare findings, although this instrument proved inadequate for the study of anthrosols. The analysis of the Olympus data was conducted under the guidance of Dr. Joshua Cheng, director of the lab.

Once analysis was completed of the soil samples, datasets were generated in Excel spreadsheets and later imported into the study’s CARIBASE, a filemaker based database that will be described in greater detail below.

4.1.5 Analyzing XRF Data

4.1.5.1 Controls

Prior to XRF analysis, soil samples were thoroughly mixed and fifty grams of soil were measured and placed within non-reactive plastic XRF soil containers. Prior to reading samples, a control reading was taken using USGS Powdered reference material AGV-2, of known material type Andesite. Readings were tested against known weight percentages and are included in Appendix A.

4.1.5.2 Soil Preparation

One of the advantages of using an pXRF instrument for elemental analysis is the minimal soil preparation required. While fine sieving is a standard form of soil preparation, soil analysis conducted for this study found that the variability in soil compaction and composition translated into some soils that were so compact that they simply could not be screened. Under closer inspection, broken up shell and bone were present in soils. All soils were fine sieved to separate
our as much material remains that might skew measurements. Contamination was also a concern regarding the sieving of soils, meaning that between sample screenings, the sieve had to be cleaned and dried. Compact soils were dried and ground up as consistent as possible in order to make a relatively homogenous mixture.

4.1.5.3 Reading Samples

Two XRF readings were taken for every soil sample with soils being agitated between readings. Certain materials require particular attention to the surface areas being analyzed. Items such as ceramics and lithics are not often homogenous, which can result in a wide range of element readings dependent on the location being analyzed. The selection of ceramic fragments meant that surfaces and bodies could be tested. Soils, however are ideal for pXRF analysis, as they are generally homogenous. Recent advances, and instrumental calibrations have resulted in instruments that are capable of analyzing main component elements such as phosphorus, magnesium, potassium, and calcium (Speakman 2012); Kaiser Pers Com 2013; see Chapter 5.1.a for validation of instrumentation).

4.1.5.4 Excavation Methods

Excavations were conducted to obtain soils from stratigraphic layers that could be compared with associated archaeological assemblages. While soil samples were available from past archaeological excavations, they were sometimes collected mechanically in artificially defined layers (10 cm intervals). Prior excavations did not always collect soil samples from small lenses or mottled soils indicative of changing context layers. The use of the portable XRF was used in the field for rapid identification of these lenses and potential features providing immediate feedback while in-field inform. General counts were made for ceramics, lithics, shell,
and bone when possible; with more extensive analysis of material remains being conducted by collaborating scholars and Ph.D. students.

4.1.5.5 Archives and Historical Documents

Historic maps and land-use registries from the 17th - 20th centuries were housed at the Saint John’s downtown museum, while archival notes from previous archaeologists were housed at The Dockyard Museum in English Harbour. These resources provided invaluable maps and physical descriptions of historical land-use and land-cover change, on-going coastal erosion threats, and hydrologic changes. The use of aerial and satellite imagery from the past 50 years were used to assess recent disturbances, particularly resulting from intensive farming practices. The use of large mechanical ploughs have resulted in some sites, such as Elliot’s, being churned and exposing sterile soils. Increasing development around Pre-Columbian sites such as Doig’s and Indian Creek have posed immediate threats to these intact village sites. Land clearing and road cutting have increased soil erosion in these already unstable areas (Hill 1996) altering the hydrology and movement of soils. These maps were georeferenced using GIS software and were used during the initial planning phase of research to collect soil samples. Notes were recorded in-field of potential site impacts and disturbances, while photos and a GPS record were maintained for archival purposes.

4.1.6 Data Collection and Statistical Analysis

This section describes the major components involved in data preparation and data analysis
4.1.6.1 Database

All data collected in the field was entered into CARIBASE, a Caribbean specific database designed using Filemaker Pro 12. This database was designed to help record soil analysis from excavations, shovel test pits, augers, and previous excavations, as well as their context, associated assemblages, and geospatial reference. CARIBASE served as an important depository for data, as well as an intermediary data format that could be exported in multiple formats for use in GIS and statistical analysis packages.

4.1.6.2 Statistical Software

The use of bivariate analysis compared compositionally similar elemental groups and evaluated their ability to distinguish features and habitation loci into behaviorally and spatially meaningful groups (Middleton 2004). This approach helped measure the impact of independent variables such as human activities, climate, and erosion on elemental patterns. The statistical analysis was conducted using SPSS 21 and mac specific Wizard 1.3.15 and Datagrapĥ statistical software packages for analysis.

4.1.6.3 Bias and Error

One of the advantages of a multiple case studies approach is that the researcher can analyze phenomena within each setting and across settings, thus creating an adaptable model for studying the causal links between archivable human activities and soils. This same advantage translates into challenges regarding the transferability of “regionally” adapted methods. The use of recording forms and an integrative database provided constant checks for maintaining
consistent collection and recording strategies.

The use of a hand auger severely limited the soil depth obtained from augering, despite previously discussed modifications made to the device. This posed particular problems for dense middens greater than 50 centimeters. In order to evaluate the reliability for this method to produce representative soil samples, Doigs and Indian Creek were selected in order to test soil augers against excavated middens and shovel tests systematically. An additional concern stems from the soil sampling intervals. During the pilot study, soil augers were collected at ~20 meter intervals throughout the limits of each site. As these results were analyzed and mapped, the spatial distribution of phosphorus helped locate and shape the second wave of soil sampling which was conducted at ~10 meter intervals, or in smaller clusters depending on the spatial anomaly. Despite the internal process of refinement, this sampling strategy can miss important and/or vital features connected to Pre-Columbian village activities. The refinement to 10 meter intervals were based on the consideration that local activity areas within Pre-Columbian villages tend to be less than 20 meters from areas of high activity (Righter & Lundberg 1991; Bartone et al. 1997; Hofman et al. 2001; Drewett 2000; Gent 2004). Regardless, it is recognized that smaller intervals may result in increasingly destructive sampling patterns and have the opposite affect for interpretation.

4.1.6.4 Summary

In designing this study, the author recognized that the “reliability and validity should not be evaluated at the end of the project, but should be goals that shape the entire research process; influencing study design, data collection, and analysis choices” (Cohen & Crabtree 2006).

This chapter is represented as a synergistic confluence of these goals, and presents a
description of the subsequent organizational structure and methodologies used. The next chapter presents the results and findings of this work.
Chapter 5. Establishing Baselines

This chapter presents both an evaluation of new innovations in pXRF technology and the subsequent study and analysis of anthrosols collected from Pre-Columbian sites on the island of Antigua. As discussed in the previous chapter, there were broad critiques involving the use of pXRF technology within archaeological context, primarily the need for calibration and appropriate detection limits for major elements being studied.

Section 5.1 compares the USGS powdered reference sample AVG-2 made of andesite from Guano Valley, in Lake County, Oregon with values established across twenty-three international laboratories using round-robin measurements. Twenty pXRF measurements were taken at thirty-second intervals; all elements fell within one standard deviation or recommended tolerance established by the USGS except for one reading out of twenty where an element fell within two standard deviations.

Section 5.2 presents findings on pXRF measurements taken of various reference samples commonly found within archaeological sites. These measurements are used to understand how Bruker’s pXRF technology characterizes these materials, as well as create a multi-element breakdown of elemental concentrations associated with each material type.

Chapter 6 uses established baselines and instrumental thresholds from Chapter 5 and presents new findings from anthrosols collected across a variety of context acquired through excavations, shovel test pits, and soil augers.
5.1 Instrument Validation

The primary objective for instrument validation is to characterize and identify elemental detection limits from known reference samples and evaluate their capacity to distinguish between datasets arising from archaeological and natural processes.

5.1.1 X-Ray Fluorescence Analysis: Testing custom calibrations

This section presents the pXRF findings for AVG-2, a powdered standard created by the USGS used to determine the limits of instrumental detection and calibrate for external comparisons. The evaluation of Bruker's Tracer IV Portable X-Ray Fluorescence Analyzer was carried out by analyzing AVG-2 for 30 seconds and was agitated between readings. Findings were reported in Table 1, comparing USGS's reported values and accepted standard deviations with Bruker's pXRF readings as reported in % weight. Additional USGS powdered reference samples were analyzed for future studies, but are not part of the central focus of this dissertation.

<table>
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<th>pXRF Measured</th>
<th>difference from actual</th>
</tr>
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<td></td>
<td>avg wt%</td>
<td>+/-</td>
<td>avg wt%</td>
</tr>
<tr>
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<td>0.11</td>
<td>8.880631579</td>
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<td>2.378736842</td>
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<td>0.09</td>
<td>3.713052632</td>
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<tr>
<td>Fe</td>
<td>4.68</td>
<td>0.09</td>
<td>4.675421053</td>
</tr>
</tbody>
</table>

Table 1: Current calibrations vs Actual Standards Average % Weight (%wt)
5.1.1.1 Mean Elemental Readings Used for Calibration

Calibrations were setup for aluminum, silicon, phosphorus, potassium, calcium, titanium, and iron; the primary elements analyzed for this dissertation. 19 readings were obtained (see tables 2-8) for the USGS powdered reference sample AVG-2 made from andesite collected from the eastern side of Guano Valley in Oregon. Comparisons of weight percentage from AVG-2 (see Appendix A1) and the mean values of the readings (n=19) by the Tracer IV pXRF fell within the reported standard deviation range provided by the USGS (see Table 1). All elements fell below 1% difference from the actual average weight percent given by the USGS, except for phosphorus which was 6.46% from the actual average percent weight or within two standard deviations. The phosphorus represents 0.21% of the entire AVG-2 sample, thus testing the lower limits of the Tracer IV. This measurement falls well within the acceptable range established by independent laboratories working with the USGS standards department.

These findings are significant, in particular for the study of anthropogenic sediments to combine portability and quantitative accuracy in the field, which greatly enhances our ability to refine and re-focus on-going sampling strategy. As discussed in the previous chapter, there is a great deal of criticism regarding the use of portable XRF instruments which often lack the capability of detecting elemental variation within anthrosols as well as conduct internal calibrations. An early trial for this study, was initiated at the Brooklyn College Soils Laboratory using their Olympus DC-4000 XRF Analyzer which proved inadequate for detecting low concentrations of phosphorus in the AVG-2 standard. Similar issues were found quantifying calcium and potassium, which led to the abandonment of this instrument in favor of Bruker's Tracer for this study.
Tables 2-8 present individual readings for each element analyzed using the USGS AVG-2 sample, along with additional analysis showing the spread, frequency, and boxplot (Charts 1-21) comparing reported values with recorded values. This is discussed in the following section.
Chart 3: Top - Histogram for Al measurements for %weight. Bottom: Density curve providing the calculated confidence interval.

Table 2: AGV-2 Aluminum

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Chart 4: X-RF Readings for Al with % Weight

Chart 5: pXRF Readings with % weight boxplot
Table 3: pXRF Readings with % weight

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Chart 6: Top - Histogram for Ca measurements for % weight. Bottom: Density curve providing the calculated confidence interval.

Estimated mean = 3.713 ± 0.01

Chart 7: pXRF Readings for Ca with % weight

Chart 8: pXRF Readings with % weight boxplot
**Chart 9:** Top - Histogram for Iron (Fe) measurements for % weight. Bottom - Density curve providing the calculated confidence interval.

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**Table 4:** pXRF Readings with % weight comparing USGS Standard AGV-2 for Fe

**Chart 10:** pXRF Readings for Al with % weight

**Chart 11:** pXRF Readings with % weight boxplot
Chart 12: Top - Histogram for Potassium (K) measurements for % weight. Bottom - Density curve providing the calculated confidence interval.

Estimated mean = 2.379 ± 0.015

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Table 5: pXRF Readings with % weight comparing USGS Standard AGV-2 for K

Chart 13: pXRF Readings for K with % weight

Chart 14: pXRF Readings with % weight boxplot
Chart 15: Top - Histogram for phosphorus (P) measurements for % weight. Bottom - Density curve providing the calculated confidence interval.

**Estimated mean = 0.197 ± 0.014**

Table 6: pXRF Readings with % weight comparing USGS Standard AGV-2 for P

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Chart 16: pXRF Readings for P with % weight

Chart 17: pXRF Readings with % weight boxplot
**Table 7: pXRF Readings with % weight comparing USGS Standard AGV-2 for Si**

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<tr>
<th>FileID</th>
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<tr>
<td>AGV-2 USGS</td>
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**Chart 18: Top - Histogram for Silicon (Si) measurements for % weight. Bottom - Density curve providing the calculated confidence interval.**

**Estimated mean = 27.686 ± 0.094**

**Chart 19: pXRF Readings for Si with % weight**

**Chart 20: pXRF Readings with % weight boxplot**
Chart 21: Top - Histogram for Titanium (Ti) measurements for % weight. Bottom - Density curve providing the calculated confidence interval.

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<td>AGV-2 SAMPLE 1 TEST 18 15 KV@240914_220754</td>
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Table 8: pXRF Readings with % weight comparing USGS Standard AGV-2 for Ti

Chart 22: pXRF Readings for Ti with % weight

Chart 23: pXRF Readings with % weight boxplot
5.1.1.2 USGS AGV-2 vs Individual pXRF Readings

The estimated mean, standard deviation, spread, and boxplot analysis (Charts 1-21) has been provided for each element to illustrate the accuracy of individual readings and the variability between readings (Tables 2-8).

The measurements taken with Bruker's Tracer IV-HD pXRF of the USGS AGV-2 standard proved acceptable for the study of anthropogenic soils, particularly the measurements of phosphorus, calcium, potassium and iron. The variability between redundant measurements were within acceptable range. These limits were set by the USGS using a round-robin study involving 23 international labs. Elemental concentrations rely on three or more independent labs using three or more independent analytical procedures are in statistical agreement. The maximum recorded range for each element was included in table 1 (right column) to further illustrate the accuracy of the instrument. The variability between individual readings were related to the limitations in both the instrument's depth of X-ray penetration being used to analyze, the homogeneity of the sample, and the sample preparation. As discussed in the method's Chapter 4, high energy elements have increasingly decreased depth of X-ray penetration, and thus measures closer to the surface of the interface between the beam and the substance. The AVG-2 standard made from andesite, was converted into a powdered substance. As the sample is mixed before each reading, it is expected that the orientation of powdered particles will shift and result in variable readings. This method was selected to account for the variabilities found when mixing soil samples being analyzed for this study, and a further discussion can be found in the methodologies chapter.
5.2 Measuring Reference Samples

5.2.1 Reference Materials Selected

Materials were selected to help characterize commonly found refuse deposits to establish baseline patterns which could be used to model habitation loci from associated soils. These materials consisted of artifacts and ecofacts commonly found within Pre-Columbian Caribbean archaeological context, and are organized into the following categories: ceramics, coral, crab, lithics, plant, shell, and bone (see table 9). There are relatively few studies comparing elemental loading and midden formation (Parnell et al. 2001; Wells 2004; Beck 2007) particularly how counts and relative abundance relate to elemental loading. Questions remain whether elemental loading is the by-product of a mosaic of material types or rather any individual artifact or ecofact. Reference materials were also selected to gauge the variability in elemental loading potential to further understand how one activity, such as food processing, may supersede other activities such as lithic production which may have a decreased elemental loading potential.

<table>
<thead>
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<th>REFERENCE TYPE</th>
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<td>AFROANTIGUAN WARE</td>
</tr>
<tr>
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<td>PRECOLUMBIAN CERAMICS</td>
</tr>
<tr>
<td>CORAL</td>
<td>CORAL</td>
</tr>
<tr>
<td>CRAB</td>
<td>CRAB</td>
</tr>
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<td>LITHICS</td>
<td>LONG ISLAND FLINT</td>
</tr>
<tr>
<td></td>
<td>JADE</td>
</tr>
<tr>
<td></td>
<td>PUMICE</td>
</tr>
<tr>
<td>PLANT</td>
<td>GREEN PLANT</td>
</tr>
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<td>WOOD</td>
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<td>SHELL</td>
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<td>BONE</td>
<td>BIRD BONE</td>
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<td></td>
<td>FISH BONE</td>
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<td></td>
<td>HUMAN BONE</td>
</tr>
<tr>
<td></td>
<td>TURTLE BONE</td>
</tr>
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<td>RODENT BONE</td>
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Table 9: List of reference material types tested using the pXRF
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<th>REFERENCE TYPE</th>
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<th>Pmg kg-1</th>
<th>Kmg kg-1</th>
<th>Camg kg-1</th>
<th>Almg kg-1</th>
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Table 10: Reference Material Mean Values
Chart 24: pXRF measurements in parts per million (mg kg⁻¹) of various reference types, including ash.
Chart 25: pXRF measurements in parts per million (mg kg⁻¹) of various reference types.
5.2.1.1 pXRF measurements of Reference Materials

pXRF measurements of reference samples reveal the various elemental signatures for different materials found within archaeological sites. Each reference material was measured in its solid form, rather than ground. Multiple measurements were taken at different locations, in particular heterogenous objects such as ceramics and lithics, to account for the instrument’s depth of X-ray penetration limits.

Elemental patterns were isolated for each reference material and contrasted with artifacts or ecofacts that maybe found associated with one another. One such example, is the organic refuse like bone, shell, and fueess which gradually breaks down through diagenesis and wood ash produced from the act of cooking. While both maybe rich in phosphorus, calcium, and potassium (see Chart 24 vs 25), testing reference materials against one another can help characterize cooking spaces from consumption spaces.

5.2.1.2 Variation in pXRF of Reference Materials of Differing Composition

5.2.1.2.a Ceramics

The samples selected for this comparison consisted of Pre-Columbian ceramics from Doigs and Indian Creek (n=9) and the historical site of Betty's Hope Sugar Plantation (n=44). Separate pXRF readings were taken of the surface and body (e.g. exposed fabric resulting from fracture) for all ceramics including slips when applied. Ceramics sampled from Betty's Hope consisted primarily of Afro-Antiguan ware, without a lack of a better term, these ceramics were recovered from a diverse spread of context and are considered unrefined earthenware created from locally available clays. A further discussion of these ceramics will be found in the disserta-
tion of Genevieve Godbout from the University of Chicago. Multiple excavations from Ms. Godbout provided a wealth of Afro-Antiguan samples centered around 18th century (Pers Comm) domestic and work spaces. Currently, a typology for Afro-Antiguan wares have not been synthesized and it is assumed for this study that ceramics comprising this assemblage range from 17th-20th centuries.

The mean values for Afro-Antiguan wares were higher in iron, aluminum, titanium, silicon, potassium, and phosphorus over Pre-Columbian wares (Table 10); although both wares were relatively rich in iron, aluminum, and titanium. Pre-Columbian wares consistently measured higher in calcium (Ca) (55,127 mg kg-1 vs 49,205 mg kg-1). This higher concentration of Ca maybe the result of differing clay sources; although mean Ca mg kg-1 from Betty's Hope soils were 126,149 mg kg-1 vs Doig's soils were 57,371 mg kg-1. Additional possibilities maybe associated with the Saladoid practice of crushing shells and incorporating them into ceramics as tempering (Donahue et al. 1990; Petersen & Watters 1995). Ceramics can exhibit very wide ranges of elemental patterns due to cultural phenomenon such as accessibility to clay sources or manufacturing practices and natural proceses affecting clay formation such as geologic, pedologic, and climatic conditions.

5.2.1.2.b Lithics

Samples of Long Island chert, jadeite, and pumice were selected from the sites of Indian Creek and Coconut Hall for study. Long Island flint, originating from the small island off the northeast coast of Antigua, were measured for elemental patterning. All samples tested were worked pieces of flint, where exposed flesh could be tested against the outer rind. Antigua tuff cherts have been extensively analyzed by Sebastian Knippenberg's work studying stone artifact
production and exchange throughout the Lesser Antilles (Knippenberg 2007). It should be noted that a great deal of elemental variability can be present in cherts, and that the samples tested may not reflect the overall elemental patterning for Long Island flint. The mean values for samples tested were: aluminum at 18,301 mg kg-1, calcium at 768 mg kg-1, iron at 750 mg kg-1, titanium at 160 mg kg-1, and potassium at 913 mg kg-1. Knippenberg sampled five different localities all showing a diverse makeup and range, and while the elemental composition of aluminum, calcium, iron, titanium, and potassium were consistent; each regional sample contained significantly different elemental ratios adding further caution (Knippenberg 2007/56).

Compared to other reference materials Long Island flint had relatively low concentrations of all trace-elements except silicon at 700,000 mg kg-1 (Chart 24), which was higher than all except Jadeite at 700,327 mg kg-1. Jadeite, while not local to Antigua has been found in Pre-Columbian sites, contained the highest quantities of iron at 203,677 mg kg-1, aluminum at 18,301 mg kg-1, titanium at 16,903 mg kg-1, and silicon at 1,813,326 mg kg-1. Recent studies (Harlow et al. 2006; Garcia-Casco et al. 2013) suggest that these Jadeite samples maybe sourced to Guatemala (North and South Motagua Fault melanges); although regional studies have suggested more local sources for Jadeite such as Cuba (García-Casco et al. 2009). Pieces of pumice have been found throughout multiple Pre-Columbian sites in Antigua (Murphy 1999), and were tested from the site of Indian Creek which contained moderate quantities of iron, aluminum, titanium, silicon, calcium, and potassium. Pumice was found to be relatively low in phosphorus.

Not surprisingly Long Island flint, jadeite, and pumice samples provided unique patterning associated with their geologic formation and environment.
5.2.1.2.c Vegetation, Wood Ash, and Shell Ash

pXRF measurements were taken of leaves and wood from a Wild Tamarind. Green leaves from the tamarind tree measured higher in both phosphorus (9,358 mg kg\(^{-1}\) vs 9150 mg kg\(^{-1}\), and potassium at 120,865 mg kg\(^{-1}\) vs 99,834 mg kg\(^{-1}\); while the bark and flesh of the wild tamarind tree measured higher in calcium at 136,455 mg kg\(^{-1}\) vs 61,671 mg kg\(^{-1}\), and iron at 6,108 mg kg\(^{-1}\) vs 2,910 mg kg\(^{-1}\). These measurements have particular significance for Pre-Columbian horticultural and proto-agricultural practices, in particular the use of root crops like manioc and cassava as well as the practice of slash and burn. As root crops are dug out for extraction, the remains of wood and leaves are often left behind gradually replenishing and maintaining soil fertility. The practice of slash and burn, takes advantage of the resulting chemical composition of wood ash which is rich in either calcium carbonates or calcium oxides, as well as iron oxides. The pXRF measurements are consistent with these findings of wood versus the leafy portion of vegetation. The wood ash samples were analyzed and found to have significantly higher phosphorus (64,690 mg kg\(^{-1}\)), calcium (1,942,015 mg kg\(^{-1}\)), iron (97,318 mg kg\(^{-1}\)), and silicon (300,646 mg kg\(^{-1}\)) than either unburned wood or leaves (Chart 24). This is the by-product of condensing vegetation into a fine ash. Ash samples #1 and #2 were wood ash, while ash #3 and #4 were burnt wood ash mixed with shell ash. While phosphorus was found to be high in both samples, there was an inverse relationship between calcium and potassium where burnt shell ash had higher calcium mg kg\(^{-1}\) and lower potassium mg kg\(^{-1}\) relative to wood ash.

A preserved archaeological wooden post was tested from the site of Doigs (PA15), excavated by the University of Calgary team in conjunction with the geomagnetic survey conducted by Brock as discussed in the previous chapter. The preserved wooden post sample was signifi-
cantly lower in phosphorus (2,299 mg kg⁻¹), potassium (5,943 mg kg⁻¹), and titanium (841 mg kg⁻¹) than the modern wood sample. These decreased measurements provide important clues to the gradual decay and diagenesis of wood samples within the archaeological record. Increased measurements of silicon (75,049 mg kg⁻¹) and iron (11,846 mg kg⁻¹) were most likely due to the process of diagenesis driven by the local burial environment (Farnum et al. 1995).

5.2.1.2.d Faunal

a) Bones

The role of diagenesis is critical in understanding elemental loading from bone refuse. Bone is a composite of one-third organic and two thirds mineral, with calcium and phosphorus comprising the majority of this matrix; where mineral loss is driven by microbial attack, pH and soil water composition (Hedges 2002).

The area of bone exposed is related to the amount of bone loss observed, and the samples measured seem to be generally consistent with these observations. Human bone dominates the highest concentrations of phosphorus (68,447 mg kg⁻¹), potassium (7,890 mg kg⁻¹), aluminum (32,808), and iron (14,561 mg kg⁻¹) in contrast to bird and fish bones (see Table 10, Chart 23). This is consistent with the thickness of compact bone in human bone samples versus bird and fish. Calcium measured in human bone (304,179 mg kg⁻¹) was found to be considerably close to rodent (286,460 mg kg⁻¹) and fish (233,680 mg kg⁻¹) bones respectively. Of particular interest, are the low fish bone measurements recorded for phosphorus (610 mg kg⁻¹), considering their substantial occurrence in early and late Saladoid middens; however their contribution maybe a by-product of both the quantity of deposition and other organic components that do not preserve
in the archaeological record contributing to elemental loading. Modern turtle bones analyzed were found to be relatively high in titanium (13,754 mg kg-1) as well as fish bones (7,674 mg kg-1) compared to mammalian bones such as human (3,063 mg kg-1) and rodent (7,318 mg kg-1). It should be noted that the dramatic loss of phosphorus from modern fish bones (7,674 mg kg-1) to archaeological fish bones (610 mg kg-1) is dramatic. While additional research is needed to expand upon these early findings, the differential effect of diagenesis across material type does vary considerably.

b) Mollusks, Coral, and Crab

While diagenesis of mollusks are the byproduct of the gradual breakdown of their calcium carbonate exoskeleton, more immediate impacts maybe the result of direct firing of mollusks which can result in a fine shell ash that is rich in calcium. Mollusks such as S. gigas and C. pica can be used for food and as raw materials for tool making. Bivalves consistently measured higher in calcium than sea snails, chitons, and whelks; which is consistent with elemental studies of mollusks (Ituen 2015). Mollusks measured the highest in calcium at 465,058 mg kg-1, followed by crab 447,874, and coral 124,656 mg kg-1. Human bone in comparison measured 304,179 mg kg-1. Coral has been found in Pre-Columbian toolkits for their abrasive properties. Staghorn coral, in particular, has been found in a number of sites in Antigua and Barbuda showing various signs of use wear. Corals tested measured the highest for potassium (9,826 mg kg-1), silicon (160,253 mg kg-1), titanium (2,849 mg kg-1), and iron (34,121 mg kg-1). Measurements for coral contained higher potassium mg kg-1 than was measured in human bone (7,890 mg kg-1). Crab shells represent the most fragile of the aforementioned species measured. Crab shell remains are often found to be highly fragile and fragmented. This makes counting crab
shells in middens difficult, as their fragile state results in increasing NISP counts from site to lab. Similar to mollusks, crab fragments can occur in highly fragmented pieces. Crab shells had an average phosphorus measurement of (8,905 mg kg⁻¹) which was significantly higher than mollusks (1,211 mg kg⁻¹) and coral (5,767 mg kg⁻¹).

### 5.2.2 Fisher Correlation & Bivariate Analysis

Based on the previous section's findings, elemental comparisons used to study anthropogenic activities were compared using Fisher Correlation and bivariate analysis. The Fisher Transformation Coefficient is a surrogate of the Pearson Correlation Coefficient, and results in the same p-value; where p-value < 0.05 is highly significant.

Bivariate analysis was then selected to compare elements that show strong correlations, and compare these relationships across a range of material types to see whether these characteristics could be used to distinguish between them.

#### 5.2.2.1 P vs Ca

Highest measurements for both calcium and phosphorus were found in both mollusks and bones due to their physical makeup. While both elements were detectable, the average measurements of calcium for mollusks were found to be 2.3 times higher than that measured in bone (see table 10). Eight commonly found mollusks were selected for this analysis and were found to be consistently higher than bone. Using the Fisher transformation coefficient analysis, a positive correlation between phosphorus and calcium was observed for both bone and ceramics (Chart 26 & 27). Bone p-value was calculated at p < 0.047, although data was much more variable than ceramics. This maybe the by-product of differences between bone density, structure, and make-
up. Fish bones, particularly the species found in Pre-Columbian Caribbean middens, are generally not as dense as human or rodent bones.

Terrestrial and aquatic bones were selected as references, and were found to be rich in calcium along with plant remains tested, although bone refuse was found to be extremely variable in their phosphorus content. Fish, turtle, and rodent bones were found to have similar phosphorus levels as did mollusks; although human bones tested highest for phosphorus measurements overall (Chart 25). While there is a great deal of phosphorus overlap between mollusks and bones, the differences observed for calcium did allow for spatial separation. Of particular significance, the bivariate comparison of calcium and phosphorus demonstrates a clear separation between ceramics, bone, and mollusks. The plant measurements overlapped with much of the ceramics tested.
Chart 26: Ceramics Fisher Transformation Test: (correlation test, \( p < 0.001 \)) A positive correlation exists between \( P \text{ mg kg}^{-1} \) and \( Ca \text{ mg kg}^{-1} \). \( z = 5.275, C - 1.96 \), Significant? \([z > C] = \text{yes}\)

Chart 27: Bone Fisher Transformation Test: (correlation test, \( p < 0.047 \)) A positive correlation exists between \( P \text{ mg kg}^{-1} \) and \( Ca \text{ mg kg}^{-1} \). \( z = 1.983, C - 1.96 \), Significant? \([z > C] = \text{yes}\)
5.2.2.2 K vs Fe

Using the Fisher transformation coefficient analysis, a positive correlation between potassium and iron was observed for ceramics (Chart 28). Ceramic p-value was calculated at $p < 0.001$, with potassium measuring in higher proportions than iron, suggesting a much wider spectrum of variability for potassium, although iron measurements represented a wider degree of variability measuring between 32,662 mg kg$^{-1}$ and 487,174 mg kg$^{-1}$. The ceramics selected as reference materials, came from a variety of archaeological excavations from the sugar plantation site of Betty's Hope as well as the Pre-Columbian sites of Doig's and Indian Creek. Only a limited number of Pre-Columbian ceramics were tested as reference materials to help establish a relative framework to compare reference types and not to identify it's origins. The variability in iron suggests local acquisition of clay resources, which will be discussed in greater detail towards the end of the chapter comparing ceramics and soils.

Plant remains measured highest for potassium with only moderate values for iron. Leafy plants, stems, branches, and hard wood were selected for this study. While modern vegetation tested high for potassium, while archaeological wooden post fragments excavated from PA15 tested at relatively low levels (modern wood at 99,834 mg kg$^{-1}$ vs 5,943 mg kg$^{-1}$). These findings maybe helpful in understanding the rate of diagenesis in wood with respect to elemental enrichment of soils. The bivariate comparison of iron and potassium distinguished mollusks, bones, and ceramics. These findings elucidate both the promise and potential of furthering these studies in order to understand the process of diagenesis within an archaeological context (Chart 25).
Chart 28: Ceramics Fisher Transformation Test: (correlation test, \( p < 0.001 \)) A positive correlation exists between K mg kg\(^{-1}\) and Fe mg kg\(^{-1}\). \( z = 5.77, C = 1.96 \), Significant? \([z > C]\) = yes
5.2.2.3 P vs K

Chart 29: Plant/Vegetation Fisher Transformation Test: (correlation test, p < 0.001) A positive correlation exists between P mg kg⁻¹ and K mg kg⁻¹. z = 3.185, C - 1.96, Significant? [z > C] = yes

Using the Fisher transformation coefficient analysis, a positive correlation between phosphorus and potassium was observed for plants and vegetation (Chart 29). The p-value was calculated at p < 0.001, with potassium measuring highest for modern hard wood. While sample size is relatively small, concentrated phosphorus and potassium are consistent with the chemical makeup of plants and hardwood highlighting their importance in shaping and maintaining the fertility of arable soils. These findings have particular relevance into how garden plants and local vegetation were managed. Large portions of elemental enrichment rely on plants and vegetation to be maintained in the same location, due to their process of diagenesis when losing leaves and branches. With respect to tubers and root crops, consistent planting and removal from soil can result in rapid depletion of soil nutrients.
The use of slash and burn as well as the burning of wood for fuel can result in ash that is enriched with phosphorus, calcium, and aluminum; all vital to sustaining fertile soils.
5.2.2.4 K vs Ca

Chart 30: Shell Fisher Transformation Test: (correlation test, p < 0.001) A positive correlation exists between K mg kg\(^{-1}\) and Ca mg kg\(^{-1}\). \(z = 3.185\), C - 1.96, Significant? [\(z > C\)] = yes

Using the Fisher transformation coefficient analysis a positive correlation between potassium and calcium was observed with shells and mollusks (Chart 30). The p-value was calculated at \(p < 0.001\), with bivalves measuring the highest for both both potassium and calcium. Burnt shells have commonly been used to make calcified lime and used as feed for livestock (Ituen 2015). Burnt shells have also been found in Pre-Columbian hearths and are susceptible to breaking down into a type of shell ash.
5.2.2.5 Ti vs Si

Using the Fisher transformation coefficient analysis, a positive correlation between titanium and silicon was observed for both ceramics and plants/vegetation (Chart 31 & 32). The p-values were calculated at $p < 0.001$ for both. Bone, ceramics, and lithics were found to share similar concentrations of titanium and silicon; and were not distinguishable from one another. Jadeite (16,903 mg kg$^{-1}$) and turtle bone (13,754 mg kg$^{-1}$) measurements represented the highest titanium values while shell (21 mg kg$^{-1}$) and Long Island flint (160 mg kg$^{-1}$) represented the lowest measured. Jade and Long Island flint represented the highest silicon measurements, which is consistent with their geologic makeup, particularly the enormous silicon dioxide microcrystals present within chert formed in limestones. As silicon is one of the most abundant elements on earth, and is a major component of the earth's crust; many common minerals contain high concentrations of silicon. The Jadeite sampled was also found to measure highest in aluminum which is consistent with it's chemical makeup (Chart 27). The relatively low levels of titanium helped discriminate shell/mollusks from other reference materials.
Chart 31: Ceramics Fisher Transformation Test: (correlation test, $p < 0.001$) A positive correlation exists between Ti mg kg$^{-1}$ and Si mg kg$^{-1}$. $z = 5.77$, $C - 1.96$, Significant? $[z > C] = \text{yes}$

Chart 32: Plant/Vegetation Fisher Transformation Test: (correlation test, $p < 0.001$) A positive correlation exists between Ti mg kg$^{-1}$ and Si mg kg$^{-1}$. $z = 5.215$, $C - 1.96$, Significant? $[z > C] = \text{yes}$
5.2.2.6 Al vs Ti

Using the Fisher transformation coefficient analysis, a positive correlation between aluminum and titanium was observed for both ceramics and shells (Chart 33 & 34). The p-values were calculated at $p < 0.001$ for both. The bivariate analysis of aluminum and titanium helped discriminate between shell, ceramics, and bone similar to the bivariate analysis of potassium and iron. Coral (56,836 mg kg$^{-1}$), green leafy vegetation (13,691 mg kg$^{-1}$), and human bone (32,808 mg kg$^{-1}$) all contained the highest organic quantities for aluminum; while sea turtle bone, rodent, and fish contained the highest titanium values measured using pXRF analysis as observed in Table 11. It is important to emphasize that these organic remains were modern samples used for comparative purposes. Only the sea turtle skeletal remains were subjected to diagenesis using store bought sand for six months stored in plastic bins on the roof of the University as part of Dr. Sophia Perdikaris’s zooarchaeology lab. Jadeite (16,903 mg kg$^{-1}$), Afro-Antiguan ware (119,926 mg kg$^{-1}$), and the white slip found on Saladoid white on red ceramics (80,017 mg kg$^{-1}$) were measured highest in aluminum. Bones generally averaged lowest in aluminum with fish bones (1,745 mg kg$^{-1}$) representing the lowest of the spectrum (Chart 28).
Chart 33: Ceramics Fisher Transformation Test: (correlation test, \(p < 0.001\)) A positive correlation exists between Al mg kg\(^{-1}\) and Ti mg kg\(^{-1}\). \(z = 12.138\), \(C = 1.96\), Significant? \([z > C] = \text{yes}\)

Chart 34: Shells Fisher Transformation Test: (correlation test, \(p < 0.001\)) A positive correlation exists between Al mg kg\(^{-1}\) and Ti mg kg\(^{-1}\). \(z = 3.482\), \(C = 1.96\), Significant? \([z > C] = \text{yes}\)
Chart 35: Bivariate analysis of calcium (Ca) versus phosphorus (P), testing multiple reference samples logarithmically.
Chart 36: Bivariate analysis of potassium (K) versus iron (Fe), testing multiple reference samples logarithmically.
Chart 37: Bivariate analysis of titanium (Ti) versus silicon (Si), testing multiple reference samples logarithmically.
Chart 38: Bivariate analysis of aluminium (Al) versus iron (Fe), testing multiple reference samples logarithmically.
Table 11: Mean pXRF readings for reference materials in mg kg-1.

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<th>REFERENCE TYPE</th>
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<th>Pmg kg-1</th>
<th>Kmg kg-1</th>
<th>Camg kg-1</th>
<th>Simg kg-1</th>
<th>Timg kg-1</th>
<th>Almg kg-1</th>
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5.3 Baseline Summary

There is a lack of research analyzing the elemental makeup of objects as a baseline to understand past human activities. Findings from this chapter illustrate both the importance and potential of establishing an elemental reference guide for everyday objects; so that a meaningful comparison can be made between anthrosols, archaeological interpretations, and the assemblages associated or dissociated with them. Part of connecting objects with their use-space, relies heavily on our understanding of how each object has the potential to contribute to elemental patterns gleaned from the multi-elemental analysis of anthrosols.

Multi-element patterns were generated for common objects and things associated with Pre-Columbian life (Chart 24 and Chart 25). These findings demonstrate how similar objects can vary in their elemental signatures, such as the range in phosphorus between different species of bone, as well as how different objects can contain similar elemental signatures such as the amount of phosphorus measured in ceramics and coral (Table 12). While each object has a different potential for contributing to unique soil signatures, it is important to flesh out an object's
'uniqueness'. These findings emphasize the danger in solely using multi-elemental analysis to interpret past activity areas; and rather demonstrate why a multi-elemental approach is necessary in creating a more robust dataset to explore these complex chemical pathways. Unique elemental characteristics of bone emerged from different species; which maybe useful in identifying spaces that may have been disturbed or re-used for different purposes. While focusing in on one element, such as phosphorus, human bones contain the highest P values followed by turtle, and rodent bones. While both fish and bird bones share similar readings for phosphorus, the integration of multi-elemental patterning shows that fish bones tested in this study contain significantly more calcium and titanium than the bird bones tested in this study. In this way, while both human burials and fish middens contain bone assemblages, it maybe possible to distinguish between them using multi-element analysis of anthroposols associated with these deposits.

The integration of soil chemistry into archaeological investigations have evolved alongside increasingly more sophisticated instrumentation, better theoretical understanding of our interpretive limitations, and development of researchers with both archaeological and geophysical backgrounds. While increased portability and quantitative resolution are becoming the norm; our ability to tease out past behaviors and activities of lived-in spaces still relies heavily on our interpretations rooted in traditional archaeological field methods. Findings from this research demonstrate the importance for additional studies necessary to expand our understanding of the elemental makeup of objects and things left behind for our interpretation.
Chapter 6. Data Analysis

6.0.1 pXRF Soil Measurements and Archaeological Assemblage Counts

This chapter tests how interpretations based on archaeological assemblages compare to the elemental patterns measured in associated anthrosols. The previous chapter provided the chemical baseline used to characterize the assemblages analyzed. Consideration of soil modification, aeration, pH, hydrology, climate, soil organisms, and anthropogenic activities (Holliday 2004) were considered when comparing soils from different sites; while attention shifted to elemental patterning when comparing anthrosols from within the same site. Due to the many variables impacting the breakdown and eventual diagenesis of archaeological deposits, it was important to explore the limitations soils can be used to infer past human activities. While all elements measured are discussed, it should be emphasized that aluminosilicates are present everywhere on the island, and their variability translates into their unreliability for identifying areas of past human activities.

By using historical accounts, archival maps, and satellite imagery some inferences can be made regarding recent human and environmental impacts shaping archaeological site's capacity to encode the physical, biological, and chemical effects (Wells 2010). Alternatively, concepts of pristine or off-site can be somewhat arbitrary when considering that humans have been modifying the Caribbean since the late-holocene. Nonetheless, archaeological sites are often defined by the material remains left behind for interpretation and can still provide us insight into their lifeways. Comparisons were made between excavation units from mechanical and stratigraphic levels, shovel test pits, and soil augering and surface deposits with a central focus on Indian Creek (Chapter 8) and Doigs (Chapter 9). Additional comparisons were made with the site of
Claremont, Blackman’s, and Coconut Hall as each site spans different geologic zones of the island each with complete assemblages available for analysis. As assemblages are richest in Pre-Columbian middens, section 6.5 focuses specifically on midden comparisons across a platitude of sites in Antigua and Long Island. The final section in this chapter (6.5) presents findings on rapid Ptest or ring tests conducted during the planning phase of the dissertation. As these results were largely qualitative and were not used for interpretation of habitation loci; it's significance is nonetheless important for field archaeologists. Rapid Ptests provide an expedient, effective, low cost technique capable of detecting areas of human activity. In section 6.6 I compare in-field color change P augers (0-5) with quantitative measurements (mg kg-1) using the pXRF to help categorize qualitative values into quantitative ranges for each P sauger (0-5).

6.1 Archaeological Excavation Units by Mechanical and Stratigraphic Levels

This section presents data comparing excavated units comprised of variable assemblages (middens, structural, and void spaces) selected for their diversity, abundance, and variability of material remains that could be meaningfully tested against pXRF elemental measurements of associated anthrosols. Despite extensive archaeological excavations conducted by Irving Rouse at Indian Creek, trenches were excavated mechanically with the primary purpose of recovering ceramics rather than the complete collection of faunal remains. University of Calgary conducted limited excavations in order to conduct a complete recovery from associated Yale Excavation Trench 6. Additional excavations at Indian Creek were conducted for this dissertation during the
summer of 2013 to obtain soil samples associated with Excavation Trench 5 (6.1.a) and excavated areas away from middens.

A series of test units excavated by the University of Calgary from the Pre-Columbian site of Doig's (6.1.b) provided a rich assemblage for soil comparison. Brock Gent's masters thesis (2004) combined Calgary's earlier archaeological findings with a geophysical survey of the site generating a synthesis of village space and activity areas that were integrated for discussion. Martin Fuess's test excavations were analyzed (6.1.c) to compare assemblages and anthrosols. These units comprise sites originating from different spatial, geologic, and environmental localities.

No discernable anomalies were observed when analyzing soils from decades old excavations versus more recent excavations. While paleobotanical and paleogenetic analysis are highly susceptible to degradation due to improper housing and storage; findings from elemental analysis suggests that for this kind of analysis 'old' soils can still be used for analysis. While the presence of bacteria can certainly change the acidity of soils, and potentially convert one compound into another, their total elemental composition should remain relatively intact.

6.2 Indian Creek Pre-Columbian Site: Stratigraphic Comparison

6.2.1 Indian Creek: Archaeological Unit ICC101

The placement of unit ICC101 was based on preliminary phosphorus color ring tests (Ptest) that identified an area with lowered phosphorus levels observed between two middens identified by Rouse as mound 5 and 6. Soils and assemblages were used to test the hypothesis that areas of depleted phosphorus may have served as either a pathway or extension of ceremoni-
al space. The majority of context layers [4001] - [4011] consisted primarily of midden materials with layers closer to the surface showing evidence of disturbance [4001] - [4003]. A neonate burial was recovered within context [4012] near to the bottom of the unit. Remains were set aside for future radiocarbon dating and isotopic analysis.

[4001] - [4003]: Surface Disturbance

Stratigraphic layers were recorded by context, and begin with [4000] = surface, and numbered accordingly. Measurements for P, Ca, K (chart 39) and Fe, Al, Ti, and Si (chart 40) for context [4001], [4002], and [4003] do not appear proportional to either the ceramic or mollusk counts. Walking southeast from Rouse's unit 5, moves gradually downslope until it levels out around ICC101. Artifacts and faunal remains are exposed throughout this area in variable concentrations on the surface, and maybe susceptible to slope wash. The area analyzed is also part of a larger walking path, where increased fragmentation of ceramics and mollusks were observed contributing to high mollusk counts [4002] n=2,416 and [4003] n=1,368. Past ploughing attempts may have also created disturbances from the top 20-30 centimeters as well, which was limited to ploughs using working animals. The coupling of multi-element analysis of anthrosols and assemblage counts can provide an indirect assessment for the extent of disturbances. This is particularly useful for CRM and cultural heritage managers who are often tasked with assessing the extent of disturbances as well as researchers attempting to interpret layers that may have been heavily disturbed.

[4005] - [4011]: Midden Contexts
Measurements for phosphorus (P) consistently matched fluctuations within the midden context. The stark increase in shells and ceramics from context [4005], [4006], [4008], [4009], and [4011] were comparable with results from P. The highest recorded P measurement was 77,923 mg kg\(^{-1}\) from context [4009], which aside from the disturbed upper layers contained the highest counts for both ceramics and mollusks. Bone counts were not available at the time of writing for this dissertation.

While Ca and K do mirror similar overall trends, there are some notable deviations such as in context [4004] where higher K values were recorded alongside lower Ca values. The highest Ca measurements were recorded from ash samples recovered inside a West Indian Top shell (C. pica) at 2,266,525 mg kg\(^{-1}\) and from soil samples at 2,194,857 mg kg\(^{-1}\) from [4009] matching the highest counts for ceramics and mollusks between [4005-4011].

Fe, Al, Ti, and Si matched the overall pattern for artifact and faunal counts for ICC101, although increased variability was observed. While P and Ca were consistent with the high counts for [4009]; Fe, Al, Ti, and Si fluctuated high and low numerous times. Aside from Jadeite, ceramics measured highest for Fe and do not correlate particularly well with ceramic counts in comparison to P and Ca. Aluminum and silicon fluctuations are most likely the result of variable clay deposits present stratigraphically. While there are many contributing factors that affect Fe content in soil, what is important is that the Fe present in ceramics do not seem to be a strong contributor of elemental Fe loading capable of superseding environmental influences. Evidence of high erosion in the area may have contributed to elemental leaching, which is discussed further in Chapter 7 using elemental mapping.
[4012] - [4017]: Unknown Contexts/Neonate Burials

The immediate drop in artifacts from contexts [4012], [4013], [4015], [4016], and [4017] resulted in comparable lowering of all elements proportionally. The marked decrease in both material remains and elemental concentrations were associated with a complete neonate burial found in context [4012]. An additional juvenile was found running into the northern wall along the same contextual layer, but was unavailable for further analysis. Long bones were collected from the wall of this second juvenile. Context [4017] contained the lowest phosphorus measurement of 2,297 mg kg⁻¹ from [4017] which were consistent with the lowest ceramic and shell counts, as well as Ca, K, Fe, Al, and Si. While titanium was also low, context [4017] was slightly elevated when compared to previous context which maybe the result of vertical leaching.

6.2.2 ICC100

Rather than rely solely on previous site plans, ICC100 was excavated in an area defined chemically as a central void space. A 1 x 2 meter unit was excavated to test how multi-element analysis could contribute to on-going debates regarding the circular form within Saladoid village organization (Siegel 1996; Keegan 2009a). Soils from this unit were collected, along with fragments from the bedrock and measured using the pXRF. The overall unit contained relatively few artifacts and faunal remains, although additional fragments of human remains were uncovered in context [5001].

[5000] Top Layer 0-8 cm

The top layer [5000], had a very thin A horizon measuring 8 centimeters consisting of highly friable sandy clay loam. No artifacts/faunal remains were recovered from this layer.

[5001] Skeletal Remains 8-25 cm
Context [5001] was excavated between 8-25 centimeters as part of the C horizon consisting of the only artifacts and faunal remains present. This layer includes the top portion of a human skull along with a single phalange recovered at a depth of 22 centimeters. In a shovel test pit 10 meters west, another human bone fragment was recovered. ICC100 was excavated stratigraphically with only three different layers identified. This layer contained the highest measurements for P, Ca, K, Al, Fe, Ti, and Si. The sparse artifacts and faunal remains from the lone cultural layer [5001] were highly worn and fragmented, with a mean P measurement of 7,191 mg kg\(^{-1}\) contrasting heavily with the P midden measurement from ICC101 [4009] of 77,923 mg kg\(^{-1}\).

**[5002] C Horizon 25-30 cm**

[5002] consisted of a rocky sandy loam C horizon, and was sampled for pXRF at 27 centimeters. This context contained no artifacts or ecofacts. The pXRF measurements for ICC100 were consistent throughout with P, Ca, and K matching up with the highs and lows of Fe, Al, Ti, and Si; with an increase from [5000] to [5001] and an eventual decline in [5002] and [5003] (chart 41 and 42).

**[5003] Bedrock 30 cm**

ICC100 bedrock samples measured lowest in Al, Ca, P, Si, and Ti compared to ICC101 with lowest measurements in K, and the University of Texas Unit: UTU1 with lowest Fe (Table 12). Only ICC100 and ICC101 were excavated for this dissertation using identical methods and recording strategies; and form the primary basis of comparison. Unit ICC101 [4016] was recorded at a depth of 170 centimeters or 140 centimeters deeper than the bedrock from [5003]. The ICC101 sterile layer measured significantly higher elemental readings than ICC100 bedrock ex-
cept for K. This is expected, considering that the sterile layer [4016] comes from the sandy clay loam soil samples from the C horizon and not directly from the bedrock and is susceptible to nutrient leaching.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Context</th>
<th>Layer</th>
<th>Al (mg kg⁻¹)</th>
<th>Ca (mg kg⁻¹)</th>
<th>Fe (mg kg⁻¹)</th>
<th>K (mg kg⁻¹)</th>
<th>P (mg kg⁻¹)</th>
<th>Si (mg kg⁻¹)</th>
<th>Ti (mg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC100</td>
<td>[5002]</td>
<td>Bedrock</td>
<td>26504*</td>
<td>14110*</td>
<td>54809</td>
<td>12534</td>
<td>2025*</td>
<td>70125*</td>
<td>3971*</td>
</tr>
<tr>
<td>ICC101</td>
<td>[4016]</td>
<td>Sterile</td>
<td>41331</td>
<td>34659</td>
<td>46216</td>
<td>11290*</td>
<td>4942</td>
<td>134026</td>
<td>5101</td>
</tr>
<tr>
<td>PA4U1</td>
<td>L10</td>
<td>Sterile</td>
<td>56383</td>
<td>51863</td>
<td>43049</td>
<td>12140</td>
<td>6536</td>
<td>177607</td>
<td>4064</td>
</tr>
<tr>
<td>UTU1</td>
<td>LC</td>
<td>Sterile</td>
<td>55813</td>
<td>321883</td>
<td>41795*</td>
<td>19460</td>
<td>27836</td>
<td>202449</td>
<td>4356</td>
</tr>
</tbody>
</table>

Table 12: Indian Creek Bedrock and Sterile Layer Comparison of Mean pXRF Measurements. * denotes lowest values

Findings from excavated units of Indian Creek show that intensive midden deposits result in an across the board elemental loading. While human remains recovered from archaeological unit ICC100 showed measurable elemental loading of associated soils, the relatively shallow depth (< 50 cm) and lack of top soil requires further comparison to additional soil samples collected throughout the site using mixed methods and is discussed in section 6.2.4

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Figure 3: Map of Indian Creek excavations, shovel test pits, and soil survey.
Chart 4.1: Indian Creek ICC101: soils analysis for Iron, Aluminum, Titanium, and Silicon

Indian Creek ICC101: PXRF Iron, Aluminum, Titanium, and Silicon (ppm) vs Ceramics and Molluscs Count

Ceramics vs Molluscs Count

Fe (ppm)

Al (ppm)

Si (ppm)
Chart 41: Indian Creek ICC100 Soils Analysis for phosphorus, calcium, and potassium.

Artifact & Faunal Cts/Wts

Context/Levels

[5000] 0-8

[5000] 0-8

[5001] 8-30

[5001] 8-30

[5002] 30

[5002] 30
Chart 42: Indian Creek ICC100 Soils Analysis for Iron, Aluminum, Titanium, and Silicon

INDIAN CREEK IC100: Iron, Aluminum, Titanium, and Silicon concentrations for various ecofacts/artifacts.
6.2.3 Shovel Test Pits

A series of shovel test pits were conducted as part of the mixed strategy to study observable activities and further test hypothesis describing village organization and formation. Shovel testing is a commonly used method in normative research, often used to help determine site locality and excavation unit placement. Soils collected during this phase of research were used to test whether we could expand the interpretive capacity of this method by comparing it to previously established relationships gleaned from soil comparisons and excavations.

For the site of Indian Creek, there remains significant questions regarding the circular space enclosed by surrounding middens, in particular the asynchronous manner in which this space became enclosed. Extensive sampling of the enclosed space recovered relatively few artifacts and faunal remains, which when recovered were often highly fragmented, emphasizing the need to further our understanding of soil chemistry for insight into the use and function of these spaces. Indian Creek is a multi-phase occupation site increasing the difficulty in interpreting village landscapes such as shifting activity areas obscuring previous ones.

6.2.4 Indian Creek PA4 Shovel Test Pits

The placement of 11 shovel test pits were concentrated around areas of "centricity" as defined by the encircling midden at Indian Creek. As previously discussed, village centers can serve as areas of ritualized activity or serve as the stage for daily activities and village life. While void spaces have been noted throughout Pre-Columbian spaces, little investigation has taken place in these areas for exploration. While some cursory research has been conducted in the area enclosed by middens (Siegel and Murphy pers Comm), no extensive or systematic exca-
vations have been conducted into this debated space (Keegan 2009a; Siegel 1996). Findings from shovel test pits conducted during the summer of 2013 are presented here.

The STPs conducted in these enclosed spaces produced relatively few artifacts and faunal remains, with many STPs producing no material remains making these soils applicable to studying void spaces. All P measurements excavated from this space fell well below the midden average of 29,656 mg kg⁻¹, with only 2 STPs 690445 and 700445 measuring above the 1st quartile of 10,708 mg kg⁻¹ (Chart 61). 3 STPs 700475, 700485, and 700495 had P measurements below those found in sterile layers for ICC100 (2,025 mg kg⁻¹), ICC101 (4,942 mg kg⁻¹), and PA4U1 (6,536 mg kg⁻¹) found in Table 12. The remaining STPs that had P measurements above sterile, eventually fell within range when depths were factored in. For example, 690445 contained a high P measurement of 11,824 mg kg⁻¹ between depths of 0-10 cm, followed by 7,483 mg kg⁻¹ between 10-30 cm, 5,139 mg kg⁻¹ between 30-47, and 3,044 mg kg⁻¹ between 47-56 cm (Chart 44).

All Ca measurements fell below the midden average of 542,675 mg kg⁻¹ with the highest measurement of 210,634 mg kg⁻¹ from STP 690445 between 0-10 cm. All STP measurements fell within range of sterile layer measurements for Ca ICC100 (14,110 mg kg⁻¹), ICC101 (34,659 mg kg⁻¹), and PA4U1 (51,863 mg kg⁻¹), regardless of depth. While similar trends identified for P were consistent with Ca, greater fluctuations were observed with P rather than Ca in these areas tested.

While K does show strong similarities to patterns found in Ti and Fe, there were significant deviations which should be noted. The bottom layers of 690445 (22,478 mg kg⁻¹) and top
of 720445 (21,823 mg kg-1) measured higher K values than observed in all sterile layers, with the highest being 19,460 mg kg-1 from UTU1.

Of particular interest Fe, Al, and Ti were found to measure consistently higher than those values identified in sterile layers; with over half of Si pXRF readings measuring above sterile values (Chart 45). The overall trend from soils observed within this space are that P, Ca, and K were found to be within range of sterile layers; while Fe, Al, Ti and to a lesser degree Si were found to be above measured values found within sterile layers measured from excavated units.

While P and Ca measurements reflected the severe differences in cultural remains found within void spaces and midden areas; comparisons of material remains with their associated STPs were more variable than the larger middens analyzed for this site. There are a number of explanations: (1) STPs represent a smaller archaeological assemblage and thus maybe an inaccurate sample of the overall space being tested (2) despite the relatively sparse presence of artifacts and ecofacts, there are some localized activities which may have not been accounted for which may contribute to changes in soil chemistry such as walking paths, garden plots, and temporary structures (3) significant disturbances may have occurred to disturb the overall context of the site, and (4) pXRF analysis may not be able to detect the relatively low contributions of refuse within these context, in particular if they were immediately cleaned or swept after activities.
Chart 43: STP 690445 P (mg kg⁻¹) Measurements by Level
Chart 44: PA4 Comparison of shovel test pit counts and elemental readings for phosphorus, calcium, and potassium.
<table>
<thead>
<tr>
<th>Shovel Test Pit ID</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>680465</td>
<td>1</td>
</tr>
<tr>
<td>680465</td>
<td>10</td>
</tr>
<tr>
<td>680465</td>
<td>100</td>
</tr>
<tr>
<td>680465</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Chart 45: PA4 Comparison of shovel test pit counts and elemental readings for Iron, Aluminum, Silicon, and Titanium**

- **Iron (Fe)**: 40 $\times 10^3$ to 100 $\times 10^3$ ppm
- **Aluminum (Al)**: 40 $\times 10^3$ to 100 $\times 10^3$ ppm
- **Silicon (Si)**: 1 $\times 10^5$ to 2 $\times 10^5$ ppm
- **Titanium (Ti)**: 6000 to 10000 ppm

**Indian Creek Shovel Test Pits: Iron, Aluminum, Silicon, and Titanium (ppm) vs Ecofact/Artifact Counts**
6.2.5 Indian Creek Soil Augers: Void Spaces and Middens

While site disturbances observed from excavation analysis at Indian Creek of the top 20-30 centimeters were consistent with some soil auger findings, the majority of augers were consistent with surface scatter remains. All areas with surface remains tested positive for elevated P and Ca values, while areas void of artifacts were almost entirely negative for elevated P values. Therefore, soil auger studies are particularly applicable at identifying presence or absence of intensive human activity. Chart 46 presents augers lumped together stratigraphically and should be expected to trend downwards; particularly the closer one gets to sterile. These findings are consistent with measurements for sterile layers observed in both excavations and STP samples. Surface areas with low but elevated P and Ca values were often associated with low surface remains; for example ICC9, ICC11, and ICC22.

It is important to point out that P and Ca measurements do not predict surface concentrations of artifacts and faunal remains, which is predominately a byproduct of surface analysis in general. Areas with no visible surface remains were consistently associated with low P and Ca measurements, supporting that these void spaces were most likely true void spaces and not the byproduct of disturbance.

Findings for K, Fe, Al, Si, and Ti continues to add credence to findings from excavations and STPs, in particular the overall enrichment of soils connected to concentrated midden deposits. Of particular interest, are the areas void of material remains with elevated K, Fe, Al, Si, and Ti which maybe a strong indicator of erosion and surface hydrology. Due to the water solubility of these elements, they have a high tendency to move with water movement unlike phosphorus(Chart 47).
<table>
<thead>
<tr>
<th>P (ppm)</th>
<th>Ca (ppm)</th>
<th>K (ppm)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOLLUSC CT</td>
<td>CERAMICS</td>
<td>CORAL</td>
<td>LITHIC</td>
</tr>
<tr>
<td>BONE COUNT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Counts

0 | 50 | 100 | 150

× 10³

0 | 5 | 10 | 15 | 20 | × 10⁵

0 | 20000 | 40000 | 60000

Indian Creek Core Identification

Indian Creek Soil cores and surface counts - phosphorus, calcium, and potassium are contrasted with surface counts of archeological deposits within a five meter radius.

Chart 46: Indian Creek Soil cores and surface counts - phosphorus, calcium, and potassium are contrasted with surface counts of archeological deposits within a five meter radius.
Indian Creek Core Identification

Indian Creek Soil cores and Surface Counts - Iron, Aluminum, Silicon, and Titanium were contrasted with surface counts of archaeological deposits within a five meter radius.

<table>
<thead>
<tr>
<th>Fe (ppm)</th>
<th>Al (ppm)</th>
<th>Si (ppm)</th>
<th>Ti (ppm)</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BONE</td>
</tr>
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<td></td>
<td></td>
<td>COUNT</td>
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<tr>
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<td></td>
<td>MOLLUSC</td>
</tr>
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<td></td>
<td>CT</td>
</tr>
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<td></td>
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<td>CORAL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LITHIC</td>
</tr>
</tbody>
</table>

Counts

- 137 -
6.3 Doigs Pre-Columbian Site (Calgary): Stratigraphic and Mechanical Comparison

Twelve Excavation units were analyzed in total, and are comprised of samples representing middens, cleared spaces, and structural spaces (figure 2) excavated primarily by the University of Calgary (Gent & de Mille 2003). Since excavation units were conducted in blocks, units were coupled together by block in order to gain a better understanding of how midden counts and soil chemistry vary within the same midden. Depths ranged from 15 cm (Units 15 & 16) to 50 cm (Unit 8) at its deepest, making the area a prime site for soil comparison, as many features were relatively close to the surface. No evidence of colluvial slope washed material was found stratigraphically throughout the excavated areas despite the surrounding volcanic hillsides (Gent 2004/125).

The first set of analysis (charts 29-30) represent counts from Cluney's zooarchaeological focused master's thesis (Cluney 2005) comparing faunal counts and weights crab and fish vertebrate broken down by unit and level. 1x1 meter units were excavated in clusters throughout the site of Doigs. Units 1, 13, 14, 17, 2, 8, and 9 comprise a cluster of units placed over midden mounds, while units 11 and 12 were placed over an area described as structural based on the geo-physical evidence, associated excavation of an intact wooden post, and paucity of midden-like remains (Gent 2004). Units 3, 4, and 6 were clustered together as are part of the same midden area towards the east of the site. While described as a midden, the assemblages recovered from these units indicate a high occurrence of bead blanks, and incomplete beads along with bead processing toolkits which was interpreted as a potential bead production area (Brock 2004). Archaeological remains were observed on the slope of a nearby hill. Unit A, a 1x1 meter test trench, is
160 meters north Calgary's primary research area, whose complete assemblage was available for re-analysis and discussed below. Martin Fuess who conducted the excavation ran a transect across the site, collecting surface deposits prior to excavation. Fuess's unit placement is of particular interest, as it sits well outside of currently visible surface deposits and approximately 30 meters higher in elevation from the center of Calgary's research area suggesting that a large portion of the village area remains unexplored.

6.3.1 Midden Units: 1, 13, 14, 17, 2, 8, and 9

Chart 48 compares pXRF measurements of P, Ca, and K with midden counts for fish bone, crab counts, crab weights, and fish vertebrate counts to determine more accurately the role of diagenesis in elemental loading of soils. Units associated with archaeological midden deposits provided the widest variability in material remains from concentrated to sterile and are discussed here. Of the midden remains selected for this study, P and Ca values were reliable indicators of midden count variability, in particular crab weight peaks and valleys. While NISP and MNI midden counts produce vital information on changing economies, hierarchies, and environmental changes to name a few; total weight seems to be one of the significant factors in characterizing elemental loading of P and Ca. The top six crab weights all were also the top six averages for Ca (mg kg⁻¹) as observed in unit 1 level 4 UI1L4, unit 14 level 1B U14L1B, unit 1 level 3 UI1L3, and unit 2 level 4 U2L4 (chart 30). This is particularly important, as crabs and mollusks were found to have the highest measured values of Ca as discussed in Chapter 5.2 Measuring Reference Samples.
The highest P value average came from unit 2 level 4 at 14,747 mg kg⁻¹ which is associated with the highest crab weights and second highest fish bone count. The previous layer, level 3 had a P value of 14,412 mg kg⁻¹ despite having a smaller overall faunal count, potentially supporting the notion that these two layers are part of the same layer. High Ca values are consistent with P findings for both level 4 at 111,513 mg kg⁻¹ and level 3 at 89,939 mg kg⁻¹.

The lowest measured averages for P (3,395 mg kg⁻¹) and Ca (27,988 mg kg⁻¹) came from U17L1 as well as low Ca values (35,493 mg kg⁻¹) from U13L1A were associated with sparse assemblage counts for units excavated within midden areas. Both units also contained high K measurements at around 10,000 mg kg⁻¹ (chart 30). These measurements support archaeological analysis indicating that these remains, while being close to the surface, are not heavily disturbed and maybe indicative of a sharp edge where midden refuse was no longer deposited.

K values had a pattern consistent with Fe, Al, Ti, and Si than P and Ca. Fe, Al, Ti, and Si pXRF measurements, measured inversely to the peaks and valleys of P and Ca respectively (chart 31). The highest measured values for K, Fe, Al, and Ti came from U13L1A; which was relatively low in count and crab weights. While the lowest measured values for K, Fe, Al, Ti, and Si came from U8L4, it also contains the highest midden counts and crab weights of all midden units analyzed from PA15. It is important to re-emphasize that this site sits on volcanic bedrock surrounded by exposed volcanic hillsides, and parent material along with natural weathering effects may have played a significant role in shaping these soil patterns. Further analysis is required to fully understand these inverse relationships, as Indian Creek middens showed an almost across the board elemental loading. The inverse relationship, however is consistent
with exposed areas surrounding Indian Creek that were void of refuse deposits. Spatial analysis of anthrosols suggest that these exposed areas are susceptible to natural forces of erosion associated with topography, slope, and surface hydrology. These findings are discussed further in Chapters 8 and 9.

6.3.2 Structural: Units 11 and 12

Units 11 and 12 were initially identified as relating to a structural feature based on the block excavation of two potential post holes along with a grinding stone feature associated with low artifact and ecofact counts by the University of Calgary team (Gent & de Mille 2003). A subsequent geophysical survey added additional evidence identifying a series of depressions occurring in a circular configuration. This section presents soil measurements from the same level the wooden post was excavated from to further our understanding of places that are absent of artifacts and faunal remains. Void spaces within Pre-Columbian village context have often been interpreted as facilitating a variety of purposeful activity spaces such as ceremonial plazas and food processing spaces (Gent 2004; Siegel 2005). Units 11 and 12 are located in the northwest quadrant of the site (picture 3, figure 4), with soils surrounding these features being characterized as moist soil patches with dark concentric soil stains. Levels 1 and 2 were found to have relatively low P (3,246 mg kg\(^{-1}\)) and Ca values (30,486 mg kg\(^{-1}\)) matching the low artifact and faunal counts (Chart 48). However, lower depths particularly levels surrounding these depressions were found to be rich in both P (11,454 mg kg\(^{-1}\)) and Ca (64,435 mg kg\(^{-1}\)). The highest values measured for P and Ca came from level 4B of units 11 and 12, which was slightly higher than the overall midden averages observed for P values (9,285 mg kg\(^{-1}\)) and slightly lower than the
overall average of Ca value (72,798 mg kg⁻¹). To clarify, there were higher and lower P and Ca values measured throughout midden context; although high values were associated with high artifact and faunal counts while low values followed low artifact and faunal counts. These units produced relatively low concentration of artifacts and faunal, while measuring high for P and Ca in direct association with these small depressions.

As previously discussed, K patterned closer to fluctuating values for Fe, Al, Ti, and Si from all seven middens and twenty-one levels analyzed. This was not observed for units 11 and 12 (chart 30 and 31). K averaged above (8,918 mg kg⁻¹) the majority of K values (7,745 mg kg⁻¹) analyzed from middens and continued to increase in places where Fe, Al, Ti, and Si decreased significantly such as U11L4A. Fe, Al, Ti, and Si measured significantly higher for units 11 and 12 in comparison to values found throughout midden samples. Based on pXRF measurements from reference samples (Chart 22), wood ash was the only sample tested containing relatively high concentrations of all elements. No evidence of fire events were described or recorded from these context. While a number of burnt postholes have been found in the Caribbean, greater attention needs to be paid towards distinguishing fire events of wood thatched homes versus the use of ash within the home space. The use of fire within living spaces would produce a useable fertilizer that could be spread around garden plots or agricultural fields and would certainly be collected within these spaces. In the North Atlantic, ash is also considered a cleansing substance that has been used historically to absorb liquids and organic compounds, particularly those that cause strong odors (Milek 2012). An alternative explanation may be that structures help trap accumulating elements from in-situ usage through compaction of the floor layer being
enclosed by Pre-Columbian structures. The analysis of shovel test pits identified as cleared spaces will be discussed in the following section providing additional insight into this discussion.

6.3.3 Potential Bead Production Units: 3, 4, and 6

Units 3, 4, and 6 were part of the larger Midden 3 (figure 2) found in the southwestern quadrant of the site. Certain characteristic were found to be consistent with midden deposits, such as large fluctuating values for P and Ca, while K more closely mirrored Fe, Al, Ti, and Si. However, fluctuating values for P and Ca do not change in relative proportion to faunal counts recorded by level. While the decrease in remains is reflected in P and Ca values for U4L5; U6L1 and U6L2 show increased spikes in P and Ca values while faunal remains relatively low. As these counts only represent a fraction of the different remains found in middens, there maybe additional contributing factors to these fluctuating differences that have not been accounted for. In particular, greater attention needs to be paid to the processing of tools and shell artifacts. Wear patterns from staghorn coral has suggested that they have been used to help sand softer materials down, along with experimental archaeology using wooden drill bits to carve holes for pendants (De Mille et al. 2008) can result in fine shavings of shell and coral that can accumulate throughout midden layers. Food processing may also help contribute to elevated elemental readings in void spaces, where food is taken to a separate location for consumption and eventual discard. It
is important to note that elemental patterning was not consistent with wood ash deposits associated with food preparation.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Context</th>
<th>Layer</th>
<th>Al (mg kg⁻¹)</th>
<th>Ca (mg kg⁻¹)</th>
<th>Fe (mg kg⁻¹)</th>
<th>K (mg kg⁻¹)</th>
<th>P (mg kg⁻¹)</th>
<th>Si (mg kg⁻¹)</th>
<th>Ti (mg kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U13</td>
<td>L2</td>
<td>N/A</td>
<td>45404</td>
<td>*53124</td>
<td>*40852</td>
<td>8392</td>
<td>*5791</td>
<td>142598</td>
<td>3268</td>
</tr>
<tr>
<td>U2</td>
<td>L5</td>
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<td>42444</td>
<td>7642</td>
<td>8341</td>
<td>137830</td>
<td>*3221</td>
</tr>
<tr>
<td>U4</td>
<td>L5</td>
<td>N/A</td>
<td>*38019</td>
<td>78279</td>
<td>40988</td>
<td>*7063</td>
<td>7081</td>
<td>*123766</td>
<td>3454</td>
</tr>
</tbody>
</table>

Table 13: Doigs Lower and Sterile Layer Comparison of Mean pXRF Measurements. * denotes lowest values
Figure 4: Map of Digs excavation work conducted by the University of Calgary showing excavated units, shovel test pits, transects, and activity areas additionally described using geomagnetic survey complementing.
Figure 5: Map of Doigs showing the locality of Martin Fuess's test unit A with respect to the University of Calgary's excavated units (Recreated from (Gent 2004))
Chart 48: Doigs archaeological units by levels. Originally excavated by the University of Calgary.

DOIGS UNIT BY LEVELS: Phosphate, Calcium, and Potassium (ppm) vs. Ecofact/Artifact Counts and Weights
Chart 50: Doigs analysis of units. Levels were combined with pXRF readings averaged to comprise a mean value for each unit.

- 149 -
Chart 52: Doigs P (mg kg⁻¹) count vs ecofact and artifact counts and weights showing a close overall association with one another.

<table>
<thead>
<tr>
<th>P (ppm)</th>
<th>Fish Vertebrate Count</th>
<th>Crab Count</th>
<th>Total Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>1000</td>
<td>101</td>
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<tr>
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<td>125</td>
<td>126</td>
<td>127</td>
</tr>
<tr>
<td>10000</td>
<td>128</td>
<td>129</td>
<td>130</td>
</tr>
</tbody>
</table>

Unit and Levels:

- U1
- U3
- U4
- U6
- U8

DOIGS CALGARY UNITS: Phosphate (ppm) vs Faunal Counts By Stratigraphic Level.
DOIGS CALGARY UNITS: Potassium (ppm) vs Faunal Counts By Stratigraphic Level

DOIGS CALGARY UNITS: Calcium (ppm) vs Faunal Counts By Stratigraphic Level

DOIGS CALGARY UNITS: Silicon (ppm) vs Faunal Counts By Stratigraphic Level

Chart 53: Doigs Top: Potassium, Middle: Calcium, Bottom: Silicon
6.3.4 Doigs (Fuess) Unit: A

Background

The placement of Doigs Unit A was based on survey work conducted by Martin Fuess. A transect approximately 340 meters north-south and 340 meters east-west ran across the 'center' of the site (figure 5). Unit A was located approximately 160 meters north from the center of Calgary's study area, slightly elevated on a gradual uphill slope 15 meters east of the north-south transect.

Midden pXRF breakdown

Charts 56 and 57 represent midden counts and weights for mollusks, bone, crab shells, coral, and ceramics. The charts were separated by their feature number/context and then by depth providing important insight into the individual contributions each kind of refuse had on soil chemistry. Charts 58-60 represent the cumulative affects of ecofacts (mollusks, crab shells, coral) and artifacts (ceramics and lithics) on soil chemistry.

The highest elevated readings for K, Si, Ti, Al, and Fe (charts 59-60) were measured between 30-40 centimeters which also contained relatively low P and Ca supporting the sparse counts for both artifacts and ecofacts. No soils from the 40-50 centimeter sterile layer were available for analysis. In comparison to the reference samples tested, this layer does not appear to match any of the patterns measured but are consistent with findings from Indian Creek midden sterile layers, where elemental leaching maybe occurring. While elevated concentrations of Si, Ti, Al, and Fe were found in wood ash samples; they were also rich in both Ca and P thus eliminating ash resulting from cooking fires, slash and burn, or other activities resulting in wood.
Chart 55: Doigs Ceramic Small Fragment Counts indicative of trampling between 0-20 cm
Chart 57: Doigs Breakdown Iron, Aluminum, Titanium, and Silicon
Chart 58: Doig's phosphorus (mg kg\(^{-1}\)) vs Ecofact and Artifact Counts

Unit by Level:

- 158 -
Chart 59: Top: Potassium, Middle: Calcium, Bottom: Silicon

- Table 2: Dollars in Column

- Figure Legend

- Graphs: ECO CT, ECO WT, ART CT, ART WT

- Data Units: ppm, Count/Wt
Chart 60: Doig's Top: Titanium, Middle: Aluminum, Bottom: Iron
6.3.5 DOIGS SHOVEL STP

The site of Doigs is a single phase occupation site spanning approximately cal AD 250-685 with relatively shallow (~40 cm) middens. The site has been extensively excavated, identifying numerous structural features along with midden spaces, and potential bead manufacturing activities. This site represents a vital comparison to Indian Creek's multi-phase occupation site with less potential for shifting activity areas obscuring previous ones, providing greater clarity in interpreting activity areas. pXRF analysis of soils from shovel test pits conducted for the site, therefore can be used to help connect the spaces between these different features and activity areas; while soil samples from these features and activity areas may help shed additional insight into spaces where no artifacts or ecofacts are present.

A series of shovel test pits were conducted by the University of Calgary complimenting 15 excavation units for the study of Early Saladoid village organization. Two transects were set-up across the site along cardinal directions, with artifacts sorted and analyzed by the archaeology team at Calgary. Subsequent geomagnetic survey of the site by Gent Brock (2004) identified a series of potential structures, confirming two structures through excavation. Future research is intended at the site of Doigs, to begin recording soils from floor layers within each structure. Soil measurements presented in this section were classified by their land-use/activity area based on previous findings and tested against the village synthesis described by Brock and Calgary.

Soil analysis from Doigs contrasts heavily with Indian Creek. While the central focus of STP sampling in Indian Creek was to explore an area relatively void of artifacts enclosed by a series of multiphase middens; STPs sampled at Doigs were broken down into central, cleared, midden, and structural. The use of central space here is used in similar fashion, and does not reflect
a space of central focus, or ritualized activity but rather a space enclosed by a series of midden areas existing between features. Certainly, this hypothesized space remains the most fluid in our interpretation.

6.3.5.1 Phosphorus

Similar to Indian Creek, elemental analysis from excavated units corresponded well with fluctuating counts from archaeological assemblages, while elemental measurements from STPs proved less representative. Small sample size, limited stratigraphic control, and surface disturbances all have contributive affects regarding interpretation. Despite these challenges, there are some important findings that need to be highlighted. Soils were categorized based on their elemental, artifactual, and spatial characterizations and are best illustrated in charts 63 and 64.

STP's catching the edges of stratified middens measured considerably lower in phosphorus than measurements taken from intensive midden layers and higher than soils analyzed from central spaces. These measurements suggest that these areas are likely to be interfaces or buffer regions between the edge of a midden and another overlapping activity. Ten excavated units contained cultural layers with at least 2,000 artifact/ecofacts or more; with a mean phosphorus concentration of 11,000 mg kg\(^{-1}\) while STP's along midden edges averaged 4,519 mg kg\(^{-1}\). Excavated layers with less than 100 artifact/ecofact counts had an average P measurement of 6,552 mg kg\(^{-1}\) within midden context; in comparison to STP sterile layers with an average of 2,099 mg kg\(^{-1}\).

Areas within proximity to structural features had an average P measurement of 6,682 higher than midden layers with assemblages below 100 artifact/ecofact counts but well below the artifact/ecofact rich layers measuring 11,000 mg kg\(^{-1}\). While additional excavations are
needed to further the interpretation, the measurements are consistent with structural units associated with domestic activities while maintaining a level of cleanliness.

STP's not associated with either a feature or midden, was tentatively classified as centralized space which measured 3,426 mg kg-1 well below excavated layers with less than 100 artifact/ecofacts and above sterile STP layers.

The Calgary team encountered a space completely void in artifacts and ecofacts. This area, it was hypothesized, to have been purposefully cleared (Brock 2004). Of particular interest was that the highest combined measurements for P, Ca, Fe, and Al occurred within this 'cleared' space, whereas K and Si measured lowest out of the different spaces identified (Chart 63 and 64).

### 6.3.5.2 Calcium

As mentioned above, Ca corresponded well with P throughout STP soil samples, although in areas hypothesized as 'central' spaces there were some noticeable deviations where increases in Ca measurements were associated with decreases in P (Chart 63). Midden edges identified with P had a mean Ca measurement of 40,710 mg kg-1 versus excavated layers with 2,000 plus artifact/ecofact counts averaged 98,526 mg kg-1. Excavated layers with less than 100 artifact/ecofact counts had an average Ca measurement of 49,734 mg kg-1 while STP sterile layers had a mean of 33,870 mg kg-1.

The STP Ca measurements associated with structural features averaged 74,005 mg kg-1 which was higher than measurements taken along midden edges at 45,627 mg kg-1, but well below rich midden layers. This is consistent with findings from P.

As previously mentioned, the 'cleared' space had the highest average measurements for Ca at 158,466 mg kg-1 compared to all other STP soils sampled. Again, this is above layers with
less than 100 artifact/ecofact counts and well below midden layer measurements with >2000 artifact/ecofact counts.

### 6.3.5.3 Potassium

Potassium followed a similar pattern as observed with Si (Chart 64). The 'cleared' space had the lowest average measurement of K at 2,663 mg kg\(^{-1}\) for STP soils sampled, whereas the highest was measured along the midden edges or peripheries. This value matches closely with midden layers with less than 100 total artifact/ecofact counts at 8,757 mg kg\(^{-1}\).

### 6.3.5.4 Fe, Al, Ti, and Si

Ti remained at relatively low concentrations throughout all the STP soils measured, except for the 'cleared' space at the Doigs village. Along with P, and Ca these three elements measured particularly high in this area void of artifact and ecofacts. While Al and Si also measured high, this is primarily the result of aluminosilicates present in rich clay deposits found throughout the site.

Fe fluctuated loosely alongside midden counts, with the exception of the 'cleared' space which accounted for the highest measured values of all classified STP soil categories.

<table>
<thead>
<tr>
<th>ID</th>
<th>Al</th>
<th>Ca</th>
<th>K</th>
<th>Fe</th>
<th>P</th>
<th>Si</th>
<th>Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>STP CENTRAL MEAN</td>
<td>40128</td>
<td>36951</td>
<td>7168</td>
<td>35624</td>
<td>3426</td>
<td>117065</td>
<td>2849</td>
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<tr>
<td>STP CLEARED MEAN</td>
<td>*52212</td>
<td>*158466</td>
<td>2663</td>
<td>10221</td>
<td>*29652</td>
<td>3773</td>
<td>*44906</td>
</tr>
<tr>
<td>STP MIDDEN</td>
<td>45627</td>
<td>40710</td>
<td>*8566</td>
<td>40754</td>
<td>4519</td>
<td>137796</td>
<td>3361</td>
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<tr>
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<td>51710</td>
<td>33870</td>
<td>7923</td>
<td>*46782</td>
<td>2099</td>
<td>*147008</td>
<td>4039</td>
</tr>
<tr>
<td>STP STRUCTURAL MEAN</td>
<td>44663</td>
<td>74005</td>
<td>7009</td>
<td>40420</td>
<td>6682</td>
<td>127112</td>
<td>3044</td>
</tr>
<tr>
<td>&lt;100 EXCAVATED LAYERS</td>
<td>47389</td>
<td>49734</td>
<td>8757</td>
<td>42586</td>
<td>6552</td>
<td>138175</td>
<td>3436</td>
</tr>
<tr>
<td>&gt;2000 EXCAVATED LAYERS</td>
<td>40274</td>
<td>137338</td>
<td>6140</td>
<td>34442</td>
<td>11195</td>
<td>121401</td>
<td>2796</td>
</tr>
</tbody>
</table>

Table 14: Shovel test pit classified soil mean values (mg kg\(^{-1}\)) compared to excavated levels separated by counts of less than 100 and greater than 2000 artifacts/ecofacts
Chart 61: Doigs Shovel Test Pit by Type: Phosphorus, Calcium, and Potassium
6.3.6 Doigs Soil auger augers: Limited Visibility

The site of Doigs sits on a former plantation that is still occasionally used for farming, although in recent years the site has lied fallow leading to thick vegetation and overgrowth. This site allows us to test the limits of what can be understood with little to no visibility. As a result, no surface deposits were recorded in conjunction with augers taken. This survey was originally part of a CRM project assessing sites in the vicinity of Rendezvous Bay which was sold as part of a resort development. While P and Ca do correlate well with one another, Ca does measures higher in a number of augers in contrast to only moderate increases of P, which was observed in some of the STP's at Doigs (Chart 64).

The elevated values for K, Al, Ti, Si, and Fe across many of the augers taken suggest a close correlation of erosion potential, and concerns of surface water hydrology (Chart 65). A watercourse runs through the northern section of the site, which will be compared to these soil findings. K, Al, and Si correspond with one another in contrast to Fe and Ti. While they all do correspond with one another; K, Al, and Si show a decrease for auger DG3, while Fe and Ti measured an increase in mg kg⁻¹. For DG2 Fe, Al, Ti, and Si increase while K decreases. These finding will be compared spatially in the following chapter.
Chart 64: Doigs soil augers and surface counts: phosphorus, calcium, and potassium (ppm)
Chart 65: Doig's Soil augers and Surface Counts: Iron, Aluminum, Silicon, and Titanium (mg kg⁻¹)

Doigs Soil Cores and Surface Counts: Iron, Aluminum, Silicon, and Titanium (ppm)
6.3.7 Fuess Archaeological Units: Stratigraphic Comparisons

As discussed in the previous chapter, archaeological remains excavated by Martin Fuess represents four different sites across Antigua: Doigs, Claremont, Blackmans, and Coconut Hall that were all excavated stratigraphically. These assemblages were analyzed and raw counts for biological refuse (ecofacts) and artifactual remains (artifacts) were presented to test whether elemental loading is the by-product of any individual ecofact or artifact versus the cumulative affects of ecofact assemblages vs artifact assemblages. While Doigs was presented in section 6.3.4, findings for the following sites are presented: (i) Claremont (ii) Blackmans (iii) Coconut Hall.

6.3.7.1 Claremont Pre-Columbian Site (Fuess)

Background

The site of Claremont sits within the same geologic plain as Doigs, the basal volcanic series, with Doigs located within Dickensons Sandy Clay Loam and Claremont located within Blubber Valley Sandy Loam. The unit: EXCA was analyzed for this dissertation and the findings are presented in this section.

Midden pXRF Breakdown

pXRF soil measurements from Claremont EXC A did not correspond to any particular kind of refuse (Charts 66 and 67), although a general pattern did match the presence and absence of artifacts and ecofacts. When midden refuse was combined and recategorized into groups of artifacts and groups of ecofacts, P corresponded very well with the overall patterning (Chart 68) while Ca matched only the lower three levels from 20-50 cm (Chart 69). This is consistent with findings from Doigs.
Surprisingly, Ca did not correlate well with mollusk counts or weights. Ca had a high measurement of 66,518 mg kg⁻¹ with a relatively low mollusk count of 718 and a weight of 1,421 gm between 0-10 cm (Charts 66); while 20-30 cm had Ca values of 61,772 mg kg⁻¹ and mollusk counts of 1,141, and a weight of 4,865 gm. This is particularly interesting, as Claremont is situated within southwestern volcanic hills region and not in the calcium carbonate rich limestone region in the north. While previous analysis of surface layers also showed inconsistencies most likely due to disturbance, this unit's location is not in an area that is farmable, and is considerably upslope along the hillside. Additionally, P values closely matched both the counts and weights of mollusks and bone from the top layers to the bottom. These findings indicate that there maybe additional activities contributing to the enrichment of Ca within this context that have not been accounted for such as ceramic processing, food consumption, food processing, and discard practices.

K and Al deviated slightly from patterns observed with Fe, Si, and Ti unlike overlapping patterns found in midden units excavated from Doigs. While K did measure relatively high for level 0-10, K (mg kg⁻¹) stayed low from 10-30 cm while slightly increasing from 30-50 cm. Al measurements increased from 0-20 cm while Fe, Si, and Ti fluctuated low but increased only slightly (Charts 69 and 70). Pattern deviations occurred predominately between 0-20 cm, potentially reflecting the high mobility of cations or surface disturbance from past farming activities. These deviations will be addressed further in the following chapter when shovel test pits and augers are integrated spatially and mapped accordingly.
Chart 69: Claremont Excavation Unit; Top: Potassium mg kg⁻¹. Middle: Calcium mg Kg⁻¹. Bottom: Silicon mg Kg⁻¹ vs Count.
6.3.7.2 Blackman's Pre-Columbian Site (Fuess)

Background

The site of Blackmans is located on the Northeastern coast of the Antiguan limestone geologic formation, and sits atop the Wetherills Clay Loam area (20C2). The unit: EXCA was analyzed for this dissertation and the findings are presented in this section.

pXRF Midden Breakdown

As previously observed, the breakdown of midden remains into its various components resulted in only a relative association where P, Ca, and K detected presence and absence rather than reflect any particular component. In contrast to other middens analyzed, the site of Blackman's contains the highest concentration of lithic refuse, in particular F6 Level 0-10 with a count of 124 and weight of 1,133 gm. P and K both do a good job of fluctuating along with counts and weights of particular artifacts and ecofacts. This is interesting, because K does not usually conform to the fluctuations of P and Ca, at least not in the other middens analyzed and maybe indicative of a different discard pattern of plant remains. Paleobotanical work in the Caribbean have identified the presence of a number of crops (Berman & Pearsall 2008; Pagán Jiménez 2011; Pagan-Jimenez 2013; Mickleburgh and Pagan-Jimenez 2012), particularly root crops, although little research has been conducted into plant use and discard within the confines of a village space. While root crops such as manioc are quite resilient in poor soils, removing the entire plant and discarding it into middens would rapidly deplete already poor soils. Whether scraps from consumed plants were discarded in middens or were left to decompose in garden plots would contribute to the distribution of P, Ca, and K.
Both P and K do measure particularly high for F10 levels 0-40 relative to the low presence of artifacts and faunal remains (Charts 73 and 74), matching elevated readings for Fe, Al, Ti, and Si (184). High concentrations of Fe, Al, Ti, and Si were associated with high P and K measurements similar to elemental patterning of wood ash, however measurements for calcium were too low. Ca however, indicates an inverse relationship for F3 and F4 while eventually matching up to P and K for the rest of the feature numbers. Increased clarity can be observed when the various components are combined. Again, both P and K closely correspond to faunal and artifact counts, while Ca is shown to have an inverse relationship to F3, F4, and now F6 as well. Si, Ti, Al, and Fe all correspond to the midden fluctuations for F3, F4, F6 and then deviates in F6 Level 10-20 and F7. As this is a single one meter test unit, further excavations are necessary in order to address this anomaly.

The discrepancies surrounding calcium measurements is most likely due to local influences arising from the limestone parent material, as the site is situated in the undulating limestone region in the north central part of the island. Soils have been identified as being highly calcareous (>10% CaCO3), resulting in highly fluctuating calcium concentrations distributed throughout the site. Natural forces such as weathering and erosion can act to mask any anthropogenic inputs of calcium, such as those arising from shell middens. Therefore, other elements such as phosphorus and potassium are required for the identification of middens.

The largest discrepancies for P and K readings occurred at levels 0-10 for F3 and F6, which is consistent with previous units likely indicative of the relative disturbance and impacts of past land-use within the site.
Chart 72: Blackman Fuess Excavation Unit; Iron, Aluminum, Titanium, and Silicon
Chart 73: Blackman's Unit 1 and 2 Phosphate Analysis

Unit by Stratigraphic Level
Chart 74: Blackman's Fuss Unit 1 & 2: Potassium, Middle: Calcium, Bottom: Silicon.
Chart 75: Blackman's Fuss Unit Top: Titanium, Middle: Aluminum, Bottom: Iron

Blackman's Unit 1 & 2: Titanium (ppm) vs Ecofact/Artifact Counts and Weights

Blackman's Unit 1 & 2: Aluminum (ppm) vs Ecofact/Artifact Counts and Weights

Blackman's Unit 1 & 2: Iron (ppm) vs Ecofact/Artifact Counts and Weights
6.3.7.3 Coconut Hall's Pre-Columbian Site (Fuess)

Background

The site of Coconut Hall is also located along the Antigua Limestone Formation, atop the Hodges Clay Loam (9B1) area. The unit: EXC 1 was analyzed for this dissertation and the findings are presented below.

Coconut Hall Midden Breakdown

Coconut Hall represents the largest concentration of mollusks in a midden unit analyzed for this dissertation; with counts close to a thousand and molluskan weight over 4,000 gm. This provided a unique opportunity to test the capacity for elemental analysis to characterize a midden with a strong calcium carbonate signal. Midden sites from Long Island were also comprised primarily of mollusks, while the archaeological assemblage counts were not analyzed for this dissertation, available soils were analyzed for comparison. This discussion will be found in the section 6.4 Midden Comparisons.

Again, P, Ca, and K are found to be good indicators of presence and absence when midden components are broken down. Despite the heavy molluskan presence, Ca does not follow the counts or weights established by level for Coconut Hall. F5 Level 0-10 sees an increase in all elements except for Ca at a mean of 5,485 mg kg-1, which decreases sharply (Chart 76). The large variability and inconsistency is most likely due to the site's location, sitting on a bedrock of limestone with alluvial plains and valleys carrying eroded limestone deposits throughout the site. Since the parent material is highly calcareous, natural processes such as weathering and erosion can act to mask anthropogenic inputs such as shell middens.
Categorizing midden refuse into ecofacts and artifacts represented an interesting challenge, as ecofact weights fluctuated inversely with artifact weights (Charts 78-80). None of the previous assemblages reflected this pattern, and tended to fluctuate together. Where artifact counts and weights increased, ecofacts fluctuated in kind. This provided a unique challenge in testing P across a wide diversity of material remains. Measurements for P did not follow either artifacts or ecofacts, but rather seems to be affected by both. While ecofact weights were relatively high for F3 Level 0-10, a sharp decrease was observed in Level 10-20 and increases slightly in Level 30-40; artifact weights at Level 0-10 are moderate and begin increasing in Levels 10-20 and 30-40 which P seems to reflect from 7,119 mg kg⁻¹, 7,349 mg kg⁻¹, and finally 7,374 mg kg⁻¹ respectively. P fluctuates with lows of both ecofacts and artifacts, but when they don't correspond with one another, P follows the higher weights measured for either ecofacts or artifacts. P appears to reflect the presence of either high amounts of artifacts or high amounts of ecofacts.

Ca was not influenced by the fluctuating highs and lows of artifacts and ecofacts, but remained relatively stable until the decreased counts in F5 Level 0-10. K, Si, Ti, Al, and Fe were found to be closely aligned with one another as was found with the Doigs units. Their measured values were relatively stable until F5 Level 0-10, where the sharp decline in counts were found to be associated with an increase of K, Si, Ti, Al, and Fe, eventually decreasing at F6 Level 0-10 (Chart 80).
Chart 76: Coconut Hall Press Unit: phosphorus, calcium, potassium

Levels
F3 0-10  F3(10-20)  F3(30-40)  F4 10-20  F5 0-10  F6(0-10)

COCONUT HALL EXC 1: Phosphate, Calcium, and Potassium (ppm) vs Ecofact/Artifact Counts and Weights
Chart 77: Coconut Hall Fuss Unit; Iron, Aluminum, Titanium, and Silicon
Chart 78: Coconut Hall EXC1 Ecofact and Artifact by P (mg kg⁻¹)

- 189 -
Chart 79: Coconut Hall's Fuss Unit. Top: Potassium, Middle: Calcium, Bottom: Silicon.
<table>
<thead>
<tr>
<th>Unit by Level</th>
<th>F3 0-10</th>
<th>F3 10-20</th>
<th>F3 (30-40)</th>
<th>F5 0-10</th>
<th>F6 (0-10)</th>
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</thead>
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<tr>
<td><strong>COCONUT HALL EXC1: F3 and F5</strong></td>
<td></td>
<td></td>
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</tr>
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<table>
<thead>
<tr>
<th>Element</th>
<th>Ecofact</th>
<th>Artifact</th>
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</thead>
<tbody>
<tr>
<td><strong>Ti (ppm)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Al (ppm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fe (ppm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chart 80: Coconut Hall's Fues Unit. Top: Titanium; Middle: Aluminum; Bottom: Iron.
6.3.7.3.a Coconut Hall Soil auger augers: Site Periphery

Augers taken in 2013 at Coconut Hall, were only obtained along the periphery of the site. Intensive overgrowth, particularly of thick acacia, has made the site largely inaccessible. The scattered surface remains were observed were in stark contrast to the intensive surface scatter observed on previous surveys conducted in 2007. Both P and Ca reflect these observations when compared to the measurements taken from the Coconut Hall midden (Chart 76-80).

Augers taken along the periphery of the site had a maximum P value of 1,991 mg kg⁻¹ and Ca value of 288,267 mg kg⁻¹ (Chart 81); whereas the sampled midden excavated by Fuess had a P maximum value of 10,554 mg kg⁻¹ and Ca maximum of 363,257 mg kg⁻¹. P and Ca, do not correspond strongly to one another as observed within the midden context as well. Based on the high Ca values in areas identified with sparse material remains, in particular along the periphery indicate that the soils within this are high in Ca and may explain the discrepancies between P and C. K, Fe, Al, Ti, and Si all do correspond well with one another (Chart 82), which is primarily the result of the local parent material present in the limestone rich region. Local clay deposits would account for the Al, Si, and potentially Fe as well. As P and Ca were absent from the periphery of the site, suggests that some sections of the site are largely intact. This is in contrast to those observations made of Elliot's.
Chart 81: Coconut Hall soil augers and surface counts; phosphorus, calcium, and potassium

COCONUT HALL SOIL AUGERS AND SURFACE COUNTS: Phosphate, Calcium, and Potassium (ppm)

Counts

Ppm

0

5

10

15

20

25

30

Cappm

1
×10^5

2
×10^5

Kppm

3000

4000

5000

6000

7000

Coconut Hall Core Identification

CH1 CH1 CH1 CH2 CH2 CH2 CH2 CH2 CH3 CH3 CH3 CH3 CH4 CH5 CH5 CH6 CH6 CH6 CH6 CHC1 CHC1 CHC1

Chart 81: Coconut Hall soil augers and surface counts; phosphorus, calcium, and potassium
COCONUT HALL SOIL AUGERS AND SURFACE COUNTS: Iron, Aluminium, Silicon, and Titanium

Chart 82: Coconut Hall soil augers and surface counts: iron, aluminium, silicon, and titanium.

COCONUT HALL SOIL AUGERS AND SURFACE COUNTS: Iron, Aluminium, Silicon, and Titanium (ppm)
6.4 Soil augering and Surface Deposit Comparison

While the presence of surface artifacts are often the first indicator alerting archaeologists and cultural resource managers in identifying 'sites', surface materials prove to be far more complicated in both how we use and interpret these early findings. By comparing surface artifacts with the aforementioned soil augering strategy we can accurately and rapidly identify the distribution of midden deposits, void spaces, and buried assemblages. The collective knowledge gained from this rapid method can provide an additional assessment of the degree of disturbance a site may have encompassed by testing the degree in which surface concentrations reflect subsurface soil findings.

Augers were taken at Pre-Columbian sites across Antigua's three different geologic regions with overlapping sugar plantations nearby the Pre-Columbian sites of Doigs and Elliot's. Elliot's is currently being used for agriculture and is subjected to intensive ploughing; these destructive processes provided an opportunity to study how these intensive processes impact the movement of material remains. Disturbed midden deposits were compared with their associated soils to discern this relationship. Soil samples were collected stratigraphically or mechanically when stratigraphic layers appeared greater than 10 cm. A five meter surface collection was setup around each auger and counted. Augers were taken at approximately 10 meter intervals unless vegetation was too thick or property was off-limits.

6.4.1 Elliot's Soil auger augers: Plough Zone Impact

The site of Elliot's provided important insight into the affect continuous ploughing with heavy machinery can have on archaeological context within a Saladoid village. Pedestrian surveys have found that in some areas, tractor ploughing has exposed brownish, grey, and white
marl. Unfortunately, levels have not been kept with respect to the site's loss of soils; although 30-40 centimeter depths were observed being churned and exposed during this research project's soil collection. While an abundance of surface materials were visible throughout the site, they vary from heavily concentrated to completely absent. Ethnoarchaeologic studies have argued that agricultural ploughing churns assemblages mixing them vertically with some expansion of the site through a dragging effect (Taylor 2000; Navazo & Díez 2008). These observations suggest that assemblages can retain some aspect of their spatial characteristic. Augers taken throughout the site of Elliot's were done with this question in mind, particularly to test the impact of heavy agricultural ploughing and explore how elemental patterning can characterize stratigraphic disturbances.

Within this context, if artifact/ecofacts have been churned rather than dragged across the site, then surface counts should be better represented by P and Ca measurements as any buried remains would be brought to the surface. Augers were sorted based on assemblage counts to compare elemental signatures. While P and Ca share some general overlapping patterns, Ca appears largely erratic with respect to P and is uncharacteristic of any excavated or augured soils analyzed from previous sites (Chart 83). While P measured consistently higher in areas rich in surface remains, P was a relatively poor indicator of both presence/absence and quantity of material remains rejecting the earlier hypothesis that ploughing does not disturb the spatial remains but rather churns them in place. It should however, be pointed out that an absence of elements does not indicate an absence of activities. In this case, intensive ploughing and agricultural land-use practices have partially erased pre-Columbian activity areas and laid new/different activity areas on top.
K, Ti, Fe, Al, Ti, and Si is also indicative of this palimpsest where disturbances and overlapping activity areas create areas such as EC4, EC5, and EC9 that do correspond with one another and require additional archaeological investigations to explore their historical context as well as areas that were largely disjointed. Within a pre-Columbian context, P and Ca demonstrate their consistent relationships (Chart 84), however further research is needed to understand the historical context of the region in order to better assess these findings. The erratic patterning and poor association with all elements were not been observed in any of the previous context analyzed, and should highlight the complexity and challenges of interpreting anthrosols from pre-Columbian sites affected by colonial and modern land-use agricultural practices. These findings do suggest that the site of Indian Creek was minimally affected by recent attempts at growing cotton, with elemental patterns remaining consistent lacking the erratic or disjointed patterns observed at Elliot's.

Intensive ploughing has resulted in the visible churning of anthropogenic sediments and associated material remains resulting in a largely erratic and somewhat chaotic elemental patterning. These findings suggest that soil augering and elemental analysis can provide important insight into assessing pre-Columbian site disturbances. These findings highlight the importance of coupling anthrosol studies with archaeological investigations, particularly regarding the study of void spaces, in assessing the land-use histories.
Picture 4: Elliot's Pre-Columbian site showing active plow zone.
<table>
<thead>
<tr>
<th>COUNTS</th>
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<th>Pppm</th>
</tr>
</thead>
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<th>MOLLUSC CT</th>
<th>CERAMICS</th>
<th>CORAL</th>
<th>LITHIC</th>
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</table>

**Chart 83: ELLIOTS SOIL augers AND SURFACE COUNTS: phosphorus, Calcium, and Potassium sorted by artifact/ecofact counts**

- 199 -
Chart 84: Elliot's Soil augers and Surface Counts: Iron, Aluminum, Silicon, and Titanium (ppm)
6.4.2 Winthorpe's Soil auger augers: Coastal Erosion

Limited augers were taken at Winthorpe's due to a lack of access and continuing erosion of the site. It was noted by Matthew Brown (Pers Com) of SUNY Farmingdale, that in 2004 the site was already experiencing heavy loss due to erosion. Only one area along the coastal erosion face was observed with any significant cultural artifacts imbedded stratigraphically. The site may continue further south, although this is currently the property of the United States Air Force, and access could not be obtained at the time of this dissertation.

WN5 and WN8 were taken within proximity of this erosion face, with P and Ca following similar trends (Chart 85). K, Fe and Ti all show loose patterning, which is indicative that the limited area available for testing is relatively undisturbed (Chart 86). The lack of available samples and limited access makes any interpretations impossible, although renewed hope for this site maybe possible as the air force is in the process of closing in the near future. Nonetheless, these observations are consistent with disturbances observed at Elliot's adding support that heavily impacted sites can be identified through the use of multi-element analysis of these context.
Chart 2: Winthorpe’s soil augers and surface counts: phosphorus, calcium, and potassium.
Chart 86: Winthorpe’s soil augers and surface counts: iron, aluminum, silicon, and titanium.

Winthorpe’s Soil Cores and Surface Counts: Iron, Aluminum, Silicon, and Titanium (ppm)
6.4.3 Betty's Hope Soil auger augers: Historical Impacts

Betty's Hope was selected as an off-site reference comparing the long-term impact of intensive sugar production amongst the landscape. While the Codrington's would have owned the lands around Elliot's, there is no direct evidence that the primary sugar complex including the great house, manager's house, sugar works, and slave village overlapped Pre-Columbian activities. It is this criteria and this space that we base the term off-site on at the site of Betty's.

P and Ca deviate from one another consistently, while K, Fe, Al, Si, and Ti do match with similar patterns (Chart 87 & 88). The matching patterns of K, Fe, Al, Si, and Ti suggest that some stratigraphic relationships are observable; although this maybe indicative of recent activities tied to tourism, multiple land-use practices leading up to abandonment, and/or erosion and modification of local hydrology (in particular the recently modified Ayers Creek). While P and Ca are often causally linked in anthrosol studies, this research does not address the impact of colonial land-use activities on anthrosols, which severely limits this research's interpretations. Recent geoarchaeological work and land-use modeling using EPIC at Betty's Hope (Wells 2015; Pratt 2015) suggests that considerable erosion and soil loss occurred not because of intensive farming, but resulting largely from land-use abandonment practices. P levels were never found above 5,000 mg kg-1, in contrast to the neighboring Pre-Columbian site of Elliot's with a maximum of 18,945 mg kg-1. Based on recent findings, the absence of P does not mean there is an absence of activities, highlighting the importance of understanding the landscape legacies (Wells 2015) inherited.

Spatially, samples taken from domestic spaces associated the with slave village complex had higher P mg kg-1 measurements in comparison to areas within the plantation complex.
These peripheral areas were associated with domestic refuse activity. Recent excavations based on landscape surveys using colonial plantation maps suggest that these areas were used during pre and post emancipation periods. P measurements around the central sugar complex were found to be significantly low with respect to the surrounding domestic spaces, although as previously mentioned, much of the sugar complex soils have been lost. While not presented in this research, heavy metal measurements were taken for Betty's Hope and Pre-Columbian soil samples. The presence of certain heavy metals in relatively high concentrations such as lead and arsenic may prove particularly useful in distinguishing pre-Columbian activity areas and colonial activity areas.
Betty's Hope soil augers and surface counts; Phosphate, Calcium, and Potassium (ppm)

Chart 87: Betty's Hope soil augers and surface counts; phosphate, calcium, and potassium PXR readings
Chart 88: Betty's Hope soil augers and surface counts; iron, aluminum, silicon, and titanium PXR readings.

BETTY'S HOPE SOIL CORES AND SURFACE COUNTS: iron, aluminum, silicon, and titanium PXR readings.
6.4.4 Galleon Beach Soil auger augers: Diachronic Context

Galleon Beach augers were taken during the summer of 2013, and represent a mixed Pre-Columbian site with 18th-19th century naval disturbances. A small scale rescue-excavation was conducted in conjunction with the BBC network, to recover human remains originating from the British Naval ships docked along the sandy beach ridge on the southern coast of Antigua. Past hurricane activity uncovered the remains of human remains eroding out to sea. Subsequent test units uncovered the remains of past Pre-Columbian activities including structural remnants, ceramics, shell axes, and scattered midden refuse. Burials from the British Naval warships were mixed with disturbed Pre-Columbian artifacts as well. augers were taken in an attempt to identify additional areas of past human activity. These samples were extremely limited due to the amount of development within the surrounding area. Housing was placed west of the beach ridge with water, waste, and electrical pipes running along this area. To the North of the beach ridge is another row of houses along the waterfront followed by a series of tennis courts further north. A seawall and road truncate the beach ridge further south, therefore leaving only this beach ridge as the only accessible area of past cultural activity.

auger samples taken fluctuated between a maximum P value of 5,438 mg kg-1 and Ca 403,619 mg kg-1, with a minimum P value of 500 mg kg-1 and Ca 18,218 mg kg-1 (Chart 89). Soils extracted from within the primary burial contexts had a mean P value of 5,442 mg kg-1 and Ca value of 375,979 mg kg-1. The Pre-Columbian context recovered at a depth of 125 cm, was associated with the preserved wooden post, had a P value of 6,831 mg kg-1 and a Ca value of 388,476 mg kg-1. Similar Ca values were later discovered to be associated with a possible Pre-Columbian living floor made up of solidified shell ash and hardened sand. The broken down
shell remnants along with sand and baking sun may have produced a type of Pre-Columbian lime-plaster living floor. Complicating the interpretation, is that this context is also associated with burials of British Navy sailors. The use of lime for burials, was also considered as the process of making lime in the Caribbean involved the use of conch shells, mussel shells, and coral from the sea. However, low P mg kg-1 was inconsistent with findings from the testing of reference samples of burnt shell and wood ash. Additional samples were taken for future research and analysis associated with the Galleon Beach Project. augers taken around the beach ridge accounted for the high P values, and low values such as GABC4 were in areas that were heavily disturbed by pipes and electrical lines to the west of the beach ridge. These readings were well below even sterile context found throughout the Galleon Beach excavations indicating that the primary component of the Pre-Columbian site appears to be isolated to the beach ridge associated with the burials (Chart 90).
Chart 89: Galleon Beach soil augers and surface counts; phosphorus, calcium, and potassium

Galleon Beach soil cores and surface counts: Phosphate, Calcium, and Potassium (ppm)
6.5 Midden Comparisons

Middens continue to play a critical role in defining and characterizing Saladoid and Post-Saladoid lifeways in the Caribbean; primarily through an understanding of economic, environmental, and sociological changes. The opportunity to study and compare soils from midden deposits across different temporal scales and geographic locations allows us to generate new bodies of data that can be applied to the island's pre-history. While many of these midden excavations represent only a small sample of entire middens, caution should be emphasized that these comparisons are an early phase of this research. Additional samples from village context are required, as well as comparative studies from other islands. Nonetheless, the comparison of small midden samples across different temporal and spatial scales from the island of Antigua represent.

The site of Indian Creek contains the highest elemental measurements across the board when compared to all other sites tested (Chart 91 & 92); which is the direct result of elemental loading from concentrated midden deposits. Indian Creek contains ceramics associated with the Early Saladoid all the way through to the Post-Saladoid; which is substantiated by the radiocarbon dates encompassing these transitions. The highest P measurement for Indian Creek is 77,923 mg kg⁻¹ with the next highest site value from Doigs at 15,853 mg kg⁻¹. These high measurements are unlikely to be due to the geologic variation, as samples from the bedrock at Indian Creek contain 2,025 mg kg⁻¹ P value, and sterile layers from within middens measured less than 5,000 mg kg⁻¹. While additional radiocarbon dates are needed for an understanding of how elemental concentrations relate to settlement duration, Indian Creek represents the longest settled village based on relative dating (ceramics).
When sorted by the highest levels of P mg kg\(^{-1}\): Indian Creek, Doigs, Royals, and Muddy Bay comprise the top four sites. These sites were observed to also the most concentrated in faunal counts, particularly fish bones and mollusks. Top measurements for Ca were Indian Creek, Galleon, Muddy Bay; Fe was Indian Creek, Claremont, Doigs; Al was Indian Creek and Claremont; K was Indian Creek, Coconut Hall, Doigs, and Claremont; Si was Indian Creek, Claremont, Doigs, and Coconut Hall; and Ti was Indian Creek, Claremont, and Doigs. Elemental patterning was found to be similar across different midden sites, with elevated P and Ca following each other closely. However, limestone regions did show evidence that parent material can impact and sometimes impede the use of calcium as an indicator of past human activities. These findings re-enforce the necessity to obtain multiple elemental characteristics in order to establish elemental patterning from different activities. When natural and cultural factors are taken into account, anthrosols analyzed at the site level are useful indicators of concentrated human activity (Bethell & Mate 1989).
Chart 9.1: Midden Comparisons for All Sites Tested. Measuring Phosphorus, Calcium, and Potassium.
Chart 92: Midden Comparison of All Units Tested Measuring Titanium, Silicon, Aluminum, and Iron.
Chart 93: Soils from excavated units by type: phosphorus, calcium, and potassium
Chart 94: Soils from excavated units by type: iron, aluminium, silicon, titanium.
6.6 Validation of Rapid Ptest

The rapid Ptest or ring color test has been used since Arrhenius's 1931 study (Arrhenius 1931) of soils to differentiate prehistoric and historic settlements. These methods have been applied to numerous regions and time periods due to the low cost, minimally invasive, and rapid techniques that can be used to produce meaningful results in the field. One of the limitations, are that these results are largely qualitative whose applications can be extremely limited. This section presents research testing qualitative against quantitative measurements in order to identify the accuracy, range, and limitations associated with this augering technique. At the time of this writing, the author is not aware of any studies looking to validate this particular method.

A total of 274 soil samples were selected for comparison encompassing different sites, soil conditions, geologic layers, temporal phases, and activity areas. Each soil sample was read twice resulting in 548 pXRF readings. Qualitative augers were conducted as discussed previously in Chapter 3, ranging from categories '0' (lowest) to '5' (highest) for phosphorus value. Total mean given in mg kg\(^{-1}\) are provided in chart 80 along with the respective spread for each category.

Comparison between qualitative Ptest and quantitative pXRF provide a number of key findings. Ptest categories represented significant corresponding differences between each value; as Ptest values generally increased so did the corresponding mean values in mg kg\(^{-1}\). It should be mentioned that Ptest value '0' and '1' were statistically indistinguishable with a mean of 1,032 mg kg\(^{-1}\) and 1,070 mg kg\(^{-1}\) respectively. Therefore, both categories should be lumped together.
rather than set apart. Of particular interest, augers of '0' were only given when no color change occurred while augers of '1' were only given when minor color changes were present.

Category '2' shows a 54% increase from category '1', with a mean value of 1,979 mg kg⁻¹. While categories '3' (6,267 mg kg⁻¹), '4' (12,405 mg kg⁻¹), and '5' (22,013 mg kg⁻¹) each showed significant differences in their mean values; outliers were observed with all three augers (Chart 95). Upon revisiting digital records for Ptesting, there remains some challenges in augering the overall formation and intensity of color change tests. In category '3' there were two mg kg⁻¹ outliers representing soil sample ICC28 20-25cm. Digital records show that while there was a section where intense color change was present, the overall color distribution was relatively minor for the surrounding ring. Therefore, it is possible to refine the method to place greater focus on the intensity of color rather than the formation of the ring.

While categories '4' and '5' had distinct differences between their mean values, their overall spread shows that a majority of these readings significantly overlapped one another. The higher mean value for '5' was due to the concentrated cluster of high mg kg⁻¹ values (Chart 96), while the highest recorded value was recorded in category '4'. These findings suggest that categories '4' and '5' should also be combined into one category.

These findings are significant, as rapid Ptests are commonly used within the field of archaeology. While there are statistical significances between categories, '0' and '1' as well as '4' and '5' should be consolidated. Each category represents a significant shift in mean mg kg⁻¹, informing us of their broad qualitative threshold. Certainly, this study reaffirms other findings that qualitative Ptests are useful in identifying and potentially delimiting certain types of archaeological sites, in particular where refuse or food related activities are present. Caution should be not-
ed for interpretation of activity areas using this qualitative method, as the resolution may often be inadequate to distinguish between different long-term practices.
Chart 95: Comparison between Rapid Ptest and pXRF readings in mg kg⁻¹. The left chart presents the Ptest qualitative augers treated as categories 0-5 compared to the mean and standard deviation. The right chart presents the spread in mg kg⁻¹ for each qualitative Ptest sauger.

Chart 96: Distribution of Ptest categories in mg kg⁻¹.
Chapter 7. Archaeology

The recent digitization of Rouse's entire collection at Indian Creek provides important insight into the spatial distribution of 'special' and 'everyday' finds which indicate concentrated ritual activities in the proximity of Yale excavations 5 and 6. While Rouse (Rouse & Morse 1999/45) discussed these findings, this chapter presents a more comprehensive breakdown of the "more artistic artifacts" distributed within this area. Recent archaeological excavations conducted in the areas surrounded by midden mounds suggest this area was kept clear of refuse. This chapter presents the findings and analysis of both past and present archaeological research conducted at Indian Creek. In parts 1-3, the Yale excavations led by the late Irving Rouse provided the context and background for the recent excavations presented in parts 4-5.

The profiles from part 1, were taken directly from Rouse (Rouse & Morse 1999), while raw data was extracted from the Yale Peabody Museum's Anthropology database; subsequently analyzed and put into table form. Part 2 presents the spatial distribution of 'special' finds, particularly objects classified by Rouse as: inhalers, zemis, anthropomorphic motifs, body stamps, and griddles. While griddles may seem to be an everyday utilitarian object, the specificity of its function makes it spatially significant to be placed into this category. Part 3 focuses on the general distribution of total ceramics, bones, and shell and coral assemblages. Part 4 provides findings from recent excavations focused on the areas central to surrounding middens (ICC100) as well as a strategically placed excavation unit (ICC101) between the Yale excavation units of 5 and 6. Part 5 presents additional shovel test pits conducted within the areas bounded by the circular midden formation.
The findings from this chapter, coupled with the soil analysis and ethnoarchaeological case studies, helped generate new discussions discussed in Chapter 8 about long-term village life at Indian Creek. These findings will be used to help generate additional discussion about Doigs and Betty's Hope as well.

7.1 Yale Excavations

7.1.1 Chronology

Radiocarbon dates originally published by Irving Rouse were entered into OxCal 4.2, for better internal comparison. The dates (Chart 97) are in chronologic order, including two early dates I-7830 and I-7842 which were excluded by Rouse as they were well outside the range and predated ceramic age sites in the Caribbean. Figure 6 provides the spatial distribution of radiocarbon dates originally reported by Rouse, stratigraphic layer, and their associated ceramic typologies in order to spatially characterize time better. The discarded dates are found in Excavation 1 to the south, associated with the earliest Indian Creek ceramic phase and radiocarbon measurements.
Figure 6: Yale Indian Creek Spatial Distribution of Radiocarbon dates
Chart 97: Calibrated radiocarbon dates from the Yale Indian Creek excavations (Rouse 1999) using OxCal (et al. Reimer 2013)
### 7.1.2 Excavation 1

Figure 7: Yale Excavation 1 profile drawing of southern walls at 25 cm intervals (Rouse 1999)

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<thead>
<tr>
<th>LEVEL</th>
<th>SECTION</th>
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<td>12</td>
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<td>Section A-4</td>
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<td>22</td>
<td>2</td>
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Table 15: Yale Excavation 1 assemblage breakdown, data compiled courtesy of the Yale Peabody Museum.

Excavation 1, located in the southern section of the village, represents the earliest phase of the site with an approximate depth of 75 cm (Rouse & Morse 1999). Direct radiocarbon analysis was conducted on charcoal from Section A-1 Level 3 and Section A-3 Level 2 yielding OxCal calibrated dates between 1189 B.C.-A.D. 377 at 95.4% (l-7830 & l-7979), which is consistent with the general period suggested by cultural artifacts recovered from these levels. Augers taken in this area were also consistent with the relatively moderate depths found in the southern
section of the site. Relatively low assemblage counts were comparable to Excavation 3 (Chart 98-100), both yielding similar depths of approximately 75 cm.
Excavation 2 represents one of the richest ceramic and bone assemblages. While bone counts must be met with extreme caution due to the sampling strategy, these disproportionate
counts do not seem arbitrary. Of particular significance, is that this is the only rich midden associated with the Western part of the site at the base of the Indian Creek hill. Excavation 2, is located in the Southwest corner of the site with direct radiocarbon analysis of charcoal from Section C-3 Level 5 and Section C-4 Level 2 respectively yielding OxCal calibrated dates ranging from 689-1431 A.D. at 95.4% (I-7984 & I-7843).

7.1.4 Excavation 3

Figure 9: Yale Excavation 3 profile drawing of southern walls at 25 cm intervals

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Table 17: Yale Excavation 3 assemblage breakdown, data compiled courtesy of the Yale Peabody Museum.
Excavation 3 represents the lowest overall assemblage (Chart 98-100) and is associated with shallow depths ranging from 25-50 cm. This midden excavation contains the least overall ceramic, bone, coral, and shell counts compared to other subsequent middens excavated. A single OxCal calibrated radiocarbon date was acquired from charcoal at Section E-4 Level 2 yielding dates between 1027-1276 A.D. within 95.4% (I-7832), which is consistent with the general period suggested by cultural artifacts recovered from these levels.
Excavation 4 is relatively rich in ceramics and bones (Chart 98-100), and has a number of recorded ash deposits as well. While this midden area is located to the north of the site, it is also
East of Exc. 3 but West of Exc. 5 and has an increased depth of approximately 100 cm. This trend of deeper strata is true around the midden areas, although shovel test pits moving eastwards show minimal depth increases in the central area. Direct radiocarbon analysis was conducted on charcoal from Section G-3 Level 5 and Section G-1 Level 2 yielding OxCal calibrated dates of between 640-1210 A.D. respectively at 95.4% (I-7834 & I-7845).

### 7.1.6 Excavation 5

![Figure 11: Yale excavation 5 profile drawing of southern walls at 25 cm intervals](image)

<table>
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<th>SHELL/CORAL</th>
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<td>36</td>
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<td>14</td>
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<td>Level I (0.00-0.25m)</td>
<td>Section I-2</td>
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<td>Level II (0.25-0.50m)</td>
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</table>
Table 19: Yale Excavation 5 assemblage breakdown, data compiled courtesy of the Yale Peabody Museum.

Excavation 5 is located in the Northeastern part of the site, where depths of 175 cm make this one of the deepest stratified area around the site. This midden area is within close proximity, approximately 30 meters of the dried up creek bed associated with the site. This midden represents the richest coral and shell ceramic concentrations of all six middens, while assemblages are also incredibly diverse. Direct radiocarbon analysis was conducted on samples originating from Section I-2 Level 6 and Section I-1 Level 2 yielding OxCal calibrated dates of between radiocarbon dates 382-1280 A.D. respectively at 95.4% (I-7355 & I-7835). A total of 8 radiocarbon dates represent the longest temporal sequence found throughout the site suggesting that continued use of this space for discard was practiced throughout much of the site's existence. Both Excavation 5 & 6 represent significant areas for special finds which will be discussed in the following sections.
7.1.7 Excavation 6

Figure 12: Yale excavation 6 profile drawing of southern walls at 25 cm intervals

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>SECTION</th>
<th>BONE</th>
<th>CERAMIC</th>
<th>SHELL/CORAL</th>
<th>STONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level VI (1.25-1.50m)</td>
<td>Section I-2</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level IV (0.75-1.00m)</td>
<td>Section I-4</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Level I (0.00-0.25m)</td>
<td>Section P-1</td>
<td>115</td>
<td>536</td>
<td>49</td>
<td>79</td>
</tr>
<tr>
<td>Level III (0.50-0.75m)</td>
<td>Section P-1</td>
<td>100</td>
<td>168</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-1</td>
<td>92</td>
<td>156</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Level V (1.00-1.25m)</td>
<td>Section P-1</td>
<td>69</td>
<td>232</td>
<td>10</td>
<td>47</td>
</tr>
<tr>
<td>Level VI (1.25-1.50m)</td>
<td>Section P-1</td>
<td>100</td>
<td>182</td>
<td>43</td>
<td>41</td>
</tr>
<tr>
<td>Level I (0.00-0.25m)</td>
<td>Section P-2</td>
<td>34</td>
<td>297</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Level II (0.25-0.50m)</td>
<td>Section P-2</td>
<td>50</td>
<td>119</td>
<td>39</td>
<td>30</td>
</tr>
<tr>
<td>Level III (0.50-0.75m)</td>
<td>Section P-2</td>
<td>34</td>
<td>82</td>
<td>21</td>
<td>32</td>
</tr>
<tr>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-2</td>
<td>167</td>
<td>65</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>Level V (1.00-1.25m)</td>
<td>Section P-2</td>
<td>65</td>
<td>166</td>
<td>33</td>
<td>46</td>
</tr>
<tr>
<td>Level VI (1.25-1.50m)</td>
<td>Section P-2</td>
<td>0</td>
<td>146</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>Level I (0.00-0.25m)</td>
<td>Section P-3</td>
<td>10</td>
<td>280</td>
<td>93</td>
<td>47</td>
</tr>
<tr>
<td>Level II (0.25-0.50m)</td>
<td>Section P-3</td>
<td>30</td>
<td>187</td>
<td>83</td>
<td>48</td>
</tr>
<tr>
<td>Level III (0.50-0.75m)</td>
<td>Section P-3</td>
<td>27</td>
<td>184</td>
<td>40</td>
<td>52</td>
</tr>
<tr>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>52</td>
<td>195</td>
<td>51</td>
<td>77</td>
</tr>
<tr>
<td>Level V (1.00-1.25m)</td>
<td>Section P-3</td>
<td>40</td>
<td>321</td>
<td>59</td>
<td>71</td>
</tr>
<tr>
<td>Level VI (1.25-1.50m)</td>
<td>Section P-3</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Level I (0.00-0.25m)</td>
<td>Section P-4</td>
<td>22</td>
<td>253</td>
<td>89</td>
<td>35</td>
</tr>
<tr>
<td>Level II (0.25-0.50m)</td>
<td>Section P-4</td>
<td>44</td>
<td>151</td>
<td>91</td>
<td>57</td>
</tr>
<tr>
<td>Level III (0.50-0.75m)</td>
<td>Section P-4</td>
<td>90</td>
<td>130</td>
<td>48</td>
<td>91</td>
</tr>
<tr>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-4</td>
<td>50</td>
<td>216</td>
<td>38</td>
<td>70</td>
</tr>
</tbody>
</table>
Excavation 6 is located along the Southeastern section of the site, and contains a relatively rich assemblage. It should be kept in mind however, that this unit is also one of the largest exposed as it was expanded from a 2x7 meter trench into a T-trench with an additional 2x7 meter trench running perpendicular. Despite the size, there is still a substantial quantity of ceramics, bones, coral, and shell. Direct radiocarbon analysis was conducted on samples from Section P-3 Level 5 and Section P-3 Level 2 yielding OxCal calibrated dates from 71-1155 A.D. respectively at 95.4% (I-7855 & I-7836). Findings for this area are consistent with Excavation 5’s sustained continuity of use. Further discussions will be made regarding the significance in special finds.

While extreme caution must be taken when interpreting faunal counts as was previously mentioned, Excavation 5 & 6 both contain high counts of coral and shell which is consistent with their proximity to the dried up creek bed.

7.2 General Distribution

A brief analysis for the general distribution of material remains by Yale provides an important comparison to the spatial distribution of special finds discussed in the following section. As Yale's primary focus was obtaining ceramics in order to develop a comprehensive Pre-Columbian typology, ceramics represent the most reliable assemblage for spatial analysis.

7.2.1 Ceramic Distribution
Ceramics were widely distributed across the site of Indian Creek, albeit concentrated around the periphery of the site. While these observations were made during Rouse's and Olsen's walk-through of the site, substantive evidence supporting this initial hypothesis have been made in the following sections describing an absence of material remains in general within the space enclosed by these surrounding middens.

Excavations 2, 4, 5, and 6 represented the highest ceramic concentrations while Excavations 1 and 3 were found to be the lowest. These findings are also consistent with the relative depth for each midden area excavated with shallow depths being associated with decreased concentrations while deeply stratified middens contained an abundance of ceramics.

The distribution of ceramics are also significant when discussing special finds related to the distribution of inhalers, anthropomorphic figures, and zemis. The ceramic assemblage repre-
presented by Yale's excavation appears to be fairly comprehensive and reliable when looking at the
distribution of ceramics and special finds as this was part of Rouse's primary objective.

7.2.2 Bone Distribution

![Distribution of Bones: Yale Excavation](image)

**Chart 99: Distribution of bones from Indian Creek Excavations 1-6**

While Rouse acknowledges that faunal assemblages were not their primary research ob-
jectives for this study, a cautionary look at these assemblages still suggest possible differences
that should not be ignored; but rather expanded on for future studies. Bone concentrations were
found to be similar to concentrations found in ceramics, albeit Excavation 2 at the base of the hill
to the West, was found to have a substantially higher concentration of bones recovered during
excavation. While this maybe a byproduct of poor sampling, further analysis of this area is need-
ed to explore the differences in faunal remains in this area to identify differences in food prepara-
tion or consumption. This requires further analysis, and will be the focus of future excavations
to obtain comparative materials to explore differences between this and areas to the East of the site alongside the creek. Excavation 1 and 2 had very low deposits, although this may be a function of shallow deposits and occurring along the base of the hillside.

### 7.2.3 Shell and Coral Distribution

![Chart 100: Distribution of coral and shells from Indian Creek Excavations 1-6](image)

The shell and coral may also be a byproduct of poor sampling and recovery strategies. Excavation 1 and 3 contain the lowest counts and is consistent with ceramic concentrations, while Excavation 5 and 6 contain a substantially high concentration of shell and coral. This may be a byproduct of midden location, as this area is within close proximity to the recently dried up river bed associated with the site.
### 7.3 Distribution of Special Finds

#### 7.3.1 Inhaler Distribution

<table>
<thead>
<tr>
<th>Title</th>
<th>Geographic Locality</th>
<th>Level</th>
<th>Section</th>
<th>Era</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incense holder</td>
<td>Excavation 5</td>
<td>Level III (0.50-0.75m)</td>
<td>Section I-?</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>Incense burner</td>
<td>Excavation 5</td>
<td>Level V (1.00-1.25m)</td>
<td>Section I-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>6 Handles incense burner</td>
<td>Excavation 5</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>Sherd incense burner fragment</td>
<td>Excavation 5</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>3 Incense burner fragments</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section I-4</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>5 Incense pot fragments</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>5 Plain incense burner fragments</td>
<td>Excavation 6</td>
<td>Level V (1.00-1.25m)</td>
<td>Section P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>White on red and black incense burner fragment</td>
<td>Excavation 6</td>
<td>Level V (1.00-1.25m)</td>
<td>Section P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>Incense burner fragment</td>
<td>Excavation 6</td>
<td>Level VI (1.25-1.50m)</td>
<td>Section P-2</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>Fragment incense bowl</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>Large fragment</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>2 Red incense burner fragments (?)</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>3 Incense burner fragments</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>Incense burner</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>Incense burner</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>Large fragment</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>3 Incense burner fragments</td>
<td>Excavation 6</td>
<td>Level V (1.00-1.25m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
</tbody>
</table>
Table 21: Distribution of Inhaler fragments from Yale excavation units 1-6. Findings compiled courtesy of the Yale Peabody Museum.

<table>
<thead>
<tr>
<th>Fragments</th>
<th>Excavation</th>
<th>Level</th>
<th>Section</th>
<th>Indian Creek period</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Fragments white and orange on red incense burner</td>
<td>6</td>
<td>III (0.50-0.75m)</td>
<td>P-4</td>
<td>period</td>
</tr>
<tr>
<td>5 Incense burner fragments</td>
<td>6</td>
<td>IV (0.75-1.00m)</td>
<td>P-4</td>
<td>period</td>
</tr>
</tbody>
</table>

The categorization of special finds for this analysis, is largely based on the criteria that these items have a specific use and function connected to ceremonial, feasting, and symbolic activities (Kaye 1999; Safford 1916). Incense burners have been found in archaeological context from early to late Saladoid phases. The distribution of incense burners (n = 44) were only found in Excavations 5 (20.5%) and 6 (79.5%), along the Eastern creek-side of the site. The temporal range of these findings occur after 382 calAD (I-7355) to 1276 calAD (I-7847) from Excavation 5; while Excavation 6 ranges from 71 calAD (I-7855) to 1155 calAD (I-7836). These findings have significant bearing on the archaeological interpretation of the site, providing evidence that the creek-side of the site may have served as an area of ritual activity. Some caution should be considered, as inhalers have also been classified as being part of spouts for large vessels (personal communication Reg Murphy). While further evaluation is necessary, their spatial distribution is still relevant. Soil comparisons discussed in the Synthesis chapter contribute to these questions regarding spaces lacking material remains in the central space.
Table 22: Distribution of zemis and proto zemis from Yale excavation units 1-6. Findings compiled courtesy of the Yale Peabody Museum.

Zemis/Cemis are portable artifacts that are associated with spiritual aspects of Pre-Columbian cultures throughout much of the Caribbean. While often associated with later period Taino sites ca. AD 1000-1550 (Oliver 2009) in the Greater Antilles, they are also found throughout parts of the Lesser Antilles as well. The majority of zemis found at Indian Creek were found
predominately in Excavation 5 and associated with the Mill Reef and to a lesser extent Mamora Bay ceramic series. Excavation 5 radiocarbon dates ranged from 656-975 calAD (I-7353) to 1020-1280 calAD (I-7835). One zemi was found in Excavations 2, 3, and 6; while nine were found in Excavation 5.

### 7.3.3 Anthropomorphic Ceramic Distribution

<table>
<thead>
<tr>
<th>Title</th>
<th>Geographic Locality</th>
<th>Level</th>
<th>Section</th>
<th>Era</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropomorphic hollowed lug</td>
<td>Excavation 1</td>
<td>Level I (0.00-0.25m)</td>
<td>Section A-2</td>
<td>Indian Creek</td>
</tr>
<tr>
<td>Large sculpted anthropomorphic lug</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-1</td>
<td>Indian Creek</td>
</tr>
<tr>
<td>Small anthropomorphic lug</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-4</td>
<td>Indian Creek</td>
</tr>
</tbody>
</table>

Table 23: Distribution of anthropogenic ceramic motifs from Yale excavation units 1-6. Findings compiled through the Yale Peabody collection.

While anthropomorphic ceramics only identified three times, their rarity adds to the potential significance to the overall use of the space. Two were found in Excavation 6, while one was found in Excavation 1. These dates clustered between 143-561 calAD (I-7854) add to both the spatial and temporal dimension of the distribution of these findings.

### 7.3.4 Griddle Distribution

<table>
<thead>
<tr>
<th>Count</th>
<th>Title</th>
<th>Geographic Locality</th>
<th>Level</th>
<th>Section</th>
<th>Era</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Griddle fragment</td>
<td>Excavation 2 surface</td>
<td></td>
<td></td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>4</td>
<td>Base griddle legs</td>
<td>Excavation 2</td>
<td>Level I (0.00-0.25m)</td>
<td>Section C-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle fragments</td>
<td>Excavation 3 surface</td>
<td></td>
<td></td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>1</td>
<td>Large griddle fragment</td>
<td>Excavation 4</td>
<td>Level V (1.00-1.25m)</td>
<td>Section G-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle legs</td>
<td>Excavation 5 surface</td>
<td></td>
<td></td>
<td>Mamora Bay period</td>
</tr>
</tbody>
</table>

- 242 -
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
<th>Excavation</th>
<th>Level &amp; Depth</th>
<th>Section</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Griddle fragments</td>
<td>Excavation 5</td>
<td>Level III (0.50-0.75m)</td>
<td>I-1</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle legs</td>
<td>Excavation 5</td>
<td>Level III (0.50-0.75m)</td>
<td>I-1</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td></td>
<td>Tab, griddle leg?</td>
<td>Excavation 5</td>
<td>Level III (0.50-0.75m)</td>
<td>I-1</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>6</td>
<td>Griddle base and griddle legs</td>
<td>Excavation 5</td>
<td>Level IV (0.75-1.00m)</td>
<td>I-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle fragment</td>
<td>Excavation 5</td>
<td>Level IV (0.75-1.00m)</td>
<td>I-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>12</td>
<td>Griddle base fragments</td>
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<td>Level VI (1.25-1.50m)</td>
<td>I-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle fragments</td>
<td>Excavation 5</td>
<td>Level VII (1.50-1.75m)</td>
<td>I-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>4</td>
<td>Tabs and spindle whorls</td>
<td>Excavation 5</td>
<td>Level I (0.00-0.25m)</td>
<td>I-2</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle leg base fragment</td>
<td>Excavation 5</td>
<td>Level II (0.25-0.50m)</td>
<td>I-2</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle base fragment</td>
<td>Excavation 5</td>
<td>Level IV (0.75-1.00m)</td>
<td>I-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>9</td>
<td>Griddle base fragments</td>
<td>Excavation 5</td>
<td>Level V (1.00-1.25m)</td>
<td>I-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>10</td>
<td>Griddle base fragments</td>
<td>Excavation 5</td>
<td>Level VI (1.25-1.50m)</td>
<td>I-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Rim sherd</td>
<td>Excavation 5</td>
<td>Level VII (1.50-1.75m)</td>
<td>I-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>4</td>
<td>Griddle legs</td>
<td>Excavation 5</td>
<td>Level III (0.50-0.75m)</td>
<td>I-3</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>4</td>
<td>Griddle base fragments</td>
<td>Excavation 5</td>
<td>Level IV (0.75-1.00m)</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>38</td>
<td>Griddle base fragments</td>
<td>Excavation 5</td>
<td>Level V (1.00-1.25m)</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle rim and leg</td>
<td>Excavation 5</td>
<td>Level V (1.00-1.25m)</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>2</td>
<td>Plain griddle fragments</td>
<td>Excavation 5</td>
<td>Level VI (1.25-1.50m)</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>5</td>
<td>Griddle base fragments</td>
<td>Excavation 5</td>
<td>Level VI (1.25-1.50m)</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td></td>
<td>Item Description</td>
<td>Excavation</td>
<td>Level Code</td>
<td>Section Code</td>
<td>Period Code</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------</td>
<td>------------</td>
<td>------------</td>
<td>--------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>1</td>
<td>Plain griddle leg</td>
<td>5</td>
<td>VI</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>3</td>
<td>Griddle fragments</td>
<td>5</td>
<td>VII</td>
<td>I-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle</td>
<td>5</td>
<td>III</td>
<td>I-4</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>12</td>
<td>Griddle base fragments</td>
<td>5</td>
<td>V</td>
<td>I-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>3</td>
<td>Griddle fragments</td>
<td>5</td>
<td>VI</td>
<td>I-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle fragment</td>
<td>Exc 5 Bot of arroyo</td>
<td></td>
<td></td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>13</td>
<td>Griddle fragments</td>
<td>6</td>
<td>I</td>
<td>P-?</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>11</td>
<td>Griddle fragments</td>
<td>6</td>
<td>I</td>
<td>P-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>19</td>
<td>Griddle fragments</td>
<td>6</td>
<td>I</td>
<td>P-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>5</td>
<td>Griddle fragments</td>
<td>6</td>
<td>I</td>
<td>P-1</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>8</td>
<td>Griddle fragments</td>
<td>6</td>
<td>III</td>
<td>P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>8</td>
<td>Griddle fragments</td>
<td>6</td>
<td>IV</td>
<td>P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>1</td>
<td>Plain tab or small griddle leg</td>
<td>6</td>
<td>IV</td>
<td>P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>18</td>
<td>Griddle fragments</td>
<td>6</td>
<td>V</td>
<td>P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>13</td>
<td>Griddle fragments</td>
<td>6</td>
<td>VI</td>
<td>P-1</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>17</td>
<td>Griddle fragments</td>
<td>6</td>
<td>I</td>
<td>P-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle fragments</td>
<td>6</td>
<td>I</td>
<td>P-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>9</td>
<td>Griddle fragments</td>
<td>6</td>
<td>II</td>
<td>P-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle fragment</td>
<td>6</td>
<td>II</td>
<td>P-2</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>No.</td>
<td>Griddle fragments/fragments</td>
<td>Excavation</td>
<td>Level</td>
<td>Section</td>
<td>Period</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------------</td>
<td>------------</td>
<td>-------</td>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>11</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-2</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>26</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-2</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>13</td>
<td>Griddle sherds</td>
<td>Excavation 6</td>
<td>Level V (1.00-1.25m)</td>
<td>Section P-2</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>6</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level VI (1.25-1.50m)</td>
<td>Section P-2</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level I (0.00-0.25m)</td>
<td>Section P-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>24</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level I (0.00-0.25m)</td>
<td>Section P-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>3</td>
<td>Griddle leg fragments</td>
<td>Excavation 6</td>
<td>Level I (0.00-0.25m)</td>
<td>Section P-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>20</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level II (0.25-0.50m)</td>
<td>Section P-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle leg fragment</td>
<td>Excavation 6</td>
<td>Level II (0.25-0.50m)</td>
<td>Section P-3</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>22</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>31</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>1</td>
<td>Mat-impressed griddle fragment</td>
<td>Excavation 6</td>
<td>Level IV (0.75-1.00m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>32</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level V (1.00-1.25m)</td>
<td>Section P-3</td>
<td>Indian Creek period</td>
</tr>
<tr>
<td>2</td>
<td>Griddle legs (1 complete)</td>
<td>Excavation 6</td>
<td>Level I (0.00-0.25m)</td>
<td>Section P-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>24</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level I (0.00-0.25m)</td>
<td>Section P-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>4</td>
<td>Mat-impressed griddle fragment</td>
<td>Excavation 6</td>
<td>Level I (0.00-0.25m)</td>
<td>Section P-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>8</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level II (0.25-0.50m)</td>
<td>Section P-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>1</td>
<td>Griddle fragment</td>
<td>Excavation 6</td>
<td>Level II (0.25-0.50m)</td>
<td>Section P-4</td>
<td>Mill Reef period</td>
</tr>
<tr>
<td>13</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level III (0.50-0.75m)</td>
<td>Section P-4</td>
<td>Indian Creek period</td>
</tr>
</tbody>
</table>
Griddle fragments were selected as special finds, less because of particular ritual activities, but more so because of their connection to the specific activity and function of producing bread-like products often made from cassava or manioc. The distribution of griddle fragments were initially assumed to be associated with household activities and hypothesized as being distributed throughout the site evenly. 98.5% (n = 530) of all griddle fragments were recovered from Excavations 5 (24.7%) and 6 (73.8%) with associated radiocarbon dates ranging from 420-766 calAD (I-7352) to 1028-1280 calAD (I-7835) in Excavation 5 and similar dates from Excavation 6. This suggests that specialized activity areas may have been designated for the production of foods made from root crops such as cassava or manioc. Other than 1 griddle fragment found in Excavation 4 at a 1 meter depth, all other pieces were found on the surface of middens. Griddle fragments where proveniences were unknown are not included in Table 24.

Table 24: Distribution of ceramic griddle fragments from Yale excavation units 1-6. Findings compiled courtesy of the Yale Peabody Museum.

<table>
<thead>
<tr>
<th>12</th>
<th>Griddle fragments</th>
<th>Excavation 6</th>
<th>Level IV (0.75-1.00m)</th>
<th>Section P-4</th>
<th>Indian Creek period</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Griddle fragments</td>
<td>Excavation 6</td>
<td>Level V (1.00-1.25m)</td>
<td>Section P-4</td>
<td>Indian Creek period</td>
</tr>
</tbody>
</table>

Griddle fragments were selected as special finds, less because of particular ritual activities, but more so because of their connection to the specific activity and function of producing bread-like products often made from cassava or manioc. The distribution of griddle fragments were initially assumed to be associated with household activities and hypothesized as being distributed throughout the site evenly. 98.5% (n = 530) of all griddle fragments were recovered from Excavations 5 (24.7%) and 6 (73.8%) with associated radiocarbon dates ranging from 420-766 calAD (I-7352) to 1028-1280 calAD (I-7835) in Excavation 5 and similar dates from Excavation 6. This suggests that specialized activity areas may have been designated for the production of foods made from root crops such as cassava or manioc. Other than 1 griddle fragment found in Excavation 4 at a 1 meter depth, all other pieces were found on the surface of middens. Griddle fragments where proveniences were unknown are not included in Table 24.
### 7.3.5 Body Stamp Distribution

<table>
<thead>
<tr>
<th>Title</th>
<th>Geographic Locality</th>
<th>Level</th>
<th>Section</th>
<th>Era</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body stamp (one corner)</td>
<td>Excavation 3</td>
<td>Level II (0.25-0.50m)</td>
<td>E-4</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>Body stamp fragment</td>
<td>Excavation 4</td>
<td>Level I (0.00-0.25m)</td>
<td>G-1</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>Body stamp</td>
<td>Excavation 4</td>
<td>Surface level</td>
<td>G</td>
<td>Mamora Bay period</td>
</tr>
<tr>
<td>Body stamp</td>
<td>Excavation 3</td>
<td>Level II (0.25-0.50m)</td>
<td>E-3</td>
<td>Mamora Bay period</td>
</tr>
</tbody>
</table>

Table 25: Distribution of body stamp fragments from Yale excavation units 1-6. Findings compiled courtesy of the Yale Peabody Museum.

Body stamps were also rare in number, although their distributions are quite different from all previous findings. These goods were found only Excavations 3 and 4 with an associated Oxcal radiocarbon date of 1027-1276 calAD (I-7832). Little can be said regarding their distribution due to their rarity, although their absence in Excavations 5 and 6 suggests that their limited use may have been connected to personal household spaces away from areas of specialized work activities. Again, without further excavations this assertion must be tested in order to understand their distribution and significance within the site.
7.4 Excavations

7.4.1 Excavation Unit 100

Chart 101: ICC100 Western Profile of the 1 x 2 meter unit

<table>
<thead>
<tr>
<th>Context</th>
<th>Ceramics</th>
<th>Bone</th>
<th>Mollusks</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5000] 0-8 CM</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>[5001] 8-25 CM</td>
<td>0</td>
<td>17</td>
<td>128</td>
</tr>
<tr>
<td>[5002] 25-30 CM</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>[5003] 30 CM Bedrock</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Table 26: ICC100 Excavation context and assemblage breakdown

Excavation Unit 100 was conducted in the center of the site as defined by the encircling middens. While it was recognized that this center occurred gradually, radiocarbon dates suggest that this center was in place for at least 400 years of the site's occupation. The 1x2 meter unit was found to be remarkably shallow at a maximum depth of 30 cm to bedrock. At approximately 15-22 cm, partial human bone fragments were recovered. This space was remarkably void of any material remains, in particular, evidence of midden refuse associated with household or specialized production activities. No complete mollusks were identified, only highly worn and fragmented pieces. Only one piece of undecorated Pre-Columbian ceramic less than 3 cm was found in the area which was also found to be heavily worn.
7.4.1.1 Human Remains

A fragmentary section of the frontal bone from one individual was recovered between 8-25 cm along with one complete right proximal intermediate phalange. Extreme caution should be considered in making any interpretations from this finding. The lack of additional remains is indicative of significant disturbances which can be the result of erosion, small scale cotton farming practices, and diagenesis. A single fragment of the cranium was found in a shovel test pit 10 meters to the west at similar depths in shovel test pit 700455; it could not be determined if this fragment was associated with this unit.
7.4.2 Excavation Unit 101

Chart 102: ICC101 Western Profile of a 1 x 1 meter unit

<table>
<thead>
<tr>
<th>CONTEXT</th>
<th>LEVEL (cm)</th>
<th>CERAMICS</th>
<th>MOLLUSC CT</th>
<th>LITHICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000</td>
<td>0-12</td>
<td>15</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>4001</td>
<td>12-24</td>
<td>47</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4002</td>
<td>24-33</td>
<td>65</td>
<td>2416</td>
<td>0</td>
</tr>
<tr>
<td>4003</td>
<td>33-45</td>
<td>13</td>
<td>1368</td>
<td>0</td>
</tr>
<tr>
<td>4004</td>
<td>45-45</td>
<td>16</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 27: Indian Creek Excavation Unit 101 Ceramic and shell counts

Unit 101 was excavated by Dr. Matthew Brown, Ph.D. (SUNY Farmingdale) and Reakashna Persaud (Ph.D. Graduate Student, CUNY) during the summer of 2013. The unit's location was determined using prior soil analysis to help obtain stratigraphic soil samples, using a complete recovery strategy for future research. Unit 101 excavated just Southeast of Excavation 5 along the creek-side of the site, show strong similarities in both concentration of material remains and depths both approximately 150 cm. These soils will be used to help synthesize this space and region in greater detail. No radiocarbon dates were submitted for these samples, but are planned for the second phase of this project. The nearby Yale Excavation 5 yielded dates ranging from 656-975 A.D. at 125 cm from Section I-1 Level 5 and 693-1151 A.D. at 100 cm from Section I-2 Level 4 at similar depths.

A number of small depressions were found between context [4010] and [4012] with no evidence of degraded wood or charcoal evidence for post-holes. These areas were identified during the time of excavation of being the result of potential on-site or post-depositional distur-

<table>
<thead>
<tr>
<th>Location</th>
<th>Range</th>
<th># Count</th>
<th># Count</th>
<th># Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>4005</td>
<td>45-51</td>
<td>27</td>
<td>353</td>
<td>20</td>
</tr>
<tr>
<td>4006</td>
<td>51-58</td>
<td>52</td>
<td>418</td>
<td>17</td>
</tr>
<tr>
<td>4007</td>
<td>58-65</td>
<td>78</td>
<td>540</td>
<td>34</td>
</tr>
<tr>
<td>4008</td>
<td>65-67</td>
<td>29</td>
<td>105</td>
<td>5</td>
</tr>
<tr>
<td>4009</td>
<td>77-83</td>
<td>104</td>
<td>914</td>
<td>42</td>
</tr>
<tr>
<td>4010</td>
<td>77-83</td>
<td>8</td>
<td>744</td>
<td>13</td>
</tr>
<tr>
<td>4011</td>
<td>83-90</td>
<td>17</td>
<td>120</td>
<td>7</td>
</tr>
<tr>
<td>4012</td>
<td>90-99</td>
<td>44</td>
<td>2</td>
<td>58</td>
</tr>
<tr>
<td>4013</td>
<td>99-110</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4014</td>
<td>110-126</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4015</td>
<td>126-136</td>
<td>11</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4016</td>
<td>141-156</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4017</td>
<td>156</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
bances possibly by local rodents or terrestrial species. As previously mentioned in Chapter 1, distinguishing between bioturbation and past human activities is problematic, without expanding excavated units. Soil analysis will be discussed regarding these features in the following Synthesis chapter.

### 7.4.2.1 Fetal Remains of Two Individuals

A complete fetal skeleton was recovered from context [4013] at approximately 1 meter below the surface, aged approximately 40 weeks. There was no discernable grave cut, but based on the completeness and articulated position, the individual was most likely buried immediately after being placed in its location. Material remains were found beneath this individual for another 40 cm, albeit both sparse and infrequent. A partial right tibia was found along the same context as the complete fetal skeleton embedded within the western edge of the unit. The tibia does not belong to the complete fetal skeleton, which based on a maximum length measurement of the partial tibia was aged to approximately 30 weeks old (Brown 2013). Caution is necessary for single bones, as objects and things can become dissociated from their original context. Elemental analysis of anthrosols from individual burials have shown that higher elemental loading is associated with hard and soft tissue diagenesis, whereas sections areas lacking in hard and soft tissue result in decreased elemental loading (Farswan 1997; Dent 2004). Fisher transformation coefficient analysis of phosphorus and calcium in non-limestone areas are closely positive in their relationship, and can be used to gauge the relative disturbance of strata with respect to their archaeological context.
7.5 Shovel Test Pits

STP 680465

Chart 103: Profile of shovel test pit 680465, and soil descriptions

<table>
<thead>
<tr>
<th>ID</th>
<th>BONE</th>
<th>CERAMIC</th>
<th>Sm. FRAG</th>
<th>SHELL</th>
<th>CORAL</th>
<th>STONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>680465</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>305</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 28: Assemblage counts for STP 680465. *Sm. FRAG = Small ceramic fragments <2 cm

STP 690445

Chart 104: Profile of shovel test pit 690445, and soil descriptions
<table>
<thead>
<tr>
<th>ID</th>
<th>BONE</th>
<th>CERAMIC</th>
<th>Sm. FRAG</th>
<th>SHELL</th>
<th>CORAL</th>
<th>STONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>690445</td>
<td>164</td>
<td>11</td>
<td>14</td>
<td>639</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 29: Assemblage counts for STP 690445. *Sm. FRAG = Small ceramic fragments <2 cm

**STP 700445**

![Chart 105: Profile of shovel test pit 700445, and soil descriptions](chart)

<table>
<thead>
<tr>
<th>ID</th>
<th>BONE</th>
<th>CERAMIC</th>
<th>Sm. FRAG</th>
<th>SHELL</th>
<th>CORAL</th>
<th>STONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>700445</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 30: Assemblage counts for STP 700445. *Sm. FRAG = Small ceramic fragments <2 cm
Table 31: Assemblage counts for STP 700455. *Sm. FRAG = Small ceramic fragments <2 cm

Table 32: Assemblage counts for STP 700475. *Sm. FRAG = Small ceramic fragments <2 cm
Table 33: Assemblage counts for STP 700485. *Sm. FRAG = Small ceramic fragments <2 cm

Table 34: Assemblage counts for STP 700495. *Sm. FRAG = Small ceramic fragments <2 cm
Table 35: Assemblage counts for STP 720435. *Sm. FRAG = Small ceramic fragments <2 cm

Table 36: Assemblage counts for STP 720445. *Sm. FRAG = Small ceramic fragments <2 cm
Chart 112: Profile of shovel test pit 720465, and soil descriptions

<table>
<thead>
<tr>
<th>ID</th>
<th>BONE</th>
<th>CERAMIC</th>
<th>Sm. FRAG</th>
<th>SHELL</th>
<th>CORAL</th>
<th>STONE</th>
</tr>
</thead>
<tbody>
<tr>
<td>720465</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 37: Assemblage counts for STP 720445. *Sm. FRAG = Small ceramic fragments <2 cm

Shovel test pits conducted throughout the area enclosed by the surrounding middens indicate a relatively shallow depth throughout ~50 cm, with very few material remains. The majority of material remains recovered were often highly degraded, worn, and fragmented. This maybe evidence of intensive site disturbances or the by-product of trampling. The Synthesis chapter incorporates soil analysis to test whether materials were indeed disturbed post-deposition.

7.6 Fuess Archaeological Units Analysis

As previously described in Chapter 6: Data Analysis, a series of archaeological units were excavated by Martin Fuess for his dissertation work in 1995. These archaeological assemblages were never analyzed; except for some ceramics that were extracted for a petrography study of Pre-Columbian ceramics. Soil samples were collected along with each archaeological excavation, and were used for this study. General counts and weights were conducted for ceramics, lithics, bone, and shell in order to provide the necessary comparative data to study anthrosols.
These counts are presented in the following section. See Chapter 6.1.c for full discussions of each site.
Table 38: Dog & (Fuess) Bar Graph (top). Assemblage breakdown (bottom).

<table>
<thead>
<tr>
<th>Column</th>
<th>100</th>
<th>7786</th>
<th>710</th>
<th>22</th>
<th>16</th>
<th>14</th>
<th>5</th>
<th>0</th>
<th>0</th>
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- 261 -
Table 39: Claremont (Fuess) Bar graph (top). Assemblage breakdown (bottom).

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Artifact and Ecofact Count/Weight

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- F4/0-10
- F3/0-10
- F6/0-10
- F6/10-20
- F7/10-20
- F7/20-30
- F10/0-10
- F10/20-30
- F10/30-40

**BLACKMAN'S EXC A: Ecofact/Artifact Counts and Weights**

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Table 40: Blackman's (Fuess) Bar graph (top). Assemblage breakdown (bottom).
### Coconut Hall EXC 1: Ecofact/Artifact Counts and Weights

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### Coconut Hall EXC 1: Ecofact/Artifact Counts and Weights

- **Feature Levels**: F3 0-10, F3 10-20, F3 30-40, F4 0-10, F5 0-10
- **Mollusk CT**: 8, 522, 471, 39, 380
- **Mollusk WT**: 91, 2267, 436, 140, 416
- **Coral CT**: 30, 116, 125, 30, 32
- **Coral WT**: 47, 436, 125, 31, 33
- **Ceramic CT**: 473, 2144, 1414, 41, 340
- **Ceramic WT**: 253, 94, 92, 33, 42
- **Lithic CT**: 71, 43, 83, 7, 83
- **Lithic WT**: 77, 107, 224, 30, 101
- **SM Frag CT**: 53, 59, 11, 6, 32
- **SM Frag WT**: 36, 36, 125, 60, 32
- **Artifact Tot**: 426, 549, 6926.6, 401, 2215
- **Artifact WT**: 932.9, 1441, 97, 675.55, 1692
Table 41: Coconut Hall (Fuess) Bar graph (top). Assemblage breakdown (bottom).
Chapter 8. Comparative Interpretation and Spatial Analysis

8.1 Introduction

This research project has attempted to deconstruct the site, by exploring the different kinds of places that make up a site, exploring the activities that shape place, and building elemental baselines for the objects and things used in these particular activities. It is recognized that many places and activities cannot be identified using this framework; and that this research focuses on only those places and activities that leave elemental traces behind in the soils. With that caveat in mind, this chapter presents both the synthesis and discussion of this research's findings.

Chapter 1 described the challenges in interpreting the lives of past people based largely on material objects, and the need for additional studies exploring the lived in spaces of Pre-Columbian people in the Caribbean. Chapter 2 discussed the manner in which sites were selected and utilized for this research. A discussion of the ontological nature of sites in the Caribbean were combined with a discussion of how repeated activities in particular spaces create a sense of place. The theoretical framework is presented in Chapter 3, exploring how objects, habitus, and place-making all contribute to our understanding of what a site is and is not. Chapter 4 described the detailed methods used to address the challenges in studying natural and cultural forces shaping the archaeological record. Chapters 5, 6, and 7 provided details on establishing elemental baselines from known soil context as well as commonly deposited objects found in Pre-Columbian middens, the secure acquisition of soil samples and archaeological assemblages for
comparative analysis, and the archaeological interpretation necessary for the spatial analysis of artifact and ecofact distribution.

8.1.1 A Synthesis of Indian Creek Village Space through Archaeological and Multi-Element Chemical Analysis of Soil

8.1.1.1 Ethnoarchaeological Evidence for High activity areas

Areas of high foot traffic including pathways, walkways, and household floors gradually compact soils. This compaction of soils, particularly clay rich, reduces the capacity of water to drain over time resulting in the gradual loss of elements such as P, K, and Ca decreasing the capacity of soils to retain moisture (Séger et al. 2009). This loss of elements, within a spatial context, can assist in identifying floor layers with frequent trampling which often become nutrient poor, particularly phosphorus and calcium (Wells 2004).

In contrast, areas where food consumption or food processing takes place can increase phosphorus and calcium and help distinguish activities within the same structure. Soil studies of probable entranceways and/or areas of high traffic areas support these observations (Hutson & Terry 2006; Wells 2004; Barba & Ortiz 1992/79). This is particularly important, because these ethnoarchaeologic observations of modern populations suggest that high activity areas have relatively immediate impact on soil conditions.

This is in strong contrast to other forms of living floors where intensive food processing and consumption have left behind discernible areas of activities in the soils, in particular P and Ca. These activity loci are only identifiable when they become deeply rooted in the routines of everyday life which may act to reinforce social structures. Additional evidence suggests that raised, compacted, and enclosed areas such as household structures, garden walls, and sometimes
middens can help trap additional elements within these areas where soils are susceptible to erosion or water movement (Neff et al. 2012; Barba & Ortiz 1992).

8.1.1.1.a Cleanliness and the Practice of Sweeping

The practice of sweeping is beginning to emerge within a Pre-Columbian narrative in the Caribbean (Hofman & van Duijvenbode 2011/28). Findings from this research provides evidence supporting that these spaces were kept clean and cleared of debris and refuse within a timeframe that wouldn't have allowed enough time for chemicals to fix themselves to the mineral particles of soils. Based on the depleted patterning of P and Ca for Indian Creek, these areas of the central plaza were maintained throughout its entirety of approximately 1400 years. Central plazas that are constantly swept clear of debris can result in the subsequent removal of soil affecting mobile cations such as Na+, K+, and Fe2+ (Entwistle & Abrahams 1997; Bintliff et al 1990; Wells 2004). This is particularly important, as the soil is slightly acidic decreasing the likelihood that bioturbation or weathering resulted in the leaching of cations (Eidt 1977; Woods 1977). Inverse distance weighted interpolation analysis for Indian Creek suggests that mobile cations Na+, K+, and Fe2+, were low in the central plaza areas relative to the periphery of the site in the northern and eastern midden areas.

8.1.1.2 Archaeological Evidence for a Central Plaza

Excavations and shovel test pits conducted across the area enclosed by middens produced relatively few artifacts or ecofacts; with ceramics consistently showing evidence of being heavily worn and fragmented (<2 cm). Two shovel test pits 700495 and 690445 did identify the edge of
midden mounds associated with Excavation 6 and 3 respectively. These areas produced relatively few artifacts, with the highest count coming from 690445 along the western edge of the central area with a total artifact count of 22, 11 ceramic and 11 lithic fragments. The archaeological patterning suggests that areas closest towards the site's Phase 2 center, the 'cleaner' the area is of refuse. These findings were expanded with a 1x2 meter test unit ICC100 to explore the void space identified. This unit alongside STP 700455 turned up fragmentary evidence of human remains along with sparse material remains. Only one highly worn non-diagnostic fragment of pottery was recovered from ICC100 at approximately 8 cm, the top portion of the cranial element recovered at 23 cm before reaching bedrock at 30 cm. Soil depths did not exceed 65 cm in test units and shovel test pits excavated within the central area, with the majority of shovel test pits reaching an average of 35-50 cm until bedrock. This is in heavy contrast to the midden excavations of ICC101 and Excavation 5 both at a depth of 170 cm.

8.1.1.3 Elemental Evidence for a Central Plaza

The majority of shovel test pits lacked the color, texture, and structural evidence for an A-horizon, suggesting a loss of topsoil. While the long-term impact of ritually clearing and cleaning a central plaza would increase the threat of erosion (Séger et al. 2009), the long-term settlement at Indian Creek suggests that these areas were heavily managed. Shallow soils were concentrated within the western edge of the site along the base of the hill into the central plaza; this follows the general slope of today's contours. Horizontal IDW mapping of Fe, K, Al, and Ti (Appendix B) indicates that elemental patterning followed the sloping terrain from east to west gradually leveling out along the central plaza. From this area it continues to slope north to south towards the nearby creek bed.
Phosphorus and calcium provides the clearest evidence for a central plaza that is surrounded by concentric middens (fig. 13; Appendix B: fig 25 & 28). While additional sites need to be explored in order to understand the influence of local geomorphic substrates and overlapping historical land-uses, this approach provides a meaningful look at the shape and persistence of clean spaces. The spatial analysis of phosphorus and calcium results in a strong positive correlation supporting evidence that both elements share similar diagenic pathways (Chart 113). Phosphorus readings from the central plaza region had a comparatively low mean value of 5,369 ± 1,493 mg kg⁻¹ versus a high midden mean value of 39,749 ± 4,820 mg kg⁻¹; while calcium readings from the central plaza provided a mean value of 54,612 ± 24,490 mg kg⁻¹ versus a midden mean value of 583,659 ± 84,100 mg kg⁻¹. These findings are consistent with the archaeological findings for a cleaned and maintained central plaza.

The deepest deposits are associated with Excavation 5, ICC101, Excavation 6, and Calgary's PA4U1 all of which are sandwiched between the northern and eastern sections of the site and directly adjacent to the west of the creek bed (Fig 13). These deeply stratified middens have resulted in creating an elevated, compact, and erosion resistant area despite the lack of vegetation. Aside from the walking path that cuts in from the main road, there is little evidence of midden material eroding out from the northern and eastern edge of the site adjacent to the creek as well. These deeply stratified middens have had the subsequent impact of stabilizing this portion of the site through a gradual buildup and compaction of materials.
Chart 113: pXRF Elemental Statistical Comparison of phosphorus (mg kg\(^{-1}\)) vs Calcium (mg kg\(^{-1}\)) for Indian Creek
Figure 13: Indian Creek IDW phosphorus Map
8.1.2 Interpreting the Spatial Characteristics of Middens

Prior to discussing the spatial configuration of Indian Creek middens, two models were produced mapping radiocarbon dates using inverse distance weighted interpolation of soils from comparable context to create a chronology of midden formation. The spatial distribution of radiocarbon dates characterizing the formation of Indian Creek middens identified two planning phases, the first phase between approximately 35 A.D. - 800 A.D. with midden excavations 1, 4, 5, and 6; and the second phase occurring after approximately 835 A.D. - 1400 A.D. with the addition of midden excavation 2 which subsequently encloses a new central plaza configuration (fig. 14). Radiocarbon dates suggest that midden 1 was eventually abandoned by approximately 200 A.D. Again, all interpretations are tentative as additional radiocarbon dates are necessary to understand site formation processes.

These models suggest an initial formation of boundaries between midden 1 and 6 forming over the first 300 years, eventually extending further north by midden 5 by approximately 500 A.D. Multi-element analysis of P, Ca, K and radiocarbon dating suggests that the space between these areas were kept clear and maintained during this initial phase. Evidence suggests that the central area began as approximately 9300 square meters whose configuration shrunk by approximately 5,000 square meters with a newly bound central area of approximately 4300 sq. meters. Elemental analysis and spatial modeling suggests that the second phase, part of the northern half of the central area, was continuously maintained for the entirety of the site's approximately 1200 plus years. The discussion regarding the spatial distribution of archaeological remains will shed further insight in the below section.
The lack of material remains from excavated unit ICC100 and shovel test pits are supported by the elemental readings from soils within these enclosed spaces. The middens analyzed at Indian Creek had a mean of 39,749 ± 4,820 mg kg⁻¹ for phosphorus while soils analyzed from the central spaces had a mean of 5,369 ± 3,677 mg kg⁻¹ for phosphorus. Central space values were in-line with elemental readings from sterile and earliest cultural soil layers extracted from ICC101 ranging from 2,542 - 4,941 mg kg⁻¹ respectively. These findings are consistent with other studies of central plazas and the relatively sparse phosphorus readings found in these maintained spaces (Wells 2004; Beck 2007; Roos & Nolan 2012). The low phosphorus readings and sparse material remains in the central space are significant as their consistency supports that previous ploughing conducted in the area did not result in significant disturbance.

Ethnoarchaeological experiments have shown that plowing primarily churns stratigraphic layers rather than dragging layers across the site (Yorston et al. 1990; Usai 2001), however some observations of plow zone impact on archaeological sites have found that some dragging does occur resulting in the expansion of sites based on artifact spread (Navazo & Díez 2008). This dissertation's analysis of the Pre-Columbian site Elliot's, overlapping a modern farm, found that intensive use of modern mechanical plows expose sterile layers at Elliot's resulting in significant disturbance of not just stratigraphic layers but an increasing vertical dissociation between in-situ soils and their associated archaeological assemblages. This is due in large part to how deep modern ploughs can extend, subsequently churning and mixing strata to the extent that elemental analysis of soils reflected more of an overall average for that location. The key finding, is that while a loss of vertical elemental inference was observed, stable elements such as phosphorus still reflected concentrated areas of midden refuse. While sections of Indian Creek were partially
cleared and plowed for cotton farming, there are no historical accounts of heavy machinery being used for such activities. Therefore the absence of P, Ca, and K along with the lack of material remains in the central plaza are inconsistent with heavy agricultural disturbances. Aerial imagery from 1968 identify plough lines running through the northern portion of the site with the southern half unplowed. Multi-elemental analysis indicates continuity for these surfaces throughout the central plaza area.

These findings add increasing confidence to the archaeological interpretation of this area serving as a central plaza that was maintained for most of the site's occupation. The consistency of relatively low phosphorus readings throughout this space suggests that the remained relatively constant with no evidence of other activities such as middens, housing structures, or food preparations activities. Persistent places related to habitation loci have been documented in other context, particularly housing locations such as the site at El Cabo. At the village site of El Cabo, an analysis of over 50 late Ceramic Age (A.D. 800-1504) structures were identified, where abandoned houses were often rebuilt within centimeters of the original space (Samson 2010).

**8.1.2.0.a Nature of Refuse**

The use of soils within an archaeological context, helps to expand the focus from middens out to areas where there is an absence of material remains. Artifacts are rarely deposited in the area they were used, and early artifact distribution studies were heavily critiqued for making such inferences from surface distributions (Flannery 1976, Manzanilla & Barba 1990, Schiffer 1985). An ethnohistoric study of 79 cultural groups using HRAF (Human Relations Area Files) formed an early study of both sedentary and migratory communities consistently discarded material elements outside of their use location (Murray 1980/80). Additional key
findings from this early study noted that periodic sweeping of living spaces was a common practice across different cultural groups with the majority discarding elements from family living spaces with discarded elements accumulating outside family living spaces. Therefore, a focus on the management of discarded objects (Siegel & Roe 1986) from in-situ midden deposits can elucidate our understanding of the kinds of activities taking place within central plazas.

8.1.2.1 Evidence for Sustained Ritual Activities: Spatial Distribution of Archaeological Assemblages

The spatial distribution of special finds is concentrated in the middens, Excavations 5 and 6 in the northeast section of the plaza, running adjacent to the nearby creek. Ceramics categorized as inhalers and griddles along with zemis were found almost exclusively in these middens. Radiocarbon dating of these objects suggest that activities associated with these objects were maintained and persisted for approximately 900 years; shaping these middens into a type of persistent place (Schlanger 1992).

Irving Rouse described Excavations 5 and 6 as containing a high concentration of special finds in particular highly decorated and painted ceramics (Rouse & Morse 1999). As detailed and categorized in the previous chapter, special finds were found to deviate from the general distribution of ceramics and faunal. Particularly, ceramic inhalers and griddles were found primarily in the northern (Excavations 5) and eastern (Excavation 6) sections of the site. These middens are adjacent to the creek containing the highest concentration of elemental patterning consistent with wood ash deposits. This is consistent with the profile descriptions for Excavations 5 and 6 of Indian Creek which contain concentrated ash deposits scattered throughout each level. Radiocarbon comparisons date these finds from 382 calAD (I-7355) to 1276 calAD (I-7847) from Excavation 5 and 71 calAD (I-7855) to 1155 calAD (I-7836) from Excavation 6. All inhaler frag-
ments (n=44) as well as 98.5% (n=530) of ceramics categorized as griddles were found in the aforementioned units in the northeast. Eight griddle fragments were found in Excavation Units 2, 3, and 4. It should be emphasized that while the units were considerably large (2 x 7 meters), they may not accurately represent the full distribution of these objects. Rouse's recovery strategy is also of some concern, particularly large mesh size resulting in poor faunal recovery.

Despite these recovery concerns, excavation areas 1, 2, 3, and 4 which lacked incense burner/inhaler fragments contained concentrated deposits for ceramics. The lack of these specialized objects are also consistent with the relative lack of ash deposits in 1, 2, and 3 described by Rouse (Rouse 1974) in his profiles. Excavation 4 does contain similar vertical ash deposit distributions as Excavation 5, thus requiring further investigation into these areas.

8.1.2.2 Elemental Characteristics of Ritual Activities

Studies of activity loci, have identified an overall enrichment of elements connected to hearths and wood ash deposits; particularly P, K, and Mg (Middleton & Price 1996; Wells 2004). Activities associated with ritual burning of herbs, plants, and medicinal remains would have resulted in concentrated deposits of ash. It should be noted that similar activities related to cooking and food preparation would also result in high concentrations of similar elemental patterning, which will be discussed below. Inverse distance weighted (IDW) interpolation of elemental distribution suggests that northern and eastern sections of the site show elemental enrichment consistent with concentrated wood ash deposit. This is also consistent with the Bruker pXRF instrument's characterization of wood ash as described in Chapter 5 measuring high concentrations for P, Ca, K, Al, Fe, Al, Si, and Ti (Chart 24). The management of refuse can result
in the episodic depositing of decorated or ceremonial artifacts in designated "ritual disposal" areas (Righter 2002) perhaps resulting from public feasting or ceremonial activities in plazas (Keeegan 2009a; Siegel 1989). At the Tutu archaeological village site, it was observed that highly decorated ceramics and greenstone inlays were ritually deposited in designated localities (Righter 2002/46). While these sites are culturally distinct, further exploration is needed to understand whether these patterns have any meaning to the role these activities played within their village communities.

The concentration of spouted ceramic inhaling bowls, associated with the Pre-Columbian use of intoxicants (Kaye 1999), were found concentrated along the northern and eastern middens of the site. These deposits are consistent with the elemental patterning found in similar episodic deposits. Their spatial association with the nearby creek should also not be overlooked, as this may have played a significant role or connection with these activities. Further comparisons of other plazas and ceremonial spaces are necessary.

8.1.2.3 Evidence for Food Production vs Consumption

The concentration of griddle fragments were recovered throughout all levels from Excavations 5 and 6 suggesting a more intimate relationship and commitment to exogenous domestic plants such as maize, manioc, and some types of beans indicative of an ever-evolving sedentary commitment (Pagán Jiménez 2011). Associated deposits were radiocarbon dated to a range of about 420-766 calAD (I-7352) to 1028-1280 calAD (I-7835) (Rouse & Morse 1999).

Ethnohistoric studies have found that consumption areas were found to be high in P whereas food preparation areas were high in P, K, and Mg evidence of wood ash used for
cooking (Middleton & Price 1996; Middleton 2004; Manzanilla 1996). The preparation of certain crops such as corn can result in high concentrations of Ca (Beck 2007) and nixtamal production yielding high P and K. The high concentrations of K were measured ~50,000 mg kg-1 for Excavations 4, 5, 6, and ICC101 along the same areas where inhalers and griddles were found as opposed to ~10,000 mg kg-1 for Excavation units 1, 2, and 3. Within the central plaza, as characterized by P, indicates that both the northern and eastern areas adjacent to the midden areas 5 and 6 have high concentrations of K and low concentrations of P. This is consistent with the ethnohistorical and ethnoarchaeological observations for food preparation areas and episodic ceremonial activities.

The southern section of the second phase of the site, just east of Excavation 2 measured high in P but low in K. These findings are consistent with the ethnohistorical and ethnoarchaeological observations for food consumption areas. This is significant, as Excavation 2 is relatively rich in both ceramics and faunal remains; however few ceremonial objects were recovered from this context. Midden analysis indicates that despite a relatively rich midden deposit, elemental readings were comparatively low for P, Ca, and K possibly indicating that food preparation may have occurred elsewhere while this area may have served as a designated space for the discards from consumption. Alternatively, while there is no evidence of early or late Saladoid peoples using seaweed as manure, sites in the North Atlantic in the Hebrides connected the use of seaweed as manure with high K concentrations and low P concentrations (Entwistle & Abrahams 1997). This kind of creativity points out the many challenges of equifinality, or the different kinds of daily routines that can potentially result in similar chemical patterning, placing greater emphasis on not relying purely on elemental analysis. Therefore, part of our research should be on
uncovering the daily rituals and activities that are part of the everyday norm. Certainly food preparation, but also cleanliness or habitual cleaning and maintaining of space was part of their habitus (Bourdieu 1980). These daily rituals and activities can transform these spaces into meaningful places. The integration of anthrosols requires an integrative approach comparing archaeological assemblages, multi-element analysis of soils, and ethnohistorical and ethnoarchaeological analogues. Additional consideration must be paid towards the affects of post-abandonment on the physical breakdown of sites.

As previously discussed, Yale's collection strategy lacked a comprehensive faunal collection strategy. Nonetheless, the utility of elemental analysis to characterize midden deposits were applied to these tenuous datasets to identify potential discrepancies and problems. The disproportionately high shell and coral counts concentrated in Excavations 5 & 6 were found to be consistent with the highest overall Ca concentrations; while high bone counts found in Excavation 2 were found to be consistent with P concentrations recorded. Horizontal mapping reveals that Ca distributions are highest in the northern and eastern areas of the site; with comparatively lower Ca concentrations in the west and south. These high elemental concentrations and shell counts may be the byproduct of their spatial association with the adjacent dried up creek bed; thus raising questions regarding the potential use of nearby creeks in either temporary storage, food preparation, or shell tool manufacturing. This contrasts somewhat with bone counts and P distributions throughout the site. Excavation 2 did yield 3,066 bone fragment counts versus Excavation 5 and 6 with counts of 2,465 and 1,220 respectively. Soil samples taken within each of the associated midden mounds suggest that P measurements are relatively high for Excavation 2 in the south ranging from approximately 7,000 - 20,00 mg kg-1; averaging higher than both Exca-
vation 1 and 2 in-line with low bone counts. Further testing, particular more in depth zooarchae-
ological analysis, is necessary in order to better understand these overall trends.

High concentrations of Fe in soils have been associated with animal butchery (Manzanilla
1996). Horizontal mapping of Fe identifies areas to the north and east of the site, which is con-
sistent with the locality for designated discard of griddle fragments, increased presence of ash, and moderate P to K ratios indicative of processing loci. Fe decreases in the southern part of the phase 2 configuration, and extends to even lower levels in the southern extent of the phase 1 configura-
tion. This maybe related to the Fe present in the local clay deposits and potentially influ-
enced by the parent material surrounding the site along the abutting hillsides. Pigments used
during ceramic production can also contain concentrated iron, mercury (cinnabar), manganese, and copper.

These findings suggest that unique places were part of Indian Creek’s social organization, and that there were specific rules regarding how spaces were used and where objects and refuse were placed. While further research is needed to critically evaluate the uses of these objects, they are nonetheless spatially significant. Elemental patterning supports the assertion that these objects were related to increased ash deposits, and that food consumption appears concentrated along the western portion of the site, just east of Excavation 2. Excavation 4, also along the western portion of the site, contained the highest concentration of faunal remains as well as less phosphorus than the ash enriched Excavations 5 and 6. While these middens did not form at the same time, certain places appear to be maintained over long periods of time.
Figure 14: IDW Pmg kg-1 modeling of Phase I (left) and Phase II (right) for Indian Creek.
8.2 Summary

The multi-element analysis of anthrosols support the archaeological findings for the village layout, but contribute additional interpretations regarding the formation of the site, elemental evidence for activity loci, and social interrelationships through time. Multi-element analysis supports the archaeological evidence for two phases of community planning taking place. Horizontal mapping of elemental readings, and archaeological excavations suggest that the central plaza enclosed during the second phase of community planning and was maintained over the span of the village's inhabitance. There is a distinct lack of enriched phosphorus and calcium in these spaces that would be indicative of a changing configuration in the central plaza.

The 1,200 years of ceremonial activities and congregation within these spaces would have acted to compact the clay soils, decreasing the capacity of water to drain and feed root systems. Eventually, a loss of nutrients associated with water soluble cations would gradually leach away. Archaeological evidence and elemental mapping support the practice of intensive clearing and use of this space depriving this space of any enrichment of P, Ca, and K. These spaces are void of material culture but full of human activity. These conditions would have forced the community to deal with the threat of erosion. While more research is needed to understand the placement of midden mounds within the planning phase of community organization, subsequent evidence suggests that the buildup of these middens resulted in the mitigation of hillside erosion. Recently, a number of sites uncovered along coastal areas have identified Pre-Columbian evidence of burnt shell and sand resulting in densely compact layers that continue to be resistant to erosion (Brown & Look 2016; Perdikaris et al. 2011). While middens are often placed on the periphery of sites and often along the edge of cliffs or heavily sloping areas, as observed at
Indian Creek, these practices produce the added benefit of potentially stabilizing these edges by building them up and decreasing their risk to continuing erosion. Particular caution should be heeded, as significant colonial deforestation of many Pre-Columbian sites have additionally exposed topsoil to both colluvial and eolian erosional forces. However, excavations and shovel test pits contained no evidence of massive topsoil erosion building downslope along the northern and eastern middens.

Some consideration must be given to the potential that Pre-Columbian peoples were capable of moving earth around in order to shape ceremonial spaces as evidenced by Mississippian cultures (Holley 1993, Kidder 2004). It has been argued that this would have been critical during the community planning phase (Holley et al. 1993). The lack of any structural and elemental evidence of an A horizon suggests that this layer was removed from the surface; which can be the result of numerous organizational practices such as central plaza maintenance or hygienic purposes. Modern and colonial land clearing may have also had an affect as well as natural processes such as erosion resulting from climatic and topographic conditions. Additional bodies of data are needed to better understand how past human activities affected local environments.
Chapter 9. Place-making in a Pre-Columbian Village

This chapter presents newly generated elemental patterns for different habitation loci categories through the collation of data from archaeological analysis, associated categorization and measurement of soil chemistry, and spatial analysis. The mean, standard deviation, and spread were presented to help elucidate both the elemental characteristics associated with different activities as well as the elemental variation for each category. Section 9.1 presents a synthesis from the site of Indian Creek, while 9.2 presents a synthesis from Doigs.

9.1 Indian Creek Synthesis

9.1.1 Ash

While ash samples measured high for phosphorus, calcium, potassium, and silicon; their variability helped distinguish between wood ash and burnt shell ash. Measurements of wood ash represented a consistently high proportion of phosphorus and calcium, approximately 69,000 mg kg-1 and 2,000,000 mg kg-1 respectively, from midden context at Indian Creek (fig 15). The distribution of ash measurements were tightly clustered for phosphorus, and variable for calcium and potassium. These differences are the byproduct of wood ash versus wood ash mixed with shell ash. While both measure high in phosphorus, wood ash measured higher in potassium than wood and shell ash mixture (Wells 2004/77); while the inverse relationship is found with higher calcium concentrations associated with shell ash mixture (chart 22). These distinct elemental patterns have been used ethnohistorically and archaeologically to identify hearths and cooking pits (Middleton & Price 1996; Manzanilla 1996; Hutson & Terry 2006). Comparable deposits were recovered from midden context [4009] unit ICC101 where two sets of distinct ash lenses were
found along the northeast and southern sections of the unit representing one deposit made of burnt wood ash and the other made of burnt shell and wood ash mixture.

These findings represent one part of a much greater potential to begin identifying ambiguous and problematic deposits that may begin placing Pre-Columbian peoples back into their lived-in spaces along with some of their objects. The use of portable XRF provides the additional benefit of identifying these deposits during field projects, whose findings can help shape and direct unit strategies and placement. On a household level, these applications can be used to determine whether designated areas were set aside for fire related activities, and potentially distinguish between areas of food preparation and food storage. The previous discussion relating to ceremonial activities from Excavations 5 & 6 at Indian Creek would be strengthened if associated ash deposits, special finds, and faunal analysis could be recognized and studied as an assemblage. While this was not done for this research, these findings argue that future excavations consider these findings.

9.1.2 Middens

Middens represent the objects and things of an entire community’s history. These confined and often designated spaces also represent the long-term habits, rituals, and activities of everyday life that are governed by rules, traditions, and political organization. While middens are not often the places where these objects were used or consumed, the manner in which they were discarded offers archaeologists an opportunity to detect these patterns of discard to explore the kinds of places that may have been shaped by their use. In many ways, middens are the baseline for what kinds of spaces are detectable through soil chemistry. Findings presented in Chapter 5 illustrate the significance of forming elemental baselines through an understanding of the
kinds of objects often discarded in middens. In Chapter 6, the combining of these baselines with anthrosols and assemblage analysis provided a more robust and critical understanding of how elemental patterning can infer meaning to different spaces. By establishing the elemental 'uniqueness' of each object, soil tests could be conducted to study whether their elemental 'uniqueness' translated into chemical loading within anthrosols.

P and Ca were found to be remarkably good indicators of fluctuating bone concentrations found in middens (chart 52 and 53). This is most likely the by-product of diagenesis, or the breakdown of bone. Ca is unreliable for sites in limestone regions, leaving P, K, Fe, and Ti as the primary indicator for midden activity. When ceramic and lithic deposits were isolated from middens, they often deviated from both P and Ca values suggesting a different elemental diagenic process if at all. Low P and Ca values for midden areas were recorded from sterile and early phases of the midden development. These measurements were consistent with sterile layers from other units and test pits and were comparable to anthrosols measured from the central plaza area. It is through the study of midden anthrosols, that can elucidate our understanding of how void spaces can be places brimming with human activity.

Elemental enrichment for K, Fe, Ti, Si, and Al were found to be consistent through all middens sampled. This suggests that midden development retains many of the chemical properties often lost during diagenesis due to erosion, leaching, and cation mobility. This maybe the result of an abundance of refuse concentrated in one area that gradually becomes compacted and built up both decreasing the susceptibility to erosion and increasing the trapping potential of erosion from other areas of the site. While Ca measurements did deviate occasionally from midden assemblages in limestone regions, they continued to correlate well with fluctuating assemblages;
however a clear distinction was found between the reliability of Ca as an indicator of anthropogenic activity in volcanic regions versus limestone regions.

These findings provide further evidence for the integration of soil studies within Pre-Columbian archaeological investigations. The close correlation between midden counts and elemental patterning were particularly useful in identifying the extent context have been disturbed. Eliot's soil analysis illustrated how elemental patterning becomes erratic and unreliable in comparison to midden counts. Building from research conducted at the ceremonial plaza of Tibes in Puerto Rico (Curet & Stringer 2010; Curet & Oliver 1998b), and the evidence for a central plaza at Indian Creek in Antigua, anthrosols may shed light into the spatial context and extent these spaces may have been modified by past peoples. This has the ramification of expanding our knowledge of the complex activities, community planning, and social organization necessary to construct these spaces.

### 9.1.3 Central Plaza

A central focus of this research studying Pre-Columbian place-making in the Caribbean has led to an exploration into the meaning of a central plaza. While the findings from this research are limited and are representative of one plaza in Antigua, a number of important insights can be gleaned from the coupling of archaeological excavations and the study of anthrosols. The identification of void spaces bounded by rich middens representing 1500 years of occupation informs us about this community's rules and social organization. Elemental patterning and archaeological investigations indicate that central plazas were an important part of the Indian Creek community. Any activities taking place in this space, required food-related refuse to be collected in a timely fashion so as not to contribute to the elemental loading due to diagenesis. In some in-
stances, refuse from certain activities may have been restricted to specific midden areas. These spaces required continual maintenance, and would have been susceptible to erosion.

The elemental characterization for the central plaza area, was highly reliant on it's spatial context within the overall site. This space was characterized by low P and Ca concentrations, associated with a lack of refuse. Anthrosols from this area were slightly enriched compared to off-site soil samples, which were often low in P, Ca, and K. Surveys and soil sampling in the surrounding area suggest that the village did not extend beyond the midden boundaries. Elemental patterns for Al and Si match K, Fe, Ti suggesting that these elemental patterns are closely tied to the geomorphic substrate in the region, particularly the distribution of aluminosilicates in the clay deposits. While all elements correlated well with midden concentrations, iron contained the some of the highest readings in the northern section of the site. Further experimental studies are needed in order to understand what these findings could potentially mean.

Compared to the rich archaeological evidence of ceremonial architecture in Puerto Rico, the concept of a plaza has been largely associated with clearly defined architectural features (Alegria 1983; Curet & Stringer 2010). Numerous sites have ascribed empty or void spaces within villages in the Lesser Antilles as part of a plaza or central space. The early findings of this research illustrate the potential to expand our understanding of these spaces and explore the relationship between people, place, and things.
9.1.4 Burials

The burial context analyzed were challenging, as neither units recovering human remains showed evidence for a grave cut. Soils directly associated with the burial were recovered for comparison. The increased P and Ca values suggest that the juvenile skeleton recovered from Unit ICC101 [4013] was in-situ; which is consistent with the archaeological interpretation based on the completeness and intact skeletal articulation recovered. Due to the relative complexity, compactness of soil, and delicate nature of the juvenile skeleton, soils were not collected around bones in contrast to areas without. However, the closely associated P and Ca values support that the context layer was undisturbed. The soils associated with the few human bone fragments recovered from the center of the place, ICC100 [5001] were slightly enriched with both P and Ca, and inconsistent with soils from this burial suggesting that the area may have been disturbed. Significant erosion is apparent based on the loss of topsoil and a thin B horizon.

These findings illustrate how the application of using anthrosols to determine context integrity can be applied to an array of situations. Elemental patterning of the juvenile burial's associated soils complimented the archaeological assessment that the burial was in-situ. However, the elemental patterning was inconsistent with the previous midden contexts suggesting that this space may not have originally been used as a midden. This is consistent with the lack of concentrated refuse deposits found in this context [4013]. A number of small depressions were found above this deposit, starting with context [4011] and will be discussed in the next section.
9.1.5 Depressions

Two small depressions or holes were identified towards the bottom of Unit ICC101 [4011], with no refuse deposits. This maybe a byproduct of bioturbation possibly the byproduct of old roots or rodent activity. While no evidence of either were recovered, the loose soil deposits filling these depressions had higher P and Ca values than the majority of soil readings taken from middens. The same can be said about the high mean values for K, Fe, Ti, Si, and Al; which collectively compare favorably to wood ash. Both P and K fall within range for measurements of wood ash, and not for the shell/wood ash mixture. These depressions may have been used to discard ash for small scale cooking or fire related activity, however these ash readings were inconsistent with readings for wood and shell ash mixture. An alternative explanation, is that these depressions maybe associated with small wooden structural beams. The elemental patterning is consistent with the structural features excavated from the site of Doigs. Unfortunately, preserved wood was not recovered possibly due to the volcanic soils present on site. A few sites in the Caribbean have found that Early Ceramic Ages were associated with the deceased buried in the midden areas or plazas, while later ceramic phases were associated with burial occurring underneath houses (Starr 1973; Curet & Oliver 1998b; Keegan 2009a; Hoogland & Hofman 2013). The juvenile burials are consistent with these interpretations, however spatial analysis of special finds along with elemental patterning offer up some insight into ways that the deceased along with the refuse surrounding them were part of a place-making process.

An expansion of baseline studies, particularly a study of bioturbation impacts, would help shed additional insight into these problematic context. Additional experiments testing ash samples from wood fired cooking of meat and bone would also be insightful.
Figure 15: Synthesis for the site of Indian Creek categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for phosphorus (top) and Calcium (bottom)
Figure 16: Synthesis for the site of Indian Creek categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for Potassium (top) and Iron (bottom)
Figure 17: Synthesis for the site of Indian Creek categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for Silicon (top) and Titanium (bottom)
Figure 18: Synthesis for the site of Indian Creek categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for Aluminum

9.1.6 Interpretation of Site Formation from Elemental Analysis and the Spatial Distribution of Material Culture

Based on radiocarbon analysis and ceramic typologies Rouse argued that Excavation 1, Excavation 5 levels 6-7, and Excavation 6 levels 3-6 formed together as part of a contemporaneous phase. Archaeological investigations have shown that the site does not extend beyond these initial middens, thus suggesting that this was a part of the early phase of community planning at Indian Creek. It should be pointed out that physical limitations certainly contributed to the spatial character of the site, such as the hillside bordering the western portion of the site and the creek-side running along the eastern portion of the site that create physical
barriers for the site. Nonetheless, the northern, southern, and eastern extent seemed to be established early on. Excavation 1 is approximately 206 meters from Excavation 5 and 115 meters from Excavation 6. By combining the spatial distribution of radiocarbon dates, ceramic typologies, and soil samples we can model two general phases of development for Indian Creek. The first phase developing between approximately B.C. 100-200 A.D. and continuing until approximately 400 A.D. (Map phase 1); and between approximately 400-700 A.D. the second phase of the site emerged (Map phase 2 w/o Trench1) with a more distinct circular form.

These findings have particular bearing on how spaces within the site can act as a generative force shaping the relationships between people, place, and things. The selection of spaces allocated for refuse do not appear to be arbitrary. Consideration for the size of the village is demonstrated by the placement of middens at Indian Creek. The early designation of the northeast region of the site and its continued preservation up until abandonment suggests that certain rules, traditions, and potentially beliefs may have carried through until abandonment. Pre-Columbian ceramic traditions in Antigua did not experience the changes and influence observed in other northern islands of the Lesser Antilles, nor did it experience the changes and influence of those islands to the south of Antigua (Murphy 2004). At least for Indian Creek, the spatial organization of the site was largely maintained throughout 1500 years of continuous occupation; and while middens were added, substantive evidence suggests that the plaza was maintained throughout it's history and presents a slow gradual process of modification similar to those changes observed in Antigua' s ceramic traditions. Further research is necessary to understand how other Pre-Columbian sites around the Caribbean compare to these findings, particularly villages where ceramic traditions were either abandoned or replaced by new ones.
9.2 Doigs Test Site

The site of Doigs was selected due to the extensive archaeological excavations conducted throughout the site with available anthrosols for multi-element analysis (Gent & de Mille 2003). Based on ceramic analysis, the site is considered a two phase site with evidence of early and classic Saladoid occupation (pers comm Benoit Berard). Two unpublished radiocarbon dates were obtained by Martin Fuess during his unfinished archaeological dissertation research from Doigs Unit A; Beta-82000 DOIGS-1 yielded calibrated dates of AD 110 to 405 (2 sigma, 95% probability) taken between 100 - 110 cm while Beta-93702 DOIGS-2 yielded calibrated dates of AD 595 to 800 (2 sigma, 95% probability) taken between 50 - 60 cm. Faunal analysis also provides support of this transition with early Saladoid ceramics associated with a limited fish species diversity with classic Saladoid ceramics being associated with increased diversity of both species and habitats (Cluney 2005). A series of structural features were identified using a mixed strategy of magnetic resistivity and excavations (Gent 2004) with soils collected from associated floor layers and post holes. This site served as a test site for direct multi-element analysis of archaeologically defined activity loci with associated anthrosols.

9.2.1 Spatial Analysis of Doigs

Excavations at the site of Doigs were conducted using block excavations and were combined with shovel test pits conducted in transects (fig. 19) (Gent & de Mille 2003; Gent 2004). Archaeological assemblages and multi-element analysis were combined through a spatial database and mapped horizontally using GIS software. While these excavations and geomagnetic surveys helped identify structural features and activity areas, the overall sampling strategy did not
encompass the site evenly. Block excavations were focused on visible middens, while transects cut between these spaces. The use of kernel density mapping was selected to help characterize these activity loci. Spatial modeling was not used due to a lack of sampling representing the overall site (fig. 19; fig. 31-37). Multi-element distribution was overlaid on top of Gent's site synthesis (Gent 2004) combining archaeological excavations and geomagnetic survey. The following section provides new discussion using combined elemental analysis of anthroposols associated with different activities and features previously identified.

9.2.2 Hearth

A cluster of fired crumbled orange clay was excavated from Units 21 and 24 at Doigs along with small pieces of charcoal and were interpreted as a potential area for ceramic firing or hearth (fig. 19). Measurements of associated soils and deposits for P, Ca, K, Si, and Ti were low with respect to any other activity loci identified (Appendix: B fig 31 - 37). Low P, Ca, and K measurements were also inconsistent with the presence of wood ash, while Fe concentrations were significantly lower than measurements obtained from Doigs reference ceramic body fragments, red paste, and white paste described in Chapter 5.2 Measuring Reference Samples. Further sampling and testing of clay hearths is necessary in order to understand their relationship with elemental characteristics. Multi-element analysis of the soil context associated with the fired clay suggest that this area was not part of its use area, rather suggestive of being a secondary deposit.

These findings pose problematic concerns regarding how we interpret certain assemblages. While the presence of fired clay associated with pieces of charcoal are reasonable lines
of evidence to suggest that the area was used for ceramic production, the lack of wood ash or any additional elemental patterning illustrates some of the limitations of interpreting and recognizing secondary assemblages.

9.2.3 Midden

Similar to Indian Creek P, Ca, and K were closely associated with faunal refuse, particularly bone and shell. Findings from Chapter 6.1.b described that total weight of material remains appeared to correlate better than overall assemblage counts. Anthropogenic midden soils also represented the widest distribution of elemental readings due to the varying deposits and context encountered stratigraphically. All elements analyzed except for titanium were found to be elevated within heavily concentrated deposits.

The midden excavations associated with Doig's provided the most comprehensive comparison between artifacts and faunal remains, particularly their variability over a relatively short period of time. Without additional radiocarbon dating of middens and additional soil sampling of the void spaces, it is difficult to compare Doig's to Indian Creek's early phase of settlement. The distribution of middens are not concentric, nor do they seem to be markers delimiting the boundaries of the site. Some of the midden deposits were found far away from the center of the site along an elevated slope. These early findings suggest that Doig's may have been a different kind of site compared to Indian Creek. This raises an important question regarding the relationship between villages and whether certain settlements played a specific role within the larger region?
Figure 20: Synthesis for the site of Doigs categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for phosphorus (top) and calcium (bottom)
Figure 21: Synthesis for the site of Doigs categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for potassium (top) and iron (bottom)
Figure 22: Synthesis for the site of Doigs categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for silicon (top) and titanium (bottom)
Figure 23: Synthesis for the site of Doigs categorized by type. Left and Right: Mean and standard deviation (left) and spread (right) for Aluminum

There are many challenges to synthesizing elemental concentrations sorted by type; in particular how data is integrated from a multi-pronged approach consisting of archaeological excavations, shovel-test pits, and remote sensing techniques. This section presents overall findings synthesized from all sites combined and analyzed by type (Figure 1) as well as by site. Additional comparisons between artifact and ecofact counts will be provided for both the site of Doigs and Indian Creek. After findings from shovel test pits are presented, a synthesis by type for each site is presented.
9.2.4 Central Areas

Based on the configuration of middens and elemental patterning, no discernible central plaza was identified. As previously discussed, archaeological investigations and multi-element analysis of anthrosols work in tandem with one another; and in this instance Doig's appears to be a very different kind of site than Indian Creek. Ti, Al, Fe, and K were predictive of midden remains, there was greater variability for the site of Doig's. P and Ca values correlated well with midden counts, although a sharp delineation of the boundary of the site was not as sharp as in Indian Creek. This lack of distinction between village central areas and offsite spaces suggests that these spaces were not intensively used in the same kinds of daily routines observed at the site of Indian Creek.

9.2.5 Cleared or Void Spaces

Areas lacking in refuse, in particular artifacts and ecofacts within the spatial context of nearby middens and evidence of structures are suggestive of spaces that may have been purposefully kept clean or clear. Multi-element analysis of anthrosols found elevated P, Ca, K, Ti, and Al in the cleared spaces excavated by the University of Calgary team. These elevated measurements are consistent with food preparation activities identified in ethnohistorical and ethnoarchaeological studies (Middleton & Price 1996; Beck 2007; Manzanilla 1996). These spaces are often enriched by fire activities and discarded organic remains, leaving behind ash and food drippings. Prior analysis of archaeological wood ash identified an across the board enrichment of elements including Fe and Si which were found to be low in these samples. These discrepancies might perhaps be a result of the heterogeneity of clay deposits, requiring further sampling of soils throughout the site. Additional caveats interpreting these results as evidence for a hearth
are the absence of ash and refuse, suggesting if these areas were used for food preparation, the affects of sweeping must be considered. Enriched P and Ca are inconsistent with routine sweeping activities of this area. Another possible explanation for this area is the possible use of the area as a garden plot, based on Gent Brock's model for village activity and organization, the cleared area is within proximity of a hypothesized work hut and small structure identified approximately 52 and 63 meters respectively. Further archaeological analysis is needed in this area, as well as a substantive analysis of the surrounding support structures which may help characterize the use of this space.

9.2.6 Structural

Identification and description of structures using remote sensing techniques were partially based on archaeological excavations (Gent & de Mille 2003; Gent 2004). Prior to geomagnetic survey, the University of Calgary team excavated posthole features in Units 11 and 12 at PA-15. Dark circular lenses were initially identified and loose soils were collected. After geomagnetic
survey was conducted, additional structural features were identified including a preserved portion of a wooden post in Unit 21. Soils from the associated context were collected and analyzed finding evidence of enrichment for all elements analyzed, in particular P, Ca, and K (fig 19. Appendix:B). Anthrosols were found to have elevated P (6,951 ± 1,564 mg kg-1) concentrations that were lower than midden P (7,547 ± 749 mg kg-1), lower Ca (53,956 ± 9,886 mg kg-1) measurements than midden Ca (72,241 ±6,601 mg kg-1), and slightly higher K (8,536 ± 586 mg kg-1) than in middens (7,861 ± 292 mg kg-1). These are observations are consistent with both ethnohistorical and ethnoarchaeological investigations finding floor layers, particularly those associated with food preparation activities to have enriched P, Ca, and K (Middleton & Price 1996; Manzanilla 1996; Hutson & Terry 2006; Beck 2007). Additional enrichment of Fe, Ti, Si, and Al were also observed (Figure 20 and 23) as well, suggestive of domestic activities. While wood ash also contained high levels of elements analyzed, soil measurements associated with structural features were far too low to be interpreted as wood ash from burnt posts or hearths, as established in Chapter 5 Establishing Baselines. Interpretation of how these structures were used were not possible, as excavations stopped after the preserved post and posthole were identified leaving the floor layers unexcavated.

Interpretation of these spaces are heavily connected to cleaning activities, process of diagenesis, and taxonomic processes. The impact of weathering of soils was found to be largely dependent on whether the structure was enclosed and covered, despite being a gradual modification of the parent material over time (Middleton & Price 1996). Findings from this research are particularly applicable to structural remains, as only a handful of households have even been explored (Samson 2010). The integration of anthrosols can re-shape our understanding of house-
Hold boundaries. While walls may act to partition space, they are not always a suitable indicator of what home may represent. Certainly future explorations of floor layers both inside and out, may additionally contribute to our understanding of re-use of space and the different kinds of uses that each structure may have had. Sharp elemental boundaries could be compared to genetic studies of Late Ceramic Age burials taking place within structural remains. Burials occurring outside of structures can be tested to see if the surrounding areas show any elemental association with neighboring structures. Both the presence of P, Ca, and K particularly, can help differentiate lived-in structures (high in P, Ca, and K) versus structures used for meetings and/or councils (low in P, Ca, and K). Exploration of floor layers within households can be tested to see whether sharp boundaries persisted, indicative of designated activity areas, or homogenous elemental distributions, which maybe the result of single or multi-use spaces.

9.2.7 Activity Areas

High concentrations of Ti were found east of Doigs midden 5 in the same location as a previously identified activity area described by Gent Brock (Gent 2004) as the second cleared area (fig 37). From Chapter 5 findings from reference samples, bone was generally found to be high in titanium in contrast to all other elements. This activity area also had elevated P, Ca, K, and Fe concentrations which is consistent with ethnoarchaeological studies identifying animal butchery or plant processing (Manzanilla 1996). The use of kernel density mapping identified an additional area of potential activity. West of Doigs excavation 4 identified an area with elevated levels of Fe and Ti, similar to the above context. This area is in a cleared space, away from all other midden mounds. While elemental concentrations were elevated, they were not within range
found with wood ash, therefore consistent with processing and not cooking as described from other ethnoarchaeological and ethnohistorical analogues. Further testing is needed due to the limited excavations taking place in this area.

9.2.8 Doigs Findings

The Pre-Columbian site of Doigs partially overlaps a historic plantation and a recently abandoned farm. While heavy ploughing can have an affect as previously discussed for Elliot's farm, no evidence of intensive ploughing is present at the site. Any use of modern fertilizers using animal manure has been observed at other archaeological sites to have had minimal impact on anthropogenic soil characteristics (Middleton & Price 1996), which was also observed at Doigs. Additional excavations are needed in order to better characterize different activity loci. The site of Doigs has immense potential to expand our understanding of households during the early Saladoid in Antigua. By combining multi-element soil analysis with archaeological techniques, areas rich and void of material remains can be contextualized and interpreted to gain new insights into Saladoid lifeways.
Chapter 10. Conclusions

10.1 Archaeological Case Study from the Island of Antigua

Findings from this research contribute to the methodological evaluation and applications for pXRF technologies used to study anthrosols in a Caribbean context; as well as add to the theoretical discourse on place-making within a Pre-Columbian context on the island of Antigua.

A substantive body of evidence was used to demonstrate how portable x-ray fluorescence (pXRF) technologies could be applied to the study of anthrosols particularly the identification of ancient activity areas within this case study region. While findings from this research demonstrate the usefulness of in-field applications of pXRF technologies in identifying activity areas across a variety of spatial, temporal, and environmental conditions; selection of an appropriate instrument must be considered when studying anthrosols. pXRF technologies are not uniform across manufacturers, and have been designed for different applications often unsuitable for archaeologists. User calibration as well as detection limits must be considered when selecting an appropriate instrument for the study of anthrosols. Findings from this research are consistent with other critiques regarding total elemental counts, which is inherently a drawback of this technology, and includes elemental counts bound in stable forms that are indistinguishable from anthropogenic sources (available). Different fractions of phosphate - labile (plant available), anthropogenic (differing levels of adsorption and complexation of ions), and diagentic (soil matrix) are combined using pXRF analysis. Findings from this research suggests that one way to buffer these problems is to do a broad scale grid, rather than a transect as illustrated at the site of Indian Creek.

There is substantive evidence that anthrosols can be used to identify spaces that are full of human activity but void of material remains. The mapping of elemental patterns can allow us to begin hypothesizing how to put people back into their lived-in spaces and return objects to their used-in spaces. This research begins with an exploration of elemental patterning associated with
objects found throughout Pre-Columbian life, and exploring the affect time may have on these objects through the process of diagenesis. From this baseline, spaces rich in artifacts were compared with elemental signatures from anthrosols in order to first evaluate the applicability of pXRF technology, and then to test how these signatures relate to their respective material remains. Findings from this research illustrate how pXRF technologies can be meaningfully applied to anthrosols in identifying and reconstructing ancient activity areas, as well as highlight the many variables that must be accounted for to address the technological limitations.

The coupling of archaeological investigations with the multi-element analysis of anthrosols helped generate new datasets that were used to synthesize elemental approaches in identifying the various places that make up and in some ways define sites. This has important implications, as some of these places that leave no artifactual trace behind are missing from the historical record, and whose concealment make it exponentially threatened by coastal and commercial development projects across the Caribbean. This chapter will summarize and integrate these findings.

10.2 Evaluation and Applicability of Portable X-ray Fluorescence Analysis

The use of portable X-ray fluorescence in archaeology relies a great deal on the user’s ability to understand the instrument’s limitations in order to develop a research framework that takes advantage of its strengths for studying ancient activity areas. Anthrosols are comprised of soils with elemental makeups primarily tied to the parent material associated with its formation and multiple fractions resulting which are anthropogenic, labile, and diagenetic. As previously described, pXRF technologies do not distinguish between these different fractionations, and rather combines all forms. The second primary concern was whether the use of Bruker’s pXRF analyzer could detect elemental levels for anthropogenic activities, which most pXRF analyzer’s are incapable of doing. As this instrument, the Tracer IV pXRF analyzer, was constructed
through a collaboration with Bruker Scientific and archaeologists studying anthrosols (Speakman 2012; Speakman & Shackley 2013), it was selected for due to its portability and potential applicability for studying anthrosols within Pre-Columbian context. It should not be understated, that being able to accurately quantify elemental components for a variety of complex soil matrices, while conducting research in the field has extraordinary benefits directly related to cost-saving, sampling strategies, and interpretations for archaeological investigations. These findings must be tempered with the technical limitations of pXRF.

Findings from this research support previous researcher’s conclusions, who have collaborated with Bruker, that the instrument is capable of analyzing anthrosols. The instrument was initially tested using USGS standards, which were quantified using inductively coupled plasma mass spectrometry (ICPMS) in a round robin lab analysis protocol using reputable labs from around the country. The standards selected, represent similar geologic makeups for the island of Antigua. For instance, if the instrument was incapable of accurately quantifying phosphorus in andesite, which is the parent material for the site of Doig’s, then it would not be applicable for studying human activity and anthrosols. The instrument’s readings were well within the standard deviation allowable, as recommended by the USGS standards laboratory.

While there are distinct advantages of integrating pXRF technologies for in-field archaeological toolkits; findings from this research supports a broad scale grid approach that mixes shovel test pits, excavations, and soil auguring across sites. Additional attention must be paid to geological conditions, environmental forces, and past land-use activities that all contribute to the formation, destruction, and layering of anthrosols. Soils are naturally heterogeneous throughout archaeological sites; therefore, this research limits itself to activity areas that deviate measurably from site wide variations. In some instances, such as sites sitting atop limestone parent material, calcium carbonate rich soils does not allow for site wide interpretations of calcium. However, elemental loading associated with midden deposits, are measurable, but within these particular context where elemental is significant. Midden formation
should also be considered as well, as middens appear to be somewhat resistant to erosion. In the case of Indian Creek, differences were on the order of magnitude of 3.8X greater phosphorus in middens (77,923 mg kg⁻¹) than was found outside these middens (2,025 – 6,536 mg kg⁻¹). By using concentrated midden deposits along with multi-element analysis, elemental baselines established from Chapter 5 were used to test the relationship between individual ‘types’ of objects and the anthrosols associated with them. Off-site variation of P was found to be measurably lower than areas within the site of Indian Creek. The findings described in Chapter 6 emphasized the role of diagenesis in elemental loading. Faunal counts resulted in the enrichment of all elements being studied, with the closest correlation being P followed by Ca. When ceramic and lithic counts were isolated and compared to elemental fluctuation, chemical signatures correlated only partially with varying object counts; which is consistent with other researcher’s findings (Parnell 2001; Eberl et al. 2012). Based on midden comparisons, this partial correlation appears to be an artifact of midden formation; rather that high ceramic concentrations happen to occur with high bone and object counts. A number of middens analyzed contained organic refuse that deviated from object counts, and under these comparisons elemental signatures were often uncharacteristic of the fluctuating object counts and rather a by-product of organic refuse. An alternative explanation, is that faunal breakdown contributes to elemental loading far greater than objects such as ceramics and lithics. Testing of isolated ceramic or lithic deposits may further our understanding of these dynamics.

10.2.1 Summary

The use of Bruker’s Tracer pXRF analyzer provides a valuable tool for archaeologists seeking to study anthrosols. A thorough understanding of the limitations both in the instrument and the extent soils can preserve past activities is vital in making meaningful interpretations of Pre-Columbian anthrosols in Antigua. These applications hold significant potential within the larger Caribbean framework, requiring further testing and additional elemental baselines for Pre-Columbian objects.
10.3 Archaeology of Void Spaces

Middens have played a central role in defining and characterizing Pre-Columbian Caribbean cultures of the past. These places of concentrated refuse contain objects that have histories of their own, whose lives played out in spaces that are often dissociated with their use. By constructing a meaningful understanding of material remains and their associated anthrosols, could these spaces be identified. Void spaces, or areas where there is an absence of material remains, poses many challenges and difficulties to archaeological interpretations of space and place. There are many different natural and social processes that can affect the absence of material remains such as erosion and flood events as well as the purposeful removal of soils. Distinguishing between these processes and identifying void spaces that were maintained and kept clear of refuse provides a powerful analytical tool to expand our knowledge of place-making. At the site level, the spatial distribution of different areas of medium to long-term human activity middens can be compared to void spaces.

The site of Doig’s contained void spaces that were rich in P, Ca, and K; consistent with elemental measurements taken for vegetation samples. This space is adjacent to a series of potential structures, and may be indicative of a place specifically designated for plant refuse or maybe evidence for the use of small gardens used to grow food crops. The paleobotanical work in the Caribbean along with isotopic analysis of diet (Berman & Pearsall, 2008; Pagán Jiménez, 2011; Pagan-Jimenez, 2013; Mickleburgh and Pagan-Jimenez 2012) has provided evidence for a reliance on food crops as an important part of their subsistence. This area of research requires a great deal more of exploration, particularly the relationship between the early evidence of corn and the later evidence of increased root crop consumption. Corn has high nutrient requirements and a relatively consistent supply of water, while root crops are highly resilient to poor soil conditions and require relatively little water. Additional studies of soil conditions and evidence of dietary consumption of food crops are needed, particularly the impact of growing crops that
require rich nutrients such as P, K, and Ca and can deplete or destabilize soil conditions.

Sites that are lived-in for centuries will undoubtedly go through reconfigurations and organizational changes, however some spaces appear to remain void of artifacts throughout the site's history. By coupling archaeological investigations with anthrosols, it becomes apparent that some void spaces were places of immense human activities, requiring maintenance and mitigation strategies to keep these spaces intact. The most obvious example of void spaces that are full of human activity are the ball courts found throughout the island of Puerto Rico or the inside of structures with compact floor layers. The challenge for this research project, was to study void spaces with no evidence of structural features that could outline their boundaries. Instead, this research relied on repeated activities that were part of everyday life that influence the formation of anthrosols.

10.4 Distinguishing Different Kinds of Activity Spaces

Findings from Chapter 9 demonstrate that archaeologically defined activity areas have unique elemental patterns. However, the parent material and relative heterogeneity of on-site soils affects which elements are practical for studying ancient activity areas. Limestone regions contain large amounts of calcium carbonate which resulted in the masking of any anthropogenic enrichment for Ca due to the soils inherent heterogeneity. Other elements, such as Al and Si, were primarily the result of aluminosilicates present in clay deposits. This phenomenon is best illustrated from the site of Indian Creek from excavation unit ICC101, While Fe, Al, Ti, and Si correlated well within midden counts, aluminosilicates are everywhere and Al and Si cannot be used for interpretations. Middens, also represent the widest range of elemental readings as these are of dynamic change made of numerous deposition events that range in highly dense to relatively sparse deposits. Therefore, how one characterizes an activity area cannot just be the total elemental value for that location, but also the inherent variability with respect to the kinds
of activities forming these areas.

While different activity areas were discernable, pXRF measurements of midden anthrosols demonstrate that elemental patterns do not distinguish between individual kinds of refuse. While P, Ca, and to a lesser extent K correlate well for grouped artifact and faunal counts, their relationships become chaotic and dissociated when attempting to compare mollusks along from crab counts. Additional findings indicate that total weight is often a better indicator of elemental loading rather than count, as fragmentation and recovery strategies can have significant impacts on counts more so than total weight.

While the focus of this research project has been on activity areas that are the by-product of medium to long-term human activities that are confined to specific places, findings from this research provide evidence for singular short-term events that are also chemically unique, such as the dumping of wood ash from cooking hearths or ceremonial activities. The elemental patterns for wood ash result in high concentrations of P, Ca, Fe, Al, Ti, and Si that supersede anthrosol measurements from even middens. Therefore, the applications for pXRF studies of anthrosols are not restricted in scale to medium and long-term activities. Again further research is needed to expand on the different kinds of deposits associated with wood firing in order to see if food preparation can be more clearly discerned from other fire related activities; such as wood ash which has been considered a cleansing substance used historically throughout the North Atlantic to absorb liquids and organic compounds, particularly those that cause strong odors (Milek 2012).

10.5 Cultural Heritage Preservation

As cultural heritage sites are increasingly threatened across the Caribbean, a greater emphasis has been placed on rapid site assessments that often place an emphasis on visible surface remains to delimit sites. Climate change and sea-level rise impacts have been recognized as an emerging threat to cultural heritage sites, and climate related impact assessments have
become part of the preservation process. This is demonstrated in part by the island’s recent acceptance into UNESCO’s list of World Heritage Sites. During the World Heritage application process for the Naval Dockyard and related archaeological sites, both a sea-level rise impact assessment and boundary justification were required. Sea-level rise models were based on 50 and 100 year projections, in order to provide an impact assessment for the site; while justification of areas, particularly those areas lacking any structural or archaeological remains had to be made.

Findings from this research have important implications and value to the island of Antigua, and potentially to the rest of the Caribbean. This research project has demonstrated how anthrosols can be used to provide both a preliminary assessment and localize ancient human activity areas, which may also include areas void of both material remains and structures. A comparison of multiple sites in Antigua across different geological, spatial, and temporal spaces comparing intact and heavily disturbed context found that contextual integrity can be measured and integrated into cultural heritage planning and protection programs. While the use of phosphorus is a valuable indicator of anthropogenic disturbances, rapid elemental characterization can be coupled with strategic excavations to distinguish between different uses of space and extend site boundaries to those places beyond middens or structures. These tools can provide archaeologists, cultural heritage managers, and local decision makers with the ability to rapidly identify and protect a more complete record of a site’s history for future researchers and Antiguans to discover.

10.6 Persistent Places

This research contributes to the theoretical discourse on persistent places, by demonstrating how soils can act as archives and situate places within a localizable village context. While an abundance of literature exists on persistent places within a landscape framework, this research contributes to the discourse on persistent habitation loci initially described by Schlanger (1992).
The gradual processes of anthrosol formation are particularly suited for studying places of habit rather than incidental localities. Findings from this research, coupled with archaeological investigations frame how persistent place theory can be applied to identifying the potential rules, taboos, and accessibility of these socially constructed places. This research focused heavily on organized spaces identifiable over deep time horizons.

Findings from this research on small scale activity areas, particularly habitation loci, illustrates how understanding persistence of place at one scale may contribute to our understanding of persistence on another. What makes sites like Indian Creek a persistent place for pre-Columbian peoples on Antigua, may be the by-product or beneficiary of small scale focus on unique and symbolically significant places, such as ceremonial plazas, which may have played a larger island-wide community role. Future research seeks to study how persistent place theory maybe used to help study cultural resistance in times of change, particularly how these constructed places may act to reinforce cultural traditions and potentially resist outside influences.

Stasis, is by no means a passive process, and can require a tremendous amount of effort to keep these places recognizable and meaningful. By considering the challenges and adaptive responses needed in maintaining these spaces, this research contributes to our understanding of the slow incremental steps/processes that may build towards transformational changes observed in the archaeological record. In this way, the maintaining of persistent places, can also provide the incremental framework for change.

This research did not address the need to study how fluid spaces that are continuously modified and altered can also come to represent a different kind of persistent place. At Tibes, early burials formed the spatial extent of where stone lined plazas would eventually be placed.
These places may have transitioned from areas of veneration or a symbolic resting place, but eventually changed to a formal stone lined plaza. While the functions and potential symbolism may have changed for the site, the integration of anthrosols may help characterize the sharpness of boundaries and the nature of their disturbance or modifications. In this manner, the integration of anthrosols may help characterize persistent places of change, where creative destruction and construction may have taken place. While this research attempts to engage these emerging concepts within persistent place theory, it is the intent of this research to take a tentative exploratory framework as well as develop an epistemological framework for studying these localizable places. Future research seeks to expand on the number of case study sites, and compare additional activity areas of persistence and change.

While this research drew largely from landscape theory, the integration of anthrosols were not applied within a broader landscape approach. Findings from this research, demonstrate the challenges and limitations of using pXRF in anthrosols study, however complex site processes coupled with long-term environmental influences may complicate soil studies as a whole, particularly in landscapes with thin lenses of exposed cultural deposits. The comparison of surface scatter and soils from augering were particularly applicable for presence/absence of subsurface remains, but relatively poor indicators of quantifying how concentrated these localities were. In this way, the use of anthrosols are more apt for identifying middens and not necessarily the ephemeral places that were revisited during various periods of cultural transitions.

10.7 Conclusions

This research project studying Pre-Columbian sites on the island of Antigua has provided evidence for the integration of pXRF analysis of anthrosols in archaeological investigations, as
well as the identification of unique activity areas that were maintained for fifteen-hundred years. Multi-element analysis of anthrosols coupled with archaeological evidence indicates that some of these places that are full of human activity were also void of material remains suggesting that spaces central to village life were filled with rules and taboos related to its use and function.

The role sites like Indian Creek had within a larger regional framework is difficult to assess at this time, as additional case studies are needed to explore the different kinds of ancient activity areas that were part of making place-making within a Pre-Columbian village. While the island of Antigua stands out as a unique cultural center for late ceramic age Saladoid pottery traditions, sites like Indian Creek offer clues to how these cultural material forms may have been retained and continuously practiced. Early findings from this research add to the discourse of ritual midden deposits throughout the Caribbean, offering up new approaches to connecting single event deposits within deeply stratified middens. The site of Doig’s is not consistent with the early formation of Indian Creek, suggesting that different contemporaneous sites may have played different roles within an island’s cultural sphere. Additional research is needed to understand why some places were abandoned, new places emerged, and others remained persistent. There is potential to investigate the unique environmental challenges related persistent settlements inhabiting the same place for centuries; particularly by coupling soil studies and paleo-environmental reconstructions related to climatic fluctuations and drought conditions. These findings would clarify the role of mitigation strategies, risk management, and environmental adaptations that continue to pose challenges for the island of Antigua.

While descriptions of centralized spaces and plazas are not unique to this research in the Caribbean, this research contributes to our understanding of how plazas or village centers are created; particularly the activities and rituals that give meaning to these spaces through the use of anthrosols. These findings arise out of the questioning of void spaces and their relationship to middens; particularly the study of lived-in spaces in contrast to discard spaces. While Greater Antillean stone lined plazas, ball courts, and village centers are visibly distinct from their midden
enclosed counterparts of the Lesser Antilles in general; we are less certain about how these spaces formed, changed, and were used during their lifetime. Future research seeks to expand explore other settlements in order to understand the diverse places that were part of Pre-Columbian life throughout the Caribbean.
Chart 115: pXRF Raw Spectra for USGS Standard BCR-2
Chart 117: pXRF Raw Spectra for USGS Standard BIR-1
Chart 118: pXRF Raw Spectra for USGS Standard COQ-1
Figure 24: Aluminum (mg kg⁻¹) Inverse Distance Weighted horizontal Indian Creek Map
Figure 25: Calcium (mg kg⁻¹) Inverse Distance Weighted horizontal Indian Creek Map
Figure 26: Iron (mg kg⁻¹) Inverse Distance Weighted horizontal Indian Creek Map
Figure 27: Potassium (mg kg\(^{-1}\)) Inverse Distance Weighted horizontal Indian Creek Map
Figure 28: phosphorus (mg kg-1) Inverse Distance Weighted horizontal Indian Creek Map
Figure 29: Silicon (mg kg⁻¹) Inverse Distance Weighted horizontal Indian Creek Map
Figure 30: Titanium (mg kg⁻¹) Inverse Distance Weighted horizontal Indian Creek Map
Figure 3.1: Aluminium (mg kg⁻¹) Kernel Density Digs Map
Figure 32: Calcium (mg kg⁻¹) Kernel Density Map

Note: The map shows the distribution of calcium in the soil, with different colors representing varying levels of calcium concentration. The legend provides a key to the symbols and colors used on the map.
Figure 34: Potassium (mg kg⁻¹) Kernel Density Map

[Map showing the distribution of potassium in the soil with various markers and labeled areas.]
Figure 35: Phosphorus (mg kg⁻¹) Kernel Density Doses Map
Figure 36: Silicon (mg kg⁻¹) Kernel Density Dig Site Map

Legend
- Midden Areas
- Potential Structures
- Activity Areas
- Test Units

Calgary Excavated Units and Sites (Adapted from Brook, schematics 2004)

Reference map of sites sampled from excavations and show of test pits.
### C: Radiocarbon Dates

<table>
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<th>MEAN DATES</th>
<th>SITE</th>
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