Modelling Archaic Age Settlement Patterns on Jamaica's Southwestern Coast Using the Ideal Free Distribution

by

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B.A, Vancouver Island University, 2018

Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts

in the
Department of Archaeology
Faculty of Environment

SIMON FRASER UNIVERSITY
Fall 2022

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Abstract

Of the three recognized 'Ages' of Pre-Columbian migration into the Caribbean, Lithic (6500 BC to 2000 BC), Archaic (4000 BC to AD 500) and Ceramic (400 BC to contact), evidence for the earliest two has yet to be discovered in Jamaica, which was seemingly not settled until AD 600. This research creates a predictive GIS model, based in the ideal free distribution, to identify likely areas of potential Archaic occupation on Jamaica's southwest coast, understand the impact of modern development on these areas, how they relate to known Redware sites (AD 600 – AD900) and where to begin field survey of these areas. Seventeen areas of high potential (hotspots), based on surrounding environmental variables and lack of modern development, were identified. Discovery of an Archaic Age settlement of Jamaica would potentially lengthen the human history of the island significantly and have significant implications for human migration routes into the Caribbean.

Keywords: Human Behavioural Ecology; Caribbean; Migration; Settlement patterns; Colonization; GIS; Predictive Model

Acknowledgements

This research was made possible by the help and encouragement of many people. I am forever grateful to my supervisor Dr. Christina Giovas for their unwavering support and advice throughout this degree. Without your inspiring scholarship and patience this thesis would not have happened. Thank you to my committee members: Dr. Dave Burley for their guidance and recommendations and Dr. Jonathan Hanna whose work is an inspiration. Many thanks to Dr. Dana Lepofsky whose kindness and passion helped design this research. Thank you to Dr. Yvonne Narganes and Dr. Lesley-Gail Atkinson for sharing key data.

Thank you to my family and friends for their love and encouragement throughout this degree. To my parents, Wendy Ann Lee and Ray Van Barneveld, thank you for believing in me and supporting my choices. I am deeply thankful to Melissa Ayling whose patience and love helped me overcome the obstacles of the past years. Thank you to my grandfather, Dr. James W. Lee, for sparking my interest in history and archaeology; I wish he were here to read this.

This project was supported by the Social Sciences and Humanities Research Council of Canada Grants, a Graduate Fellowship and a Travel and Research Award through the Department of Archaeology at SFU.

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Chapter 1.

Introduction

The Caribbean region is composed of several archipelagos located in the Caribbean Sea north of South America and east of the Gulf of Mexico (see Figure 1). The region is divided into two main parts: the Lesser Antilles and the Greater Antilles. The Lucayan (Bahaman) Archipelago is also often included as part of the Caribbean despite being located in the Atlantic. The Lesser Antilles, generally divided into the Windward Islands in the south and the Leeward Islands in the north, is an arc of volcanic islands stretching from Trinidad and Tobago to the British Virgin Islands. The Greater Antilles is a group of larger (except for the Cayman Islands) islands in the northern Caribbean, that includes the Cayman Islands, Cuba, Hispaniola, Jamaica and Puerto Rico. The Lucayan Archipelago consists of the Bahamas and the Turks and Caicos Islands. The Leeward Antilles lie in the southern Caribbean and consists of Aruba, Bonaire, and Curaçao and Venezuela's offshore islands.

People began moving into the Caribbean as early as 7000 years ago (Keegan and Hofman 2017). Jamaica, however, seems to have been settled only as recently as 1,500 years ago, and this late settlement is largely seen as anomalous among Caribbean archaeologists (Allsworth-Jones 2008; Callaghan 2008). Of the three waves (Lithic, Archaic and Ceramic) of Pre-Columbian people to have migrated into the Caribbean, evidence for the first two has yet to be discovered in Jamaica. Evidence for the first two occupation phases, conjunctively discussed here as the Archaic Age, have been widely found on the neighbouring islands of Cuba, Hispaniola, and Puerto Rico (Hofman and Antczak 2019; Keegan and Hofman 2017; Rouse 1992). Almost implausibly, the consensus is that Archaic Age peoples failed to discover the large nearby island of Jamaica for several thousands of years despite being competent seafarers and marine-focused peoples (Callaghan 2008; Erlandson and Fitzpatrick 2006; Keegan and Hofman 2017).

Figure 1: Map of the modern day Caribbean (Nations Online Project: Political Map of the Caribbean Island (West Indies))

Several explanations have been proposed for the absence of sites predating the Ceramic (400 BC to contact) Age on Jamaica, such as invisibility of the island from Cuba and Hispaniola or the possibility of rising sea-levels obscuring sites (Torres and Ramos 2008; Callaghan 2008). Callaghan (2008) has argued thappeat the rough seas along the north coast of Jamaica made reaching the island difficult until seafaring technologies were further developed. Other researchers suggest that these sites have not yet been found despite attempts by archaeologists over the years (Keegan 2019). Several authors remark that there have been no systematic surveys of the island for archaeological sites (Howard 1965; Keegan 2019, 196; Rampersad 2009, 25), even though over 270 Ceramic Age sites have been recorded for Jamaica (Allsworth-Jones 2008). The arguments made for the absence of pre-Ceramic sites on Jamaica are not satisfying (Keegan 2019). Thus, this research aims to create a practical plan for surveying for and locating an Archaic Age settlement of Jamaica.

In this research I create a predictive model for the southwest coast of Jamaica using an ideal free distribution (IFD) theoretical framework. The IFD is based in human behavioural ecology and states that humans will choose the most suitable locations to settle first (Kennett 2005; Kennett, Anderson and Winterhalder 2006; Hanna and Giovas 2019; Giovas and Fitzpatrick 2014). The predictive model is based on the availability of environmental variables regarded as relevant to Archaic Age peoples in other islands, such as proximity to reefs, freshwater sources, beaches and agricultural soil quality (Hanna 2018; Lee 2006; Keegan and Hofman 2017). The same variables located on Jamaica are then combined in ArcMap to create the GIS predictive model. Systematic ground truthing of this predictive model represents the recommended next step to continue this research line.

This research has four objectives: 1) identify areas that would have been the most suitable locations for Archaic Age peoples to settle along the southwest coast of Jamaica; 2) understand how modern coastal development has affected these areas and highlight areas minimally impacted by this development with represent a higher potential for undisturbed Archaic Age materials; 3) understand how these suitable areas relate to the sequent Redware ceramic phase (~400 – 900 AD) settlement pattern which Keegan (2019) has argued represents a later occupation of Archaic Age peoples; and 4) select the most favourable areas to field survey for Archaic Age sites through a prioritized list of areas which combine both the most suitable locations and those least impacted by modern development.

Discovery of an Archaic Age site through a predictive model, assessment of modern development impacts and, ultimately, field survey is the goal of this research. The discovery of a pre-Ceramic site in Jamaica would significantly push back the known human occupation of the island. Furthermore, it would have significant implications for the understanding of migration of people throughout the Caribbean. By assuming that Jamaica was not discovered until AD 600, archaeologists studying the migration of people into the Caribbean must also assume humans did not cross the viewscape of Jamaica before this time (Torres and Ramos 2008; Keegan 2019). Archaeologists' acceptance that Jamaica was not settled until AD 600 creates an unproven assumption that there was a large voyaging shadow which heavily restricts potential migration routes (Keegan 2019). Finally, this research creates a framework for the systematic survey of larger areas of Jamaica which later studies can build upon.

This thesis comprises seven chapters. In Chapter 2, I discuss the theoretical model used in this research, the ideal free distribution (IFD), more fully. In Chapter 3, I discuss the Caribbean environment and pre-Columbian background of the region in relation to the Archaic Age. Chapter 4 outlines the methods used to create the predictive GIS model while Chapter 5 presents the results of these methods. Lastly, in Chapter 6, I discuss the interpretations and significance of these results and provide recommendations for field survey and future avenues for research into the Jamaican Archaic Age.

Chapter 2.

An Ideal Free Distribution Model

In the Caribbean, cultural-historical narratives of migration, settlement and subsistence patterns have been the predominant form of archaeological research. Culture history models rely heavily on assumptions and inductive reasoning based on classification of material culture by its age, spatial distribution and form (Rouse 1986, 2; Webster 2008, 19). Human behavioural ecology models (HBE), on the other hand, are structured through hypothetico-deduction, meaning they present testable hypotheses (Prentiss 2019, 217). HBE models, such as those of foraging theory, the ideal free distribution (IFD) and ideal despotic distribution (IDD), have been successfully used more recently in the Caribbean (Giovas and Fitzpatrick 2014; Hanna 2018; Hanna and Giovas 2019). The IFD can also be used to study the colonization and settlement of habitats in terms of timing, chronology and spatial patterning (Giovas and Fitzpatrick 2014, 576; Jazwa et al. 2016; Kennett et al. 2006). In this chapter, I discuss both culture history and HBE approaches to archaeological thought and how they are applicable to my research. I also discuss the names and terms used in Caribbean archaeology to clarify their use throughout this research.

This research uses an IFD framework to address the absence of Archaic Age sites on Jamaica. During the Archaic Age (ca. 4000 BC – AD 400) people from south and central America settled much of the Greater Antilles and northern Lesser Antilles (Keegan and Hofman 2017). The IFD is a HBE theoretical model that states humans will settle first in the most suitable locations (Kennett 2005). I use a predictive GIS model, founded in the IFD to identify the most likely areas Archaic Age people would have chosen to settle on Jamaica if it was inhabited prior to the first archaeologically documented arrival of humans around ca. 400 AD during the Ceramic Age (Allsworth-Jones 2008). The IFD can be used to predict how people behave in a colonization scenario, making it a suitable model to anticipate where these peoples might have first settled (Giovas and Fitzpatrick 2014; Jazwa et al. 2016; Keegan and Hofman 2017; Kennett et al. 2009; Madden et al. 2002; Yamaguchi and Ito 2006).

As the goal of this research is to create a predictive model identifying Archaic Age settlements in Jamaica, I use established archaeological understanding about the behaviours of Caribbean Archaic peoples to make predictions. This project will identify and rank environmental variables that influence habitat suitability for Archaic groups by using known settlement patterns and resource use in the Greater Antilles. Through its history, Caribbean archaeology has largely employed cultural-historical models to reconstruct migrations and explain change in the archaeological record (Keegan and Hofman 2017, 16). The increasing use of HBE theories in the Caribbean will produce testable results that can begin to fill gaps in our understanding of how this region was settled. While each theorical framework addresses different questions, by employing both HBE and cultural-historical models in this research, I present a more balanced approach to archaeological questions in the Caribbean. Below I discuss the predominant school of thought in Caribbean archaeology (culture history), the increasing use of HBE models in Caribbean archaeology and critiques of both.

2.1. Culture History in the Caribbean

Culture history has been the primary archaeological approach used to explain movement and migration in the Caribbean throughout the 20th century (Keegan and Hofman 2017, 16). The earliest forms of culture-history in the Caribbean, beginning in the early 20th century, had the goal of creating cultural timelines for human migration into the area (Murray 2017, 190). Where HBE models often use a hypothetico-deductive model (except in the case of middle-range theories which incorporate ethnoarchaeology and ethnology), culture history approaches rely heavily on classification of material culture by their spatial and temporal location as well as their form (Rouse 1986, 2; Webster 2008, 19). Based on these classifiers, artifacts, sites and assemblages can be chronologically ordered to create a history of the culture under study across space and time (Siegel 2013, 22).

The role of theory in Caribbean archaeology has followed trends similar to the wider field of archaeology (Siegel 2013, 22). Pestle et al. (2013) have argued that Caribbean archaeology's reliance on cultural historical frameworks to shape current research has hindered the development of other theoretical models within the field. Irving Rouse was the foremost contributor to Caribbean culture history over the span of almost six decades between 1930 and 1990 (Curet 2011, 13). Perhaps Rouse's most lasting contribution to Caribbean archaeology has been the classification and typology of material culture, artifact assemblages and culture groups that remain central to any discussion of Caribbean Pre-Columbian history (see Chapter 3).

Over the course of his career, Rouse primarily used culture history approaches to develop detailed historical sequences and typologies, which he applied to study potential migration patterns and routes. Rouse started with the normative view of culture; that is, culture is defined by a distinct set of norms that represent patterns of behaviour (Webster 2008, 12). Rouse (1986, 14) argued that to understand migration, archaeologists must first define established cultural area-units through these cultural norms, with the result representing both people and their culture. These cultures must then be arranged hierarchically into subseries and series, which in turn represent families of ceramic ‘languages’ (Rouse 1986, 14). Archaeologists could then begin to interpret population movement and relationships between groups through these organizations and hierarchies based on ceramic similarities and differences (Rouse 1986, 14). However, HBE models offer a different approach to questions of migration and settlement patterns similar to those tackled by culture history because they employ a theory-informed testable hypothesis through which results can be recreated and verified whereas culture history models cannot be tested in this way.

2.2. Human Behavioural Ecology and The Ideal Free Distribution

Human behavioural ecology (HBE) is the application of evolutionary ecological theories to the study of human behaviour (Cronk 1991, 25; Hames 2001). More simply, it is the study of human behaviour in terms of the adaptations made over time (Nettle et al. 2013). It differs from culture history approaches to explaining archaeological patterns in that it uses quantifiable and testable concepts that apply to the questions being investigated. Evolutionary biological approaches were originally used to study animal behaviour but began to be employed to look at human behaviour in the 1960s and 70s (Cronk 1991, 26). Social, reproductive and foraging patterns in animals were some of the first subjects studied by ecologists through behavioural, or evolutionary ecology (Bird and O’Connell 2006, 144; Krebs and Davies 1978; Milinski 1979; Wilson 1975). Much of the appeal of using an HBE approach is that it focuses on the relationship between humans and their natural and cultural environments (Kennett 2005, 12). HBE also separates itself from most other theories in that it focuses on the selections that individuals (even if part of a collective) make in order to improve their inclusive fitness, meaning that decisions made by individuals benefit the collective rather than just the individual and their own offspring (Hames 2001, 6947). The selections made by these individuals in turn lead to the cultural characteristics that archaeologists examine today (Hames 2001, 6947). The IFD, discussed below, is a branch of HBE theory and is the major theoretical model used in this research.

The IFD states that humans will choose the most suitable locations to settle first and once those habitats decrease in quality, populations will settle in successively less suitable areas (Kennett 2005; Kennett et al. 2006; Hanna and Giovas 2019; Giovas and Fitzpatrick 2014). The model assumes that individuals will select the highest quality habitat available to them to settle and that their movement to do so is unrestricted (free to choose) (Kennett et al. 2006, 270). When the quality of the first habitat falls below that of the second-best habitat, the model assumes people will begin to migrate from the first to the second (Kennett et al. 2006). An ideal free distribution would appear as a settlement sequence where the oldest sites are located at the highest quality habitats, with progressively younger sites appearing in successively lower quality habitats. The IFD has been used extensively and successfully in the field of behavioural ecology for studying animal movements, such as the foraging patterns of Blue Tits (*Parus caeruleus*) (Díaz et al. 1998), IFD correlations in fisheries (Gillis and Van Der Lee 2012), and predator-prey migration patterns within the IFD (Carlos et al. 1999), among other studies (Maszcyk et al. 2017; Nicolai et al. 2014; Shepherd and Litvak 2004).

Increasingly, the IFD has been used in archaeological contexts to examine human settlement patterns, migration and cultural interactions (Giovas and Fitzpatrick 2014; Jazwa et al. 2016; Kennett et al. 2009; Madden et al. 2002; Yamaguchi and Ito 2006). In these studies, the environmental variables characterizing the ideal habitat depend on the specific goals of the settling people, including economic, social and political ends (Jazwa, et al. 2013, 75). These goals depend on the landscape features, climate and resource distribution of the area (Jazwa et al. 2013, 75). Cultural variables such as religion, technological development and relationship with other settlements also influence settlement choice (Jazwa et al. 2013, 75). The IFD assumes that the suitability of the habitat declines due to increase in population density through immigration or growth, or non-density dependent variables, such as seasonal changes in resource availability (Kennett 2005, 34). Density independent variables, such as extreme climates and key landscape features, can drastically influence a location's suitability. For example, protected sandy beaches were vital as canoe haul outs in California's northern Channel Islands (Jazwa et al. 2016). Such variables are subject to change over time; for example, canoe haul outs can be affected by sea level change. However, they remain unaffected by a growing population which can impact habitat quality through resource depletion, interference by other individuals, or other variables (Kennett 2005, 34). Increased population places a greater strain on key resources, such as mineral deposits, soil richness, and prey resources.

The IFD has also been used to study colonization patterns and chronology of islands settled during the Ceramic Age, from 400 BC up to contact (Giovas and Fitzpatrick 2014, 576; Jazwa et al. 2016; Kennett et al. 2006). Traditional models for the colonization of the Caribbean during this period state that settlers used the Lesser Antilles as a stepping-stone archipelago, gradually moving up the islands from the coast of South America (Keegan and Hofman 2017; Rouse 1992). Thus, it is expected to find the oldest sites in the southern Lesser Antilles, while the most recent sites are expected to be found in the Greater Antilles and the Bahamas. However, as increased radiocarbon dating showed that Ceramic Age peoples had settled Puerto Rico and the Leeward Islands significantly earlier that the Windward Islands, the stepping-stone model has gradually lost ground (Hanna 2018; Napolitano et al. 2019). Evidence for other proposed routes of migration have begun to emerge. The southward route hypothesis proposes that settlers, most likely Ceramic Age peoples, travelled directly from mainland South America to Puerto Rico, where they began to colonize other islands (Fitzpatrick 2013; Fitzpatrick et al. 2010, 166). This has been supported by seafaring simulations conducted by Callaghan (2001; 2017) based on wind conditions, currents, seafaring technologies and launching points. These seafaring simulations reinforce the anomaly that Archaic Age peoples settled islands directly beside Jamaica for thousands of years despite seemingly never travelling to Jamaica itself. The IFD can offer insights into processes of migration into a region, particularly as it relates to proposed routes.

Giovas and Fitzpatrick (2014) used the IFD to examine possible migration routes and interactions between waves of Ceramic age settlers and Archaic Age peoples. They showed that habitat quality, as measured by net primary productivity correlated with settlement sequence, albeit with Jamaica appearing as an anomaly in the progression. They suggested that the ideal despotic distribution (IDD), a variant of the IFD in which competition between individuals over habitats and resource selection occurs, may have more success in predicting interactions between new settlers and current inhabitants. Under the IDD, individuals might not have been able to settle in the most ideal locations as they were restricted from doing so by pre-existing populations (Giovas and Fitzpatrick 2014, 582; Kennett 2005, 35). Based on this model, Giovas and Fitzpatrick (2014) argue that certain migration routes may have been restricted, either by original Ceramic Age settlers or previous Archaic Age populations (Hanna and Giovas 2019, 12). This can potentially be seen in gateways between certain islands, such as between the Leeward and Windward Islands (Dominica Passage) and between Puerto Rico and Hispaniola (Mona Passage), which both show evidence of long pauses before further migration into the area by Ceramic age peoples (Keegan and Hofman 2017; Giovas and Fitzpatrick 2014; Keegan 2006). Given its successful application elsewhere, the IFD could be applied to other questions of human migration in the Caribbean to advance understanding, including the absence of Archaic Age sites in Jamaica.

Studies of the IFD can vary in spatial scale depending on the environment under consideration. Emigration to the next best habitat might not entail movement to an entirely different island, but rather another part of the same island (Giovas and Fitzpatrick 2014, 581). Studies using the IFD have been applied to create predictive models of settlement sequences of individual islands or island groupings rather than the entire Caribbean. Hanna (2018) developed a predictive model, based in the IFD, to locate and identify areas of high probability for settlement on the island of Grenada. While the model was validated by existing data, field survey identified several sites and concluded that Pre-Columbian settlement of Grenada generally agreed with an IFD model (Hanna 2018, 3). Hanna's model was successful in (re)locating sites due to the specificity and detail of the environmental variables used in his model. He was able to achieve this high resolution as the environmental variables used were not speculative but rather derived from characteristics of known archaeological sites from both Archaic and Ceramic Age sites in Grenada. The environmental variables used in this thesis are assumed to hold predictive power based on what archaeologists know about the Archaic Age sites among Greater Antilles islands.

By using the IFD in this research I create a testable framework to survey for Archaic Age sites and upon which future research can build. I use the IFD to predict where Archaic Age peoples may have first settled by attempting to identify environments with the highest habitat quality, as valued by these settlers. Furthermore, I use the IFD to attempt to ground truth the environmental variables (reefs, fresh water, beach access and soil quality) argued to be important to Archaic Age peoples. I argue that Archaic sites closer in proximity to these environmental variables should be the oldest sites, while those further away should be younger. Ground truthing of the IFD is discussed further in Chapters 5 and 6.

2.3. Complications

By using a behavioural ecological model, this research is subject to the criticisms of HBE. Perhaps the most significant of these criticisms is the fact that behavioural ecological models rely heavily on assumptions of behaviour and that these behaviours remain the same through time (Prentiss 2019, 217). Often these assumptions are warranted; for example, the assumption that all humans need food and water. However, assumptions of specific resource use or the value placed on different variables may be difficult to maintain. Despite this issue, I choose to use the IFD as the specific benefits of a hypothetico-deductive method (such as quantitative testing and replicability) are well suited for studying the Archaic Age settlement of Jamaica.

2.4. Conclusion

Archaeology in the Caribbean has largely been understood through a culture history lens (Keegan and Hofman 2017; Rouse 1992). While these models continue to provide structure and insight into archaeological research in the Caribbean, behavioural models, such as the IFD, present testable hypotheses that can build on the foundation of these culture histories. Rather than rely solely on culture history models to investigate the absence of Archaic Age sites in Jamaica I ground this research in the IFD to take advantage of the testable and reproducible nature of HBE studies. In the following chapter I discuss the Caribbean environmental and archaeological contexts as they relate to my research.

Chapter 3.

Caribbean Environment and Pre-Columbian History

Understanding the Pre-Columbian timeline of the Caribbean along with proposed migration routes and settlement patterns is central to grasping Jamaica's historical position within the region. Humans have been traversing the Caribbean region for up to 7000 years (Hofman and Antzcak 2019). Archaeologists have accepted that humans did not settle Jamaica – among the most ecologically diverse islands in the Caribbean (Atkinson 2006) – until *c.* AD 500. Recent chronometric hygiene and Bayesian modelling shows that neighbouring islands in the Greater Antilles were settled much earlier: Cuba (145 km away) *c.* 5400 BC; and Hispaniola (190 km away) *c.* 4500 BC (Napolitano et al. 2019). The absence of sites pre-dating AD 500 on Jamaica appears anomalous when compared to the general settlement pattern for the Caribbean. In this chapter, I discuss settlement of the Caribbean islands, the history of the region and proposed explanations for the absence of pre-Ceramic Age sites in Jamaica.

3.1. Caribbean Climate and Geography

The Caribbean has a tropical climate with fluctuating wet and dry periods and is heavily influenced by the northeast trade winds (Newsom and Wing 2004, 14). Significant differences in topography and position among the islands create high levels of variability in weather; for example, low-relief islands, such as the Turks and Caicos Islands, receive much less rain (533 mm annual average) than islands with large mountain peaks, such as Jamaica (2082 mm annually) (Newsom and Wing 2004, 13). The region lies in the North Atlantic hurricane belt and is subject to tropical cyclones, particularly between July and October (Keegan and Hofman 2017). Geologically, most of the Caribbean islands are volcanic in origin, with secondary limestone formations making up much of the current land masses, except for the Bahama Archipelago which is primarily limestone (Lee 2006).

3.1.1. Jamaican Environment

At 11,264 km^2, Jamaica is the third largest island of the Greater Antilles. Geologically, Jamaica has a volcanic foundation, although the vast majority of its bedrock is limestone (Robinson 1997; Lee 2006). The earliest deposits on the island are Cretaceous (165 mya to 65 mya) and are made up of volcanic submarine rock seen mainly in the Blue Mountains to the east (Robinson 1997). These rocks were covered by a top layer of limestone during the early and later Tertiary period (65 mya to 2.6 mya) (Robinson 1997). Soils found in hillier areas are usually red to brown weathered clays while plains and interior lowlands are usually brown cracking clays, alluvial soils and loamy soils (FAO 1994). The interior of the island is mountainous; the highest point is Blue Mountain peak at 2256 m, while to the centre and west, the Dry Harbour Mountains and the Cockpit Country cover much of the interior at heights of up to 670 m (Morrissey 1989). Jamaica's coast creates a continuous area of lowlands, with large coastal plains up to several kilometres in width along the south coast (Lee 2006, 92). These coastal alluvial plains, such as Pedro Plains, Clarendon Plains, and George's Plains, make up most of the area covered in this research (Morrissey 1989).

Jamaica (shown in Figure 2) has a maritime tropical climate, with trade winds coming from the northeast. The Blue Mountains create a large rain shadow over the southern coast (Allsworth-Jones 2008, 39; Morrissey 1989). Areas north of the Blue Mountains can receive over 6300 mm of rainfall annually, while much of the south coast of the island experiences less than 1000 mm annually (Morrissey 1989). Along the southwest coast the environment consists of mostly semi-arid or dry limestone scrub forests with intermittent coastal mangrove forests.

Figure 2: **Map of Jamaica (Encylopaedia Britannica Inc. 2000, Ferguson et al.)**

The bathymetric history of the region is important to consider as rising sea levels have potentially inundated early sites or migration routes. Jamaica's bathymetry (see Figure 3) follows a trend similar to the terrestrial landscape, with a steep gradient along much of the north coast of the island and a very gradual one on the south (Mclaughlin and Morrissey 2004). Jamaica lies at the farthest extent of the Nicaraguan Rise, a submerged topographic shelf extending from Central America (Robinson 1997, 111). To the north of the island is the Cayman Trough, the deepest part of the Caribbean, with a depth of 7200 m and a sharp drop off of 500 m around 1 km offshore (Donnelly 1997; NOAA 2020; Robinson 1997). The southwest coast of the island is part of the relatively shallow Nicaraguan Rise (maximum depth 1219 m), while farther south and east is the much deeper Columbian Basin (maximum depth 4379 m) (NOAA 2020; Robinson 1997). More locally, the coastal shelf south of the island is known as the South Coast Shelf with shallow depths of up to 25 m extending over 12 km offshore (NOAA 2020; Robinson 1997). The shallow waters along Jamaica's south coast coupled with sea level rise over time as discussed later in section 3.3.1 indicate the potential for there to be submerged Archaic Age sites on the island.

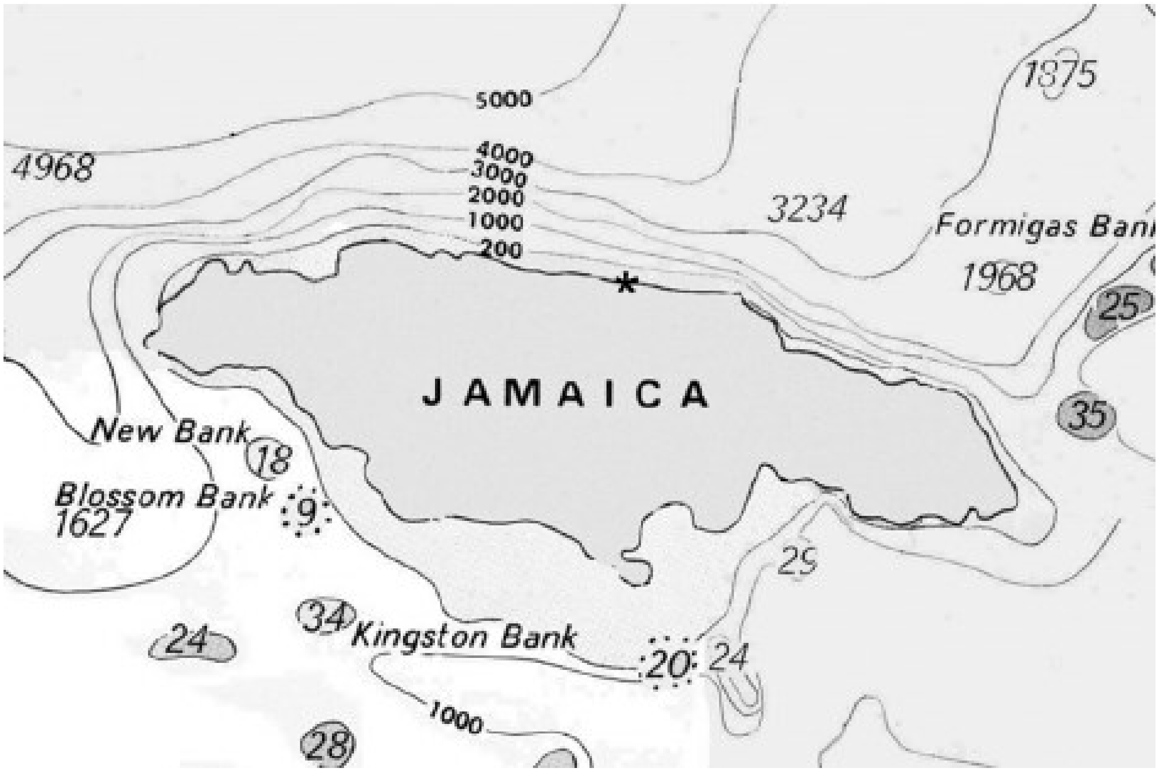

Figure 3: Bathymetic Map of Jamaica (McLaughlin and Morrissey 2005)

Jamaica also has complex ecosystems and high levels of biodiversity (Armstrong 2020; Lee 2006, 94). Known as the 'Land of Wood and Water', the island also possesses an abundance of rivers and endemic flora and fauna (Lee 2006). There are over 200 bird species found in Jamaica, many of which are seasonal visitors (Lee 2006;95). At least 29 endemic species of bird are found on the island (Haynes-Sutton et al. 2009; Lee 2006). Mammals found on Jamaica are relatively few. A species of giant guinea pig (*Clidomys osborni*) once inhabited the island but went extinct prior to human colonization (Fincham 1997). A highly endangered species of coney or hutia (*Geocapromys brownii*) is also found on the island and was once a large part of the pre-Columbian diet (Allsworth-Jones 2008, 49). Several species of snakes are found on the island as well as an endemic iguana (*Cyclura collei*) (Lee 2006). Marine biodiversity is also significant, with over 600 species of fish and mollusc found in Jamaican waters, along with four sea turtle species (Lee 2006). Jamaica also possesses more than 3000 species of flowering plant found on the islands about 30% of which are endemic (Armstrong 2020; Lee 2006). Many wild plants and cultigens were introduced by pre-Columbian peoples, including cassava (*Manihot esculenta*), sweet potato, (*Ipomoea batatas*) and yam (*Discorea trifida*), among others (Rashford 1993). Thus, resource richness or diversity with respect to human exploitation was likely not a limiting factor in the human colonization of Jamaica.

3.2. Caribbean Pre-Columbian History

3.2.1. Cultural Historical Framework

An understanding of the different ways that Caribbean archaeology has been discussed and classified over time is important for appreciating the irregularity that Jamaica represents in Caribbean settlement history as well as understanding the region's culture history. Caribbean archaeology has been and continues to be heavily influenced by culture history models of chronology and systematics, with the names and relationships ascribed to the culture historical units and material culture of the Caribbean varying over time (Wilson 2007, 19). Below, I review the relevant cultural historical framework and terminology, and discuss their application in this research.

Pre-Columbian Caribbean history has traditionally been classified into three ages, the Lithic (6500 BC to 2000 BC), Archaic (4000 BC to AD 500) and the Ceramic (400 BC to European contact) (Rouse 1992). Some scholars (Keegan and Hofman 2017; Hofman and Antczak 2019) group the Lithic and Archaic together, and for the purposes of this research, I will do the same since Lithic sites are infrequent and both periods share similar settlement patterns. These ages will be discussed more fully in section 3.3. The three ages are based on the material culture and lifeways of peoples settling the region at certain times and they overlap with one another.

These three ages, along with the work and classification system of Irving Rouse (1960; 1992) (see Chapter 2), remain the most enduring example of culture history models in the Caribbean. Rouse (1982, 10) used a phylogenetic approach to create a system of series and subseries to organize material cultures in space and time, adding the suffix -*oid* to denote a series (e.g., Casimiroid) and the suffix -*an* for a subseries (e.g., Casimiran). Rouse's system is largely based on pottery forms and designs in the case of the Ceramic Age, or stone and shell toolkits for the Lithic and Archaic Ages. Each of the three ages is associated with one or more techno-economic traditions. For example, the Lithic Age is usually associated with the Casimiroid tradition; the Archaic with the Ortoiroid and the Ceramic with the Saladoid and Ostionoid (Rouse 1992). This classification system has been increasingly criticized by Caribbean archaeologists (Bérard 2019; Curet 2004; Keegan and Hofman 2017; Keegan 2001; Wilson 2007), with one of the main arguments being that these essentialized units of classification obscure spatial and temporal variation and that this phylogenetic approach does not allow for cultural fusion. Curet (2004, 197) argues that while Rouse's system remains useful for regional chronology and comparison, more localized units of classification would be more appropriate for more specific or smaller scale studies. Despite this, Rouse's system of classification remains widely used throughout Caribbean archaeology.

An important consideration is that the names for both the culture history traditions and the three-age system represent material cultures and lifeways. The people associated with these cultures have been assigned ethnonyms that are separate from the terms ascribed to their material culture. The term 'pre-ceramic' has often been used to label cultures that fall before the Ceramic Age. However, it is becoming apparent that Archaic Age peoples used pottery to varying degrees based on the archaeological recovery of pottery at several Archaic Age sites throughout the Caribbean (Rodríguez Ramos et al. 2008). The debate over the use of pottery in the Archaic Age may lead to confusion or misidentification of Archaic Age sites as Ceramic Age sites (Keegan and Hofman 2017). The use of the term 'Archaic' also comes with connotations of primitiveness (Hofman and Antzcak 2019, 31). Furthermore, amalgamating a period that exhibited apparent cultural change over time under one name presents the same problem of homogenizing the past as Rouse's culture history model (Hofman and Antzcak 2019).

Despite these criticisms it is necessary to specify that the focus of this research is a material culture previously unseen in Jamaica. Thus, throughout this project, I use the term Archaic for all potential Pre-Columbian settlements of Jamaica that are not classified as part of the Ceramic age. The exception is below, where I review each of the three ages in more detail to give a clearer overview of the region's Pre-Columbian history.

3.2.2. The Lithic Age (6500 BC to 2000 BC)

Archaeologists generally agree Lithic Age colonists originated from the Isthmo-Colombian area and began moving into the Caribbean *c.* 5000 BC (Keegan and Hofman

2017; Keegan 2000; Napolitano et al. 2019; Roksandic 2016; Wilson 2007). The earliest Lithic Age dates on Hispaniola come from the Vignier III site (*ca.* 4500 BC), while the earliest site found on Cuba is the Levisa site (*c*. 3200 BC) (Keegan and Hofman 2017, 25). Rouse (1992, 56) suggests that these peoples could have travelled along the Mid-Caribbean Islands, an intermittent chain of islands stretching from Nicaragua to Jamaica. However, without evidence of a Lithic Age settlement in Jamaica, this proposed route has gained little acceptance. Some Cuban archaeologists have argued that the microlith technology found at Lithic Age sites in Cuba is like that found in Florida and the southeastern United states (Keegan and Hofman 2017, 25). However, this suggestion is problematic because the remaining material culture of the two areas is significantly different (Keegan and Hofman 2017).

The defining feature of Lithic Age sites is the presence of flaked-stone tools used as knives and scrapers and the absence of ground-stone tools and pottery (Sajo 2014; Wilson 2007, 33). There are very few known Lithic Age assemblages, and those that are known are largely workshop sites that do not show the entirety of cultural activities (Keegan and Hofman 2017, 28). Examples of workshop sites are Seboruco and Levisa on Cuba, which date to around 4190 BC, and Casimira (the Casimiroid type site assigned by Rouse) and Berrera-Mordan in the Dominican Republic, which date to around 2400 BC (Sajo 2014). Lithic Age peoples are thought to have been nomadic and to have exploited both inland and coastal resources but not engaged in agricultural activities (Keegan and Hofman 2017; Sajo 2014).

3.2.3. The Archaic Age (5000 BC to AD 400)

The most accepted Archaic Age migration routes originate in the Orinoco Delta of Venezuela with migration into the Caribbean through the Lesser Antilles beginning around 4000 BC (Fitzpatrick 2015; Roksandic 2015). A proposed alternative route for Archaic Age colonization involves migrants travelling directly from South or Central America to Puerto Rico (Callaghan 2001; Keegan and Hofman 2017). Richard Callaghan (2001) developed a series of seafaring simulations that showed this route is feasible and easier than navigating through the Lesser Antilles due to favourable ocean currents in that direction. Furthermore, apart from the Banwari Trace and St. John (both *c.* 5000 BC) sites on Trinidad and the Heywoods site on Barbados dating to around 2500 BC, there is limited evidence for Archaic Age sites in the Windward Islands (Fitzpatrick 2015; Fitzpatrick 2011; Keegan and Hofman 2017; Wilson 2007).

Archaic Age settlers are often described as marine oriented, and their settlement patterns and assemblages show this (Rouse 1992, 66; Keegan and Hofman 2017; Wilson 2007). The majority of their sites are located along the coast, although there are exceptions, with some Archaic Age sites on Cuba and Hispaniola found inland (Keegan and Hofman 2017; Rouse 1992). Archaic Age sites are usually defined by the presence of ground-stone tools, such as celts and grinders, the lack of pottery and little evidence of agricultural activity (Rouse 1992). However, it is becoming increasingly clear that Archaic Age populations were engaging in pottery making and agriculture long before Early Ceramic Age (Saladoid) settlers arrived in the region (Keegan 2006), as indicated by sites with evidence of pottery use such as the Cayo Jorajuria site (*c.* 2100 BC) on Cuba and the El Caimito site (*c*. 400 BC) on Hispaniola (Fitzpatrick 2006; Rodríguez Ramos et al. 2008, 50). Archaeologists have tried to explain this departure from the expected lack of ceramics in several ways. For example, Cuban archaeologists argue that these Archaic Age sites containing pottery represent a 'proto-agricultural' phase of beginning farming in the region (Keegan 2006).

The level of variation among Archaic Age assemblages is heightened by the wide distribution of sites and the relatively small pottery sherds present (Keegan 2006). Generally, Archaic Age pottery vessels were tempered with sand, had coarse finishes, and were decorated with red, white or black slip (Keegan 2006; Rodríguez Ramos et al. 2008). Decorative finishes on Archaic Age pottery including incisions and punctations were also seen in some cases (Keegan 2006; Rodríguez Ramos et al. 2008). Other Archaic Age artifacts include bone projectile points and barbs and shell tools (Reid and Curet 2009, 16; Rouse 1992).

3.2.4. The Ceramic Age (800 BC to AD 1500)

The Ceramic Age is usually divided into the Early Ceramic Age (400 BC – AD 400) and Late Ceramic Age (AD 400 – AD 1500) (Keegan and Hofman 2017; Keegan 2000). The former begins with initial entry of people originating from the Orinoco Basin in South America. The route of entry is debated, but the most widely accepted hypothesis is that migrants used the Lesser Antilles as a series of stepping-stones, gradually moving north through the islands until they reached Puerto Rico. Here, they seemed to pause for almost 1000 years before entering the rest of the Greater Antilles after AD 600 (Keegan 2010, 17). This long pause is attributed to the presence of Archaic Age populations that prevented further expansion into the region (Rouse 1992, 90). Current research, including radiometric dating, is beginning to refute the stepping-stone model. The earliest Ceramic Age sites are found in Puerto Rico and the northern Lesser Antilles, suggesting that these settlers bypassed the southern islands and instead moved gradually south after settling in the northern Caribbean (Fitzpatrick, et al. 2010; Napolitano et al. 2019; Reid and Curet 2009; Wilson 2007). Known as the Saladoid, based on the ceramic type site of Saladero in Venezuela, these people are characterized by their finely-grained tempers and decorated ceramics (Wilson 2007, 61).

Saladoid pottery styles consist of red, white-on-red and black paint with distinct zone-incised-crosshatchings (ZIC) (Fitzpatrick et al. 2010; Reid and Curet 2009, 18; Rouse 1992). Saladoid peoples practiced agriculture, hunting, and fishing (Reid and Curet 2009). They are also thought to have been an egalitarian society, based on burials and size-rank characteristics of settlements (Reid and Curet 2009, 21). There is significant evidence for cultural variation among different Saladoid groups as they developed in the Caribbean (Reid and Curet 2009, 28).

Between AD 600 and AD 900 significant cultural changes occurred in the Greater Antilles, representing the onset of the Late Ceramic Age (Keegan and Hofman 2017, 83). Archaeologically, this is represented by a dramatic change in pottery styles and further expansion of Ceramic Age peoples into Hispaniola (AD 600), Cuba (AD 600), Jamaica (AD 650) and the Lucayan Archipelago (AD 900) (Keegan and Hofman 2017; Wilson 2007). Several distinct pottery styles developed in this period, such as the Ostionan Ostionoid, which appeared in the eastern Dominican Republic around AD 600 (Keegan and Hofman 2017). The Ostionan tradition appears to represent the first settlement of Jamaica and is also found along the south coast of Cuba (Rouse 1992, 96). The Meillacoid tradition first appears around AD 800 and is found in most of modern-day Haiti and widely throughout Jamaica by AD 900 (Allsworth-Jones 2008; Rouse 1992).

3.3. Pre-Columbian History of Jamaica

Jamaican archaeology is often considered less studied and less interesting when compared to the wider Caribbean region (Atkinson 2014; Howard 1956; Rampersad 2009). However, this is not accurate as Jamaica has a lengthy history of investigation, although the results of these investigations have circulated mainly within the country and not beyond (Atkinson 2006; Allsworth-Jones 2008; Keegan and Hofman 2017, 187). Antiquarian interest in Jamaica's Pre-Columbian history began as early as the early 17th century and continued until the early 20th century, when more scientific work began (Atkinson 2014; Duerden 1895). The first systematic field work by a trained archaeologist was by Robert Howard, whose 1947 – 1948 dissertation research categorized Jamaica material culture using Rouse's classification system (Howard 1950). Canadian geologist James Lee became the principal surveyor and recorder of archaeological materials between the 1960s and 1980s (Atkinson 2014; Allsworth-Jones 2008). Lee created his own grid and mapping system and set out to record all known archaeological sites on the island, recording a total of 280 cave, midden and, occasionally, petroglyph sites (see Figure 4) (Allsworth-Jones 2008, 75). As of 2006 there are 357 known Pre-Columbian archaeological sites found on Jamaica (Richards 2006).

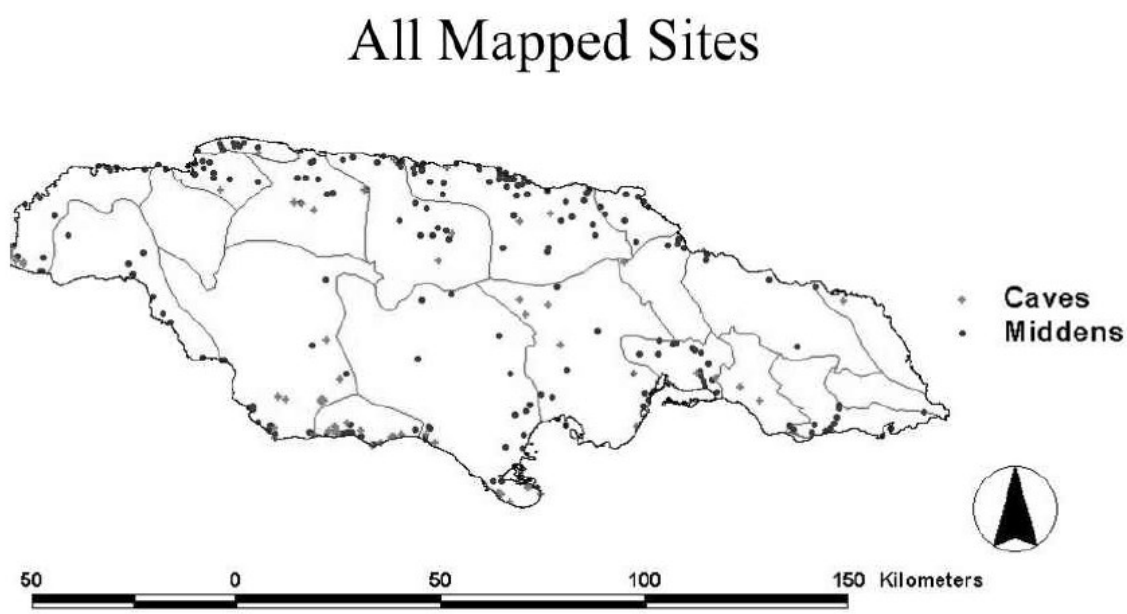

Figure 4: Mapped archaeological sites of Jamaica. (Sites mapped by James W. Lee as per Allsworth-Jones 2008).

There are two types of archaeological sites distinguished in Jamaica: Redware sites and Meillacoid sites. Currently, the earliest sites are Redware (or the Ostionian Ostionoid pottery style), with the earliest associated dates indicating settlement beginning around AD 650 (Keegan and Hofman 2017). The type site for Redware culture is the Little River site excavated in 1933 (Allsworth-Jones 2008). There are 21 known Redware sites on the island (Rampersad 2009; Allsworth-Jones and Knisely-Marpole 2011). The name Redware comes from the pottery's reddish colour. Redware is simply decorated with zoomorphic figures and usually has fine-grained tempers, without filleted rims or large handles as seen later (Atkinson 2014, 202; Lee 2006, 155).

Settlement patterns and pottery styles are what distinguish Redware sites from the later Taíno sites found on the island. With a few exceptions, Redware sites are located on the North and South coast at the high-water mark, beside a sandy beach and with a shallow midden (Allsworth-Jones 2008, 86; Lee 2006). Due to their coastal location, these sites have been adversely affected by wave action and modern coastal settlement to the point where many are destroyed, including the Little River type site (Allsworth-Jones 2008; Rampersad 2009; Richards 2006). This pattern of coastal settlement is particularly interesting since it is similar to Archaic Age sites on other islands in the region (Keegan 2019; Rampersad 2009). However, Redware assemblages contain significant amounts of pottery and other items relating to agricultural uses. Keegan (2019) has argued that Redware people represent Archaic Age colonists that had already adopted the use of pottery and agriculture before arriving in Jamaica.

Another settlement wave occurred around AD 900 when Meillacoid style pottery associated with Taíno peoples appears on the island (Allsworth-Jones 2008; Atkinson 2006). The Taíno inhabited the Greater Antilles and the Lucayan Archipelago at the time of European contact (Rouse 1992). Rouse (1992) further classified Taíno into two main regional groups that he argued were culturally distinguishable. The Classic Taíno, found on Hispaniola and Puerto Rico, emerged around AD 900, while the Western Taíno, found on Jamaica, Cuba, and the Lucayan Archipelago, emerged around AD 1200 (Rouse 1992, 107). It is important to note that the Meillacoid style is distinct from the Chicoid pottery associated with the Classic Taíno in Hispaniola and the Virgin Islands. Also, there is no conclusive evidence that existing Redware peoples interacted with or were assimilated by the incoming people with Meillacoid pottery styles (Rampersad 2009).

Meillacoid pottery is found widely throughout the island, with the vast majority (82%) of known sites attributed to this style (Allsworth-Jones 2008, 86). Meillacoid pottery-making communities settled both along the coast and inland, but hilltop settlements were common (Allsworth-Jones 2008). Roughly 40% of Meillacoid sites are located between 200 m and 400 m in elevation and have an overall average elevation of 172 m (Allsworth-Jones 2008, 80). They are also located an average of 5 km from the coast (Allsworth-Jones 2008, 80). Among the Meillacoid materials found on the island, there are two primary styles; the more widespread White Marl style, dating to around AD 900, and the Montego Bay style, which appears later around AD 1180 (Atkinson 2006). Meillacoid sites are found in two geographic parts of the island. The White Marl style is found predominately along the central north coast, with many sites also located on the southeast side of the island. The Montego Bay style sites are located primarily on the northwest side of the island (Allsworth-Jones 2008, 80).

3.3.1. On the Absence of Archaic Settlement of Jamaica

Three forms of explanation have been proposed for the apparent absence of Archaic Age settlement in Jamaica: 1) Archaic Age peoples did not settle on the island; 2) evidence of such a settlement has yet to be found; or 3) the evidence has been destroyed or submerged.

The most common argument is that Archaic Age people did not settle Jamaica. For example, as noted above, Callaghan (2008) has suggested that rough seas along the north coast of the island prevented Archaic Age settlers from landing on the island with seafaring technologies of the period. While marine conditions along the North coast of the island are often quite rough, I note that there are frequent, if irregular, periods of calm when voyages would have been possible (personal observation). While I cannot attest to the conditions of the entire distance between Jamaica and Cuba or Hispaniola, these calm conditions can last for several days. Callaghan's (2008, 63) computer simulations, with rough seas accounted for, suggest that canoe travel from Cuba or Hispaniola to Jamaica only takes one to two days at a comfortable pace of 2.0 knots. Furthermore, when rough seas are excluded from Callaghan's (2008) computer simulations, the results show that journeying between Cuba or Hispaniola and Jamaica would have been relatively easy based on modern wind and current patterns. Reconstructions of previous climatic conditions show that while there has been some variation during the Holocene, conditions have been relatively similar to today since approximately 2000 BC (Hodell et al. 1991, 192).

Another argument made to suggest people did not reach the island is that Jamaica is not in the viewscape of any other island. Because Jamaica is one of the few islands in the region that cannot be seen from any other island, Torres and Rodríguez Ramos (2008) suggest people were unaware of its presence until relatively late in Pre-Columbian history. This argument could be correct, but there is no way to test it.

It has been suggested that evidence for Archaic occupation simply has not been uncovered yet. Howard (1965) stated that he expected Archaic Age sites would be discovered in Jamaica with increased archaeological scrutiny. Keegan (2019) notes, however, that subsequent archaeological surveys done by Lee and George Lechler in an effort to locate Archaic Age sites have been unsuccessful. The details of these surveys are unknown as researchers have been unable to locate field notes or published reports. Despite significant archaeological work, mostly aimed at Redware or Taíno contexts, systematic survey data for archaeological sites are scarce. Several other authors have argued that there needs to be more methodical scrutiny of the island for earlier sites (Howard 1965; Keegan 2019; Rampersad 2009).

A final explanation is that evidence of earlier settlements in Jamaica has been erased in some way. Many archaeologists have suggested that sea level rise following the Archaic Age period may have obscured sites along the coast (Callaghan 2008; Keegan 2019). Khan et al. (2017, 31) argue that around 5000 BC, sea levels around Jamaica were -4.4 ± 0.3 m below current levels. Between 3000 – 2000 BC levels rise to -1.7 ± 0.3 m below current levels and slowly reach today's sea level around AD 1000 (Khan et al. 2017). While the change in sea level over this period is not drastic compared to the rise seen in the Pacific northwest coast for example (Mackie et al. 2018), settlements immediately on the coast would be submerged today particularly along Jamaica's south coast where the bathymetry is very shallow (Robinson 1997). Furthermore, Jamaica has been subject to significant coastal development throughout its colonial and modern history (Rampersad 2009; Richards 2006). It is highly possible that evidence of Archaic Age settlements has been destroyed by this development.

3.4. Discussion of Environmental Variables Used in Predictive Model

Relevant to the model developed in this research, archaeological investigations show that Archaic sites tended to be located near rich marine resources, sandy beaches and access to perennial fresh water (Keegan and Hofman 2017; Rouse 1992). These three environmental variables (coastal location, sandy beaches, fresh water) form the basis of the predictive model created in this research. Although, some Archaic Age sites are found further inland, particularly in Puerto Rico and Cuba (Rouse 1992; Ulloa Hung and Rojas 2019), archaeologists generally agree Archaic Age peoples were mainly marine foragers who relied heavily on molluscs (Keegan 1994; Keegan and Hofman 2017; Rouse 1992).

Archaic Age sites are largely found in close proximity to the coast (Hackenberger et al. 2021; Keegan and Hofman 2017; Kelly and Hofman 2019; Rouse 1992). For example, of the 33 Archaic Age sites in Aruba, 30 of them are located within 1-2 km of the coast (Kelly and Hofman 2019, 149). Similarly, in Antigua, of the approximately 45 known Archaic Age sites (as of Davis 2000 in Cherry and Ryzewski (2019), 41 of them are located along the coast. Again, this trend continues in Hispaniola and Cuba with the majority of sites being found along the coast (Ulloa Hung and Rojas 2019).

Archaic Age sites are also often located near a sandy beach, reinforcing the impression of a strong littoral and marine focused lifestyle (Hanna 2018; Rouse 1992). While not used in Caribbean focused modelling, sandy beaches have previously been used successfully as a variable in ideal free distribution studies (Jazwa et al. 2016). Jazwa et al. (2016) found that sandy beaches in the California Channel Islands served as important canoe haul-outs for the largely marine-focuses peoples there. Archaic Age peoples likely found sandy beaches useful for the same purpose, especially as there is evidence of over-water interaction and trade among islands during this period; for example, the trade in Long Island (Antigua) flint among the Lesser Antilles (Gijn 1993; Keegan and Hofman 2017, 76).

Archaic Age reliance on the coast and marine resources is also represented on the faunal assemblages found at these sites. For example, at the Archaic site of Maruca (2890 – 1945 BC) in southern Puerto Rico, marine species made up 83% of the faunal material recovered (Wilson 2007, 55). In Aruba, the majority of Archaic Age sites are coastal shell middens consisting of oysters and other bivalves (Kelly and Hofman 2019, 148). Heavy reliance on marine subsistence strategies is also seen in Archaic Age skeletons whose stable carbon and nitrogen isotope ratios suggest a diet largely made up of species from coral reefs and sea grass habitats (Keegan and Hofman 2017, 43). Fresh water resources were also exploited regularly by Archaic Age peoples. The Krum Bay site (1000 BC) in the Virgin Island, for instance, has a predominately freshwater and inshore marine faunal assemblage (Wilson 2007, 55).

Fresh water is a universal human necessity. Several arid smaller islands in the Caribbean have a history of efficient water management, such as Curaçao, Carriacou and Long Island, Bahamas (Schultz 1995). However, Jamaica is rich with perennial fresh water, limiting the need for strategic water management solutions (Atkinson 2006; Richards 2006). Because of this, proximity to rivers is included as a key environmental variable in the model.

Additionally, I consider soil quality as variable for Archaic Age settlement. As stated previously, there is significant evidence that Archaic Age peoples practiced agriculture to some degree (Pagan-Jimenez et al. 2019; Hofman and Antzcak 2019; Fitzpatrick 2018). For example, Pagan-Jimenez et al. (2019, 90) argue that there is evidence of domesticated plants, such as maize (*Zea mays*), sweet potato (*Ipomoea batatas*) and wild yam (*Dioscorea villosa*), as early as 5500 BC at the site of St. John in Trinidad. Thus, to account for the possibility of Archaic Age domestication or cultivation in Jamaica, the suitability of soil for agriculture will be considered in the predictive model. This discussion of the environmental variables identified above provide ample reason to suggest these variables represent good predictors of habitat quality for Archaic Age peoples.

The final environmental variable that I consider in this research is modern coastal development. Jamaica has been subject to intensive coastal development throughout the 20th and 21st centuries, particularly along the north coast of the island (Richards 2006). Significant destruction of archaeological sites and cultural heritage is common. While archaeological sites have been located in urban areas, such as the Saladoid-period Main Street site in St. Thomas, intact sites are much more likely to be discovered away from centres of development (Keegan et al. 2018). This does not mean that archaeologists should not look for sites in developed areas but rather, for the purpose of creating and refining this model, it makes more sense to focus on areas with little modern disturbance. Thus, in order to build a practical and usable predictive model of Archaic sites I have included heavily developed areas as a negative factor.

3.5. Conclusion

Encompassing more than 7000 years, Pre-Columbian time-space systematics are strikingly complex. Archaic Age peoples have long been defined based on their subsistence patterns, particularly their reliance on marine resource and low occurrence of *protoagricola* (early forms of pottery use and agricultural practice) (Keegan 1994). This rigid definition does not allow for the study of the interaction between Archaic age peoples and Ceramic age peoples who were moving into the region while the former still occupied much of the Caribbean (Keegan 2019). It is clear is that there are significant gaps in research efforts among the islands, topics and time periods within Caribbean archaeology, particularly in the case of Jamaica. Archaeologists have been calling for increased scrutiny into Jamaica's Pre-Columbian past to fill in gaps in our understanding of when the island was settled and by whom (Atkinson 2006; Howard 1965; Keegan 2019; Rampersad 2009). The absence of Archaic Age settlements in Jamaica is one such gap. In this chapter I provided an overview of Caribbean culture history in relation to Jamaica and discuss current arguments made for this absence. The explanations given for the lack of Archaic Age sites in Jamaica are flawed and it is possible evidence of an Archaic Age settlement of the island remains to be found. In this research I select environmental variables related to Archaic Age settlement patterns and socio-economic lifeways and build a predictive model for Archaic Age sites in Jamaica. The next chapter discusses the methods I use to create the predictive model of Archaic Age sites on Jamaica's southwest coast.

Chapter 4.

Methods

This thesis develops a foundation for the systematic survey of the southwest coast of the Caribbean island of Jamaica by creating a predictive model of Archaic Age sites in this region. As discussed in Chapter 2, I utilized the ideal free distribution to predict areas with a high probability of Archaic settlement. Here, I discuss the focus area of this research and lay out the environmental variables for Jamaica that are used to create the GIS model and how these variables were processed and analyzed. I also discuss the limitations of the data used, choices made when producing the model and note amendments made in response to preliminary results.

4.1. Focus Area and Origin of Archaic Age Settlers

As noted above, I chose the southwest coast as the most likely region for surviving Archaic Age material culture because of the much lower level of development along this side of the island's coast. Furthermore, I argue that the southwest coast of Jamaica represents the part of the islands that Archaic Age peoples would most likely have settled. The ability of this type of model to account for where people may have first landed is limited.

While the model highlighted the largely habitable areas of the southern coast of Jamaica, the model does not provide insights about how or where Archaic Age peoples first arrived on the island. Discussions of where Archaic Age peoples might have first arrived on the island are scant among Caribbean archaeologists. Most academics who have commented on this question (Callaghan 2008; Torres and Rodríguez Ramos 2008) suggest Archaic Age peoples would likely have first arrived in Jamaica from Cuba or Hispaniola, making the north and northeast coast of Jamaica the most probable region of landfall. Callaghan (2001) also notes that passage to the Greater Antilles from Central or South America was viable based on seafaring simulations. Also, Wilson et al. (1998) suggest that the now submerged Nicaraguan Rise may have been a potential migration route for Lithic or Archaic settlers into the Caribbean, making the south coast of Jamaica a prime landing area. Rather than be constrained by speculations on original landfalls, I selected the area for field survey that is most likely to contain possible surviving Archaic sites.

4.2. Jamaican Predictive Model Variables

Based on current research on first settler migrations (Napolitano et al. 2019; Rodríguez Ramos et al. 2008; Roksandic 2016; Torres and Rodríguez Ramos 2008), I selected and ranked four variables for measuring the suitability of a habitat on Jamaica's southern coast using the IFD: 1) access to perennial fresh water; 2) proximity to fringing reef structures; 3) access to a sandy beach; and 4) soil richness. In addition to these four variables, I also took into consideration the high level of modern coastal development that Jamaica has experienced up to present. These four variables follow from discussion in Chapter 2, where I identified environmental factors frequently associated with Caribbean Archaic Age sites that likely reflect underlying habitat quality preferences of Archaic peoples.

As a preliminary first step I conducted a Spearman's rank order correlation test on Archaic sites found on Haiti and Puerto Rico using ArcMap 10.7.1 to assess the types of environments Archaic Age peoples chose to settle in and test the suitability of certain variables for measuring habitat quality in the Jamaican predictive model. This test was done to look for a correlation between Archaic Age site proximity to reefs, sandy beaches and perennial fresh water sources and site age with the theory that older sites would be located closer to these resources (data in Appendix). Meaningful results were not able to be gained from this testing due to the quality of the available environmental variables and site location data. Many sites lacked the specific coordinate data that would allow proximity to environmental variables to be measured. A significant number of the sites that did have specific coordinate data relied on legacy dates that did not meet chronometric hygiene standards (data in Appendix) (Fitzpatrick 2006; Napolitano et al. 2019). In the future, a larger dataset with better chronometric hygiene and more accurate site location coordinates would allow for more robust statistical testing of the selected environmental variables and the ideal free distribution model.

In addition, elevation data for Jamaica were originally incorporated into the predictive GIS model. Rather than improve the precision of the model, however, the inclusion of elevation data did not impact the model. When added to the model, inland areas of low elevation worked against the coastal variables (beaches and reefs) to lower precision of hotspots throughout the modelled area. Based on these preliminary findings, I decided not to include elevation data in the predictive model for Jamaica.

The four above environmental variables chosen for Jamaica, while general in nature, provide a basis for establishing the predictive model that can be later refined through ground-truthing of more specific variables such as seagrass beds, turtle nesting habitats and wetlands etc. Therefore, I use these four variables, access to fresh water, proximity to a coral reef, access to a sandy beach and soil quality, to inform the IFD model for predicting the location of Archaic sites in Jamaica. I discuss the data for these variables, and their sources, below.

4.2.1. Access to Fresh Water

Freshwater data for Jamaica were obtained through the World Wildlife Fund's HydroSHEDS (Lehner et al. 2008; Lehner and Grill 2013). These data are a shapefile of polyline data representing rivers and streams found throughout the island, shown in Figure 3. The freshwater data were derived from a high-resolution elevation model recorded during NASA's Shuttle Radar Topography Mission (SRTM) (Lehner et al. 2008). Data were recorded at 15 arc-second spatial resolution, and rivers or streams were defined as having a catchment area exceeding 10 km^2 (Lehner et al. 2008). Lehner et al. (2008) explain that streams smaller than this were increasingly unreliable in their spatial representation when using the data collection methods applied here.

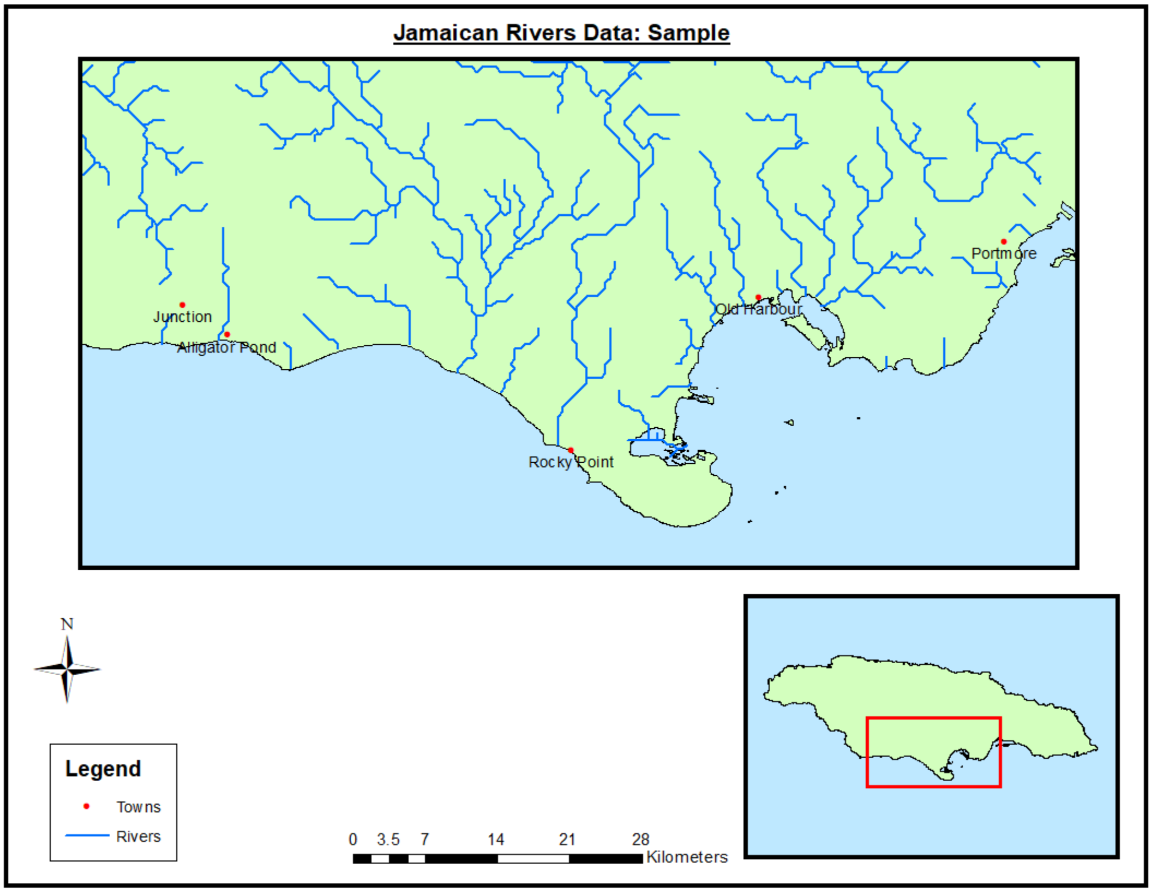

Figure 5: **Sample of shapefile of perennial rivers on Jamaica's southwest coast. (Scale bar relates to top map)**

4.2.2. Proximity to Fringing Coral Reef

Reef data were obtained through the Nature Conservancy Caribbean Marine Maps (Schill et al. 2021) and consist of raster data representing the different types of reef structures, including fore reef (the reef portion facing the sea), back reef (reef facing land), and reef crest (between fore and back reef). The data also include coral and algae deposits that represent reef die offs on the expectation that these deposits would have been healthy benthic habitats during the period being scrutinized (Schill et al. 2021). The Jamaican data largely consist of fringing reefs, meaning reefs that are directly adjacent to the shore or close to the shore and separated by a section of more shallow water. Because most of the reefs were classified as fringing reefs, the productivity of these reefs was treated as equal. These data were created using 4 m resolution imagery from the PlanetScope Dove Classic SmallSat constellation (Schill et al. 2021). This imagery was then processed using object-based analysis of benthic habitat in up to 30 m water depth (Schill et al. 2021). These data are currently the most up to date publicly accessible benthic habitat data.

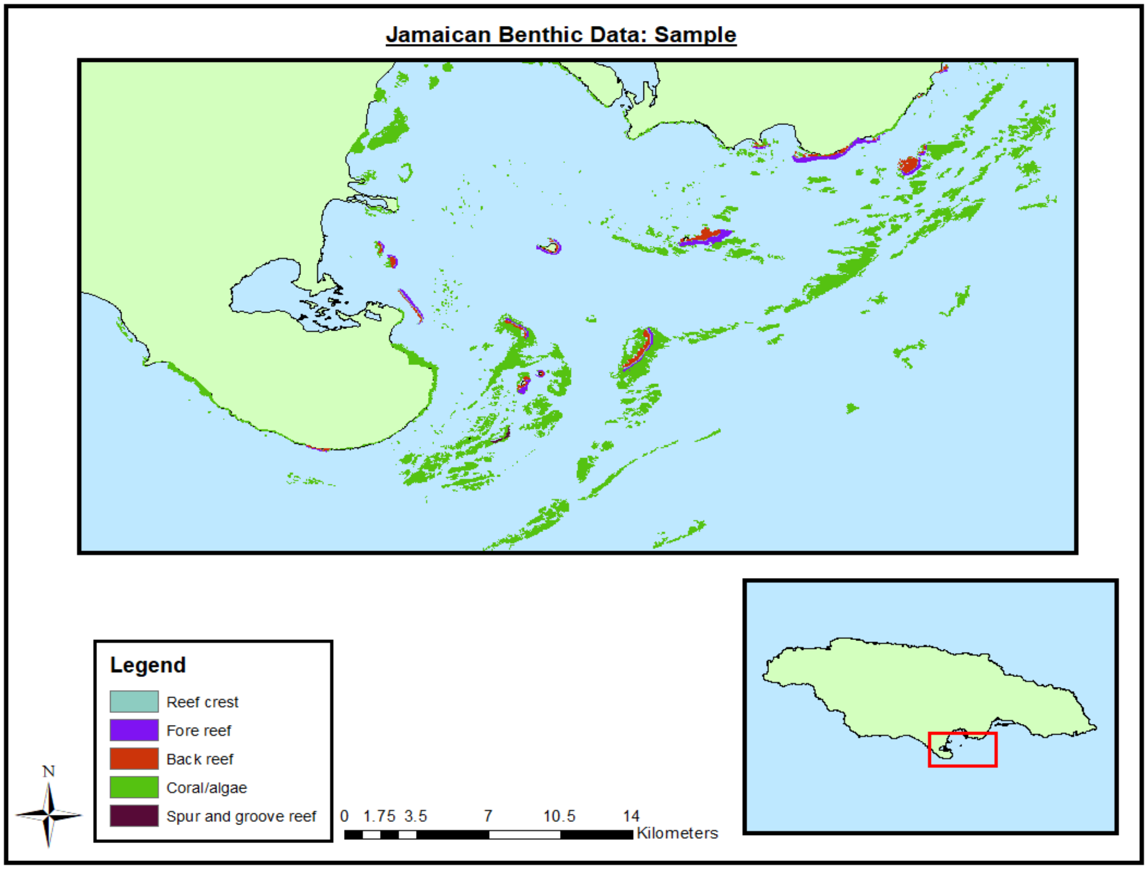

Figure 6: Sample of benthic habitat data used in predictive model. (Scale bar relates to top map)

4.2.3. Access to Sandy Beach

Beach data were created by using satellite imagery in ArcMAP to create a shapefile of sandy beaches in the region. The shapefile consists of vector data representing the area of each individual sandy beach. These data correspond accurately to modern beach locations. However, a limitation of this variable is that in highly developed areas sandy beaches have been heavily damaged or obscured. This presents a complication for the study model as the coastline in the past was likely different from the coastline of today due to sea level rise and coastal erosion. The solution to this problem requires significant bathymetric modeling and coastal survey and thus was not pursued for this project.

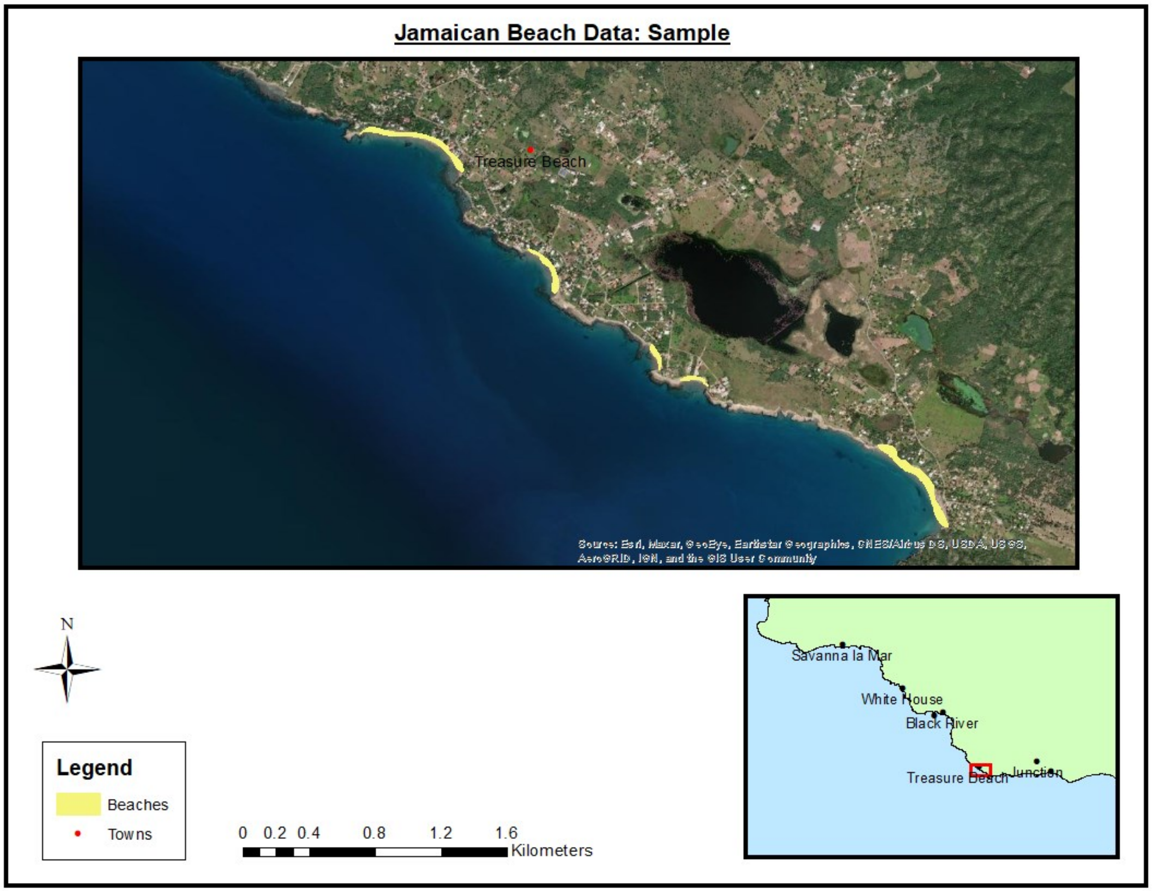

Figure 7: Sample of south coast beach data. (Scale bar relates to top map)

4.2.4. Soil Quality

Soil richness was evaluated by determining which soil type presented the best suitability for the selection of crops that Archaic Age settlers might have cultivated or managed based on current research, such as cassava (*Manihot esculenta*), and yam (*Discorea trifida*) (Rashford 1993). Soil type data was obtained from open-source soil texture data found on arcgis.com. The data consist of a shapefile containing a texture map of soil types found throughout Jamaica.

4.2.5. Disturbance from Development

Modern coastal development must be taken into consideration for this model to be practical when applied to ground truth possible Archaic archaeological sites. I apply this variable to the model after identifying high potential areas based on the previous environmental variables. Development is one of the main destroyers of archaeological sites, and it would be a waste of both time and money to prioritize areas that have been significantly damaged by modern activities before assessing areas that have not been subject to modern development. The entire Jamaican coast is highly developed by both residential and urban areas (Richards 2006). The southwest coast is less developed than most other areas, such as the north coast, but its coastal development is significant, and several Redware sites have already been destroyed by construction or agriculture (Rampersad 2009; Richard 2006). Development data was obtained through OpenStreetMaps and consists of a shapefile of individual buildings (OpenStreetMaps contributors 2017).

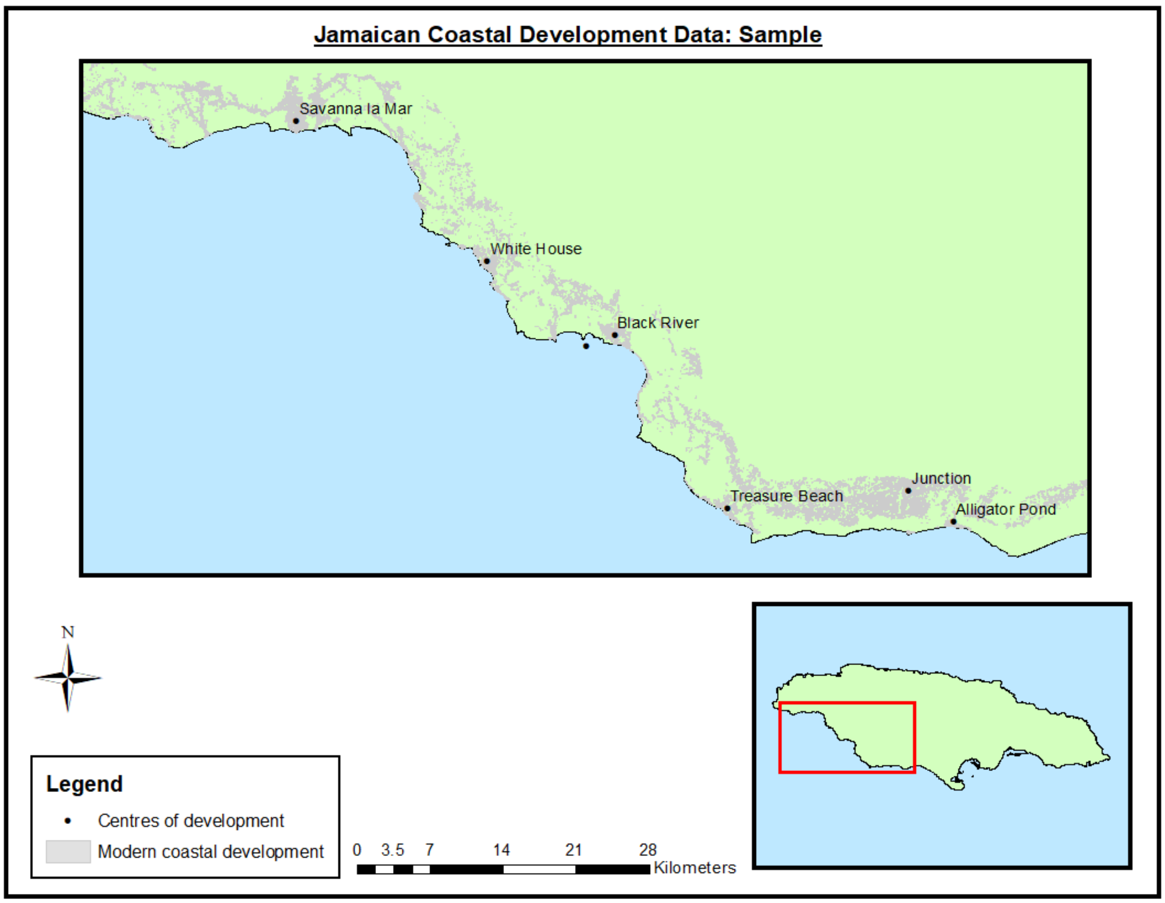

Figure 8: Sample area of modern southwest coastal development data. (Scale bar relates to top map)

4.3. GIS Model Based in the IFD

I used ArcMap 10.7.1 to view, compile and analyze the data sets listed above. First the data were clipped to the section of the south-west coast that is the focus of this thesis. The reef raster data were converted to vector data and the unwanted values (seagrass, muddy bottom, sand and boulders) were removed leaving only the coral reef data. This was done largely to highlight reef structures since combining those values with reef structures would account for most of the near coastal area. Multi-ring buffers were added around river, beach, and reef features. River and beach data were both buffered by 500 m, 1500 m, 3000 m and 6000 m rings. Reef data was buffered first at 1000 m to account for the distance between the coast and the reef, and then by 2000 m, 3000 m and 6000 m rings. These buffered vector data were then clipped using a boundary vector of the entire island to eliminate data overlay with the sea.

A field called *Index* was assigned to each of the newly buffered vector data sets. *Values* were assigned to each of the different buffered rings, with the smallest distance given a value of 1.0 and subsequent rings valued at 0.75, 0.5. and 0.25. These buffered and valued data sets were then converted to raster data with the Index value as the designated value field. A cell size of 50 m was chosen as a middle point between realistic computer processing time and model applicability. Finally, the raster calculator tool was used to combine the rasterized data.

To incorporate the disturbance from land development into the model, the building shapefile was buffered by 20 m to account for disturbance surrounding the building. These data were then overlayed on the combined environmental variable raster. This was done to clearly show both habitat quality prior to modern development and current levels of development at the same time. These data were then rasterized and assigned a value of 1.0. Using the raster calculator, this dataset was subtracted from combined river, beaches and reefs data to represent a negative impact on the model. Additionally, the buffered building data set was removed entirely from the beaches, rivers and reef data, thus highlighting areas that have remained largely undisturbed by modern human development.

Soil richness data were incorporated by assigning an Index value to the desired soil types, as discussed in the Chapter 3. Loam soil was assigned a value of 1.0, clay loam a value of 0.75 and stony loam a value of 0.5. Jamaican soils are largely clay based, with pockets of varying amounts of organic material (FOA 1994). Soils with balanced sand and silt content and slightly less clay content, or loams, are usually the best soils to facilitate plant growth (FOA 1994). These data were then overlayed onto the combined beaches, rivers and reefs data and areas of high habitat quality. Areas that already had a high density of the other geospatial variables and were also in close proximity to the chosen soil types were additionally assigned the soil type's value. Thus, areas that do not fall directly within a highly valued soil type were assigned that soil's value if that soil type was found nearby.

By combining all variables using ArcMAP, areas can be identified that are in close proximity to all environmental variables (representing high-quality habitat) and remain undeveloped. These areas are defined as hotspots, meaning they have the highest likelihood of containing undisturbed Archaic Age sites.

4.4. Focus Area and Origin of Archaic Age Settlers

While the model highlighted the largely habitable areas of the southern coast of Jamaica, the model does not provide insights about how or where Archaic Age peoples first arrived on the island. As discussed above, I chose the southwest coast as the most likely region for surviving Archaic Age material culture because of the much lower level of development along this side of the island's coast. Furthermore, I argue that the southwest coast of Jamaica represents the part of the islands that Archaic Age peoples would most likely have settled. The ability of this type of model to account for where people may have first landed is limited.

Discussions of where Archaic Age peoples might have first arrived on the island are scant among Caribbean archaeologists. Most academics who have commented on this question (Callaghan 2008; Torres and Rodríguez Ramos 2008) suggest Archaic Age peoples would likely have first arrived in Jamaica from Cuba or Hispaniola, making the north and northeast coast of Jamaica the most probable region of landfall. Callaghan (2001) also notes that passage to the Greater Antilles from Central or South America was viable based on seafaring simulations. Rather than be constrained by speculations on original landfalls, I selected the area for field survey that is most likely to contain possible surviving Archaic sites.

4.5. Limitations

Perhaps the most notable limitation of the approached used here is the assumption that current environmental variables used in the GIS model reflect the same conditions as *c.* 4000 years ago. Environmental change is most likely to affect sandy beach data since in highly developed areas sandy beaches have been heavily damaged or obscured in the recent past (Rampersad 2009). Modern coastline data also do not reflect past conditions since, as noted in Chapter 2, sea levels have risen approximately +1.7 ± 0.3 m over the past 4000 years (Callaghan 2013; Khan et al. 2017). Rising sea levels coupled with coastal erosion mean it is likely that the coastline in the past was somewhat different from the coastline of today (Rampersad 2009; Atkinson 2006). There are two implications of this for the model. The first is that land that was previously above water is now submerged and would require bathymetric modeling to be fully represented in this project. The second is that the beach data used might not accurately reflect past conditions and thus this aspect of the model could be distorted.

Similarly, coral reefs were significantly more abundant and healthier during Pre-Columbian history and before 1983 when a die-off of the urchin *Diadema antillarum* which, along with bleaching events and disease outbreaks, led to a significant collapse of Caribbean coral reefs (Mumby et al. 2006). However, as mentioned above, the data used in this model include algae deposits that account for these die-off areas, and it is unlikely that reef structures have changed significantly in location in the past 4000 years (Schill et al. 2021). Reef habitats grow at the rate of 6.6± 12.5 mm per year on the reef crest and up to 3.1± 10.2 mm per year on the outer reef (Kench et al. 2022). These extremely slow growth rates mean reefs can take up to 10,000 years or longer to develop and often develop on top of or in close proximity to existing reef structures. Research on environmental changes of rivers and soil quality for Jamaica is inaccessible or not in existence.

The chosen variables for habitat suitability are based on Archaic Age site settlement patterns (Hofman and Antzcak 2019; Keegan and Hofman 2017; Rouse 1992). However, by limiting the model to four variables (not including modern development) there is the possibility of essentializing the choices people might have made. These variables represent my selection of both the most likely features to have influenced settlement locations based on current archaeological evidence, combined with variables which are easily quantified and evaluated among the Greater Antilles. In doing so, I might be assigning too much importance to some variables while underestimating or disregarding other potential factors.

On the other hand, including several more environmental variables risks imposing too many assumptions about the choices that possible Archaic Age settlers to Jamaica made and could result in an overly-restrictive predictive model that misses areas of high-suitability locations, thus reducing its practical use. Archaic Age settlement patterns are too varied to create a highly specific, realistic predictive model. Limiting the model to the above five variables thus allows for the creation of a simpler initial model based on the most likely predictive variables, which may be subsequently refined as needed.

The number of variables used in the predictive model must be considered in terms of scientific model trade-offs where a model cannot simultaneously maximize generality, realism and precision (Levins 1966; De Langhe 2019). Generality refers to how widely applicable a model may be, for example over a range of species or time periods. Realism refers to the products of scientific theories and models being counted as ‘real’ in the physical world. Precision is how targeted or specific a model or theory is. Thus, to improve precision, generality and realism must suffer and vice versa (Levins 1966: De Langhe 2019). In order to create a usable predictive model, a balance of trade offs must be made. In the case of the present research, by limiting the amount of variables I incorporate into the GIS model, I improve precision and practicality at the cost of realism.

A Spearman’s rank order correlation test was attempted on Archaic sites found on Haiti and Puerto Rico using ArcMap 10.7.1 to assess the types of environments Archaic Age peoples chose to settle in and test the suitability of certain variables for measuring habitat quality in the Jamaican predictive model. This test was done to look for a correlation between Archaic Age site proximity to reefs, sandy beaches and perennial fresh water sources and site age with the theory that older sites would be located closer to these resources (data in Appendix). Meaningful results were not able to be gained from this testing due to the quality of the available environmental variables and site location data. Many sites lacked the specific coordinate data that would allow proximity to environmental variables to be measured. A significant number of the sites that did have specific coordinate data relied on legacy dates that did not meet chronometric hygiene standards (data in Appendix) (Fitzpatrick 2006; Napolitano et al. 2019). In the future, a larger dataset with better chronometric hygiene and more accurate site location coordinates would allow for more robust statistical testing of the selected environmental variables and the ideal free distribution model.

Additionally, elevation data for Jamaica were originally incorporated into the predictive GIS model. Rather than improve the precision of the model, however, the inclusion of elevation data did not impact the model. When added to the model, inland areas of low elevation worked against the coastal variables (beaches and reefs) to lower precision of hotspots throughout the modelled area. Based on these preliminary findings, I decided not to include elevation data in the predictive model for Jamaica.

4.6. Conclusion

This thesis develops a predictive model based in the IFD to create a framework for the systematic survey for Archaic Age sites. This chapter outlines which data were used in this thesis and where they were sourced. The Jamaican environmental data were processed, buffered and assigned values based on the buffered distances. These buffers were then combined to produce a predictive model for the southwest coast. Modern development data, also buffered to an extent, were overlaid on the combined environmental variable values to identify areas of high potential. In the next chapter I provide the results of the predictive model.

Chapter 5.

Results

In this chapter, I provide results from the predictive GIS model based in the ideal free distribution (IFD) and discuss how each variable influenced the model and which areas along the southwest coast of Jamaica represent the most suitable habitats where Archaic Age peoples might have settled. I examine the impact of modern development on these potentially suitable habitats and focus on the inclusion of modern development in this predictive model as that iteration represents the most practical tool for field survey.

5.1. Predictive GIS Model of Potential Archaic Settlements for Jamaica

The predictive GIS model shows significant areas of high density of the variables (HDV) throughout the southwest coast of Jamaica, particularly when modern development is excluded from the model. HDV areas represent locations where habitat quality is high and where Archaic Age sites, if present in Jamaica, have a higher possibility of being discovered. HDVs are areas that achieved a score of three or greater as per the raster calculator discussed in Chapter 4, with the exception of one hotspot area which scored a two, detailed below. Importantly, HDVs do not consider modern development as a variable. On the other hand, hotspots are areas of HDV that are found in locations where modern development is not significant and represent the best chance of locating Archaic sites.

Seventeen hotspots in total were recorded (Figure 9), of which twelve have a value of 3 and five have a value of 4, meaning the latter were positively influenced by the soil quality in the surrounding area, i.e., the value of the area, as assigned by the predictive model, is increased by being in closer proximity to desirable soils. Areas situated in mangrove or swampy locations are excluded from the hotspots, regardless of the presence of HDVs, due to the practical difficulties of pedestrian survey in these locations. It may be possible to assess these areas through subsurface coring. Section 5.1.1 briefly discusses the results of the predictive model without modern development being considered as a variable while section 5.2 provides the results of the predictive model with modern development incorporated as a model variable.

5.1.1. Predictive Model Without Modern Development Included as a Variable

When modern development is not included in the GIS model, the south coast of the island is a largely habitable region. Fresh water is abundant along the southwest coast of the island, and with a few exceptions, there are rivers frequently and consistently along the coast (Figure 5). Exceptions include the areas east of Rocky Point, in between Treasure Beach and Alligator Pond, and at the far west area of the island towards Negril. Notably, the most significant rivers coincide with the areas of high-density development, such as Black River, Savanna-la-Mar and Old Harbour.

Beaches are also found regularly along the south coast of the island, although there are several large areas of rocky coastline, such as around much of Portland Ridge (east of Rocky Point) and on the west side of Jamaica towards Negril (Figure 9). These sections of rocky coast also coincided with areas lacking rivers.

Fringing reefs occur along much of the southwest coast. However, there is a section of limited reef structure between Treasure Beach and Rocky Point that is divided by significant fringing reefs south of Alligator Pond (Figure 12). The largest reefs are south of Savanna-la-Mar, Black River and Old Harbour.

The inclusion of soil fertility proved impactful in two areas along the southwest coast. Large deposits of clay loam surrounding Treasure Beach and east towards Alligator Pond improved the density of variables in these areas (Figure 12). However, as that area also coincides with sections of limited benthic resources, the impact of these areas of high soil quality on the model was not as pronounced as it would have been otherwise. Not surprisingly, areas with the highest density of variables and in close proximity to the most significant benthic resources and fresh water sources correspond directly with the largest modern settlements in this region: Savanna-la-Mar, Black River and Old Harbour. White House, Alligator Pond and Rocky Point also represent significant modern settlements that show high habitat quality.

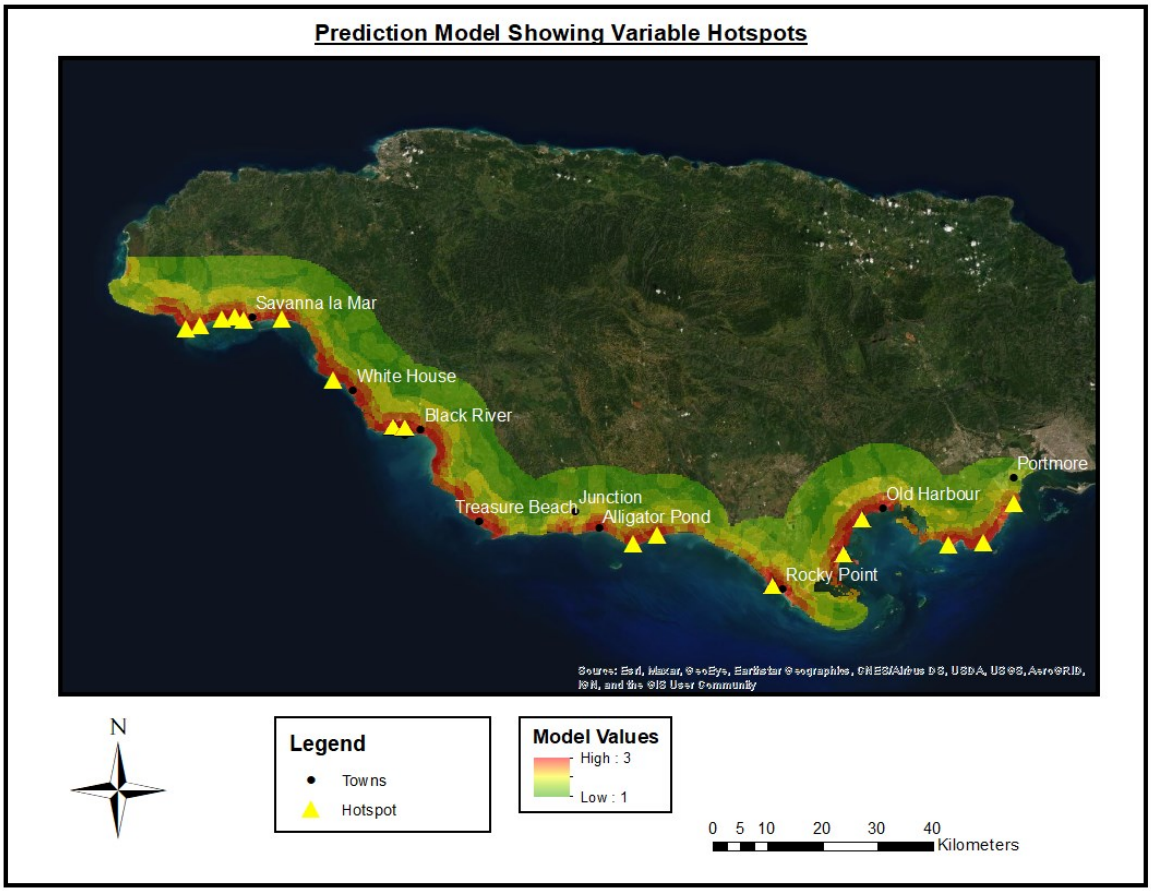

Figure 9: Map of predictive model showing hotspots.

5.2. Inclusion of Modern Development as a Variable in the Predictive Model

The model changes drastically when modern development is taken into consideration. There are several significant present-day settlements along the southwest coast, particularly Savanna-la-Mar, Black River and Old Harbour, which, as stated above, would have represented the most suitable habitats for Archaic settlement prior to modern development (Figure 9). Several other smaller settlements and linear coastal development cover much of the southwest coastline. However, there are seventeen hotspots between Old Harbour and Portmore in the east (Manatee Bay). There are groupings of hotspots to the right of Alligator Pond and in the area around Gut River, on the outskirts of Black River to the west (east of Longacre and south of Sandy Ground) and on either side along the coast near Savanna-la-Mar. I divided these hotspot areas into five subsections starting from west to east: western hotspots, southwestern hotspots, central hotspots, central eastern hotspots and eastern hotspots. Below, I discuss each in detail.

Table 1: Hotspot information.

Hotspot #	Hotspot Ranking	Variable Value	Locations	Latitude	Longitude	Region
H1	3	3	0.5 km southeast of Salmon Point	18.19751244	-78.24134608	Western
H2	4	3	1.5 km west southwest of Old Hope Wharf	18.20293761	-78.21864603	Western
H3	5	3	3.5 km east northeast of Old Hope Wharf	18.21450179	-78.18334672	Western
H4	6	3	1.6 km south of Big Bridge	18.21774976	-78.16082512	Western
H5	7	3	2 km southwest of Savanna-la-Mar	18.21239597	-78.14808311	Western
H6	1	3	1.5km south southwest of Paradise	18.21482302	-78.08426596	Western
H7	2	3	4.5 km northwest of White House	18.11389735	-78.00039032	Southwestern
H8	13	4	1 km southeast of Crawford	18.03782446	-77.90198871	Southwestern
H9	14	4	3 km west of Black River	18.03559597	-77.88266445	Southwestern
H10	8	3	3 km south of Marley Hill	17.84604344	-77.51016865	Central
H11	9	3	0.5 km west of Gut River	17.85996329	-77.47055062	Central
H12	10	4	3 km west of Rocky Point	17.77890218	-77.28131105	Central Eastern
H13	11	4	1.7 km east of Salt River	17.82938464	-77.16462154	Central Eastern
H14	12	4	800 m southwest of Port Esquivel	17.88740565	-77.13489325	Central Eastern
H15	15	3	10 km southwest of Hellshire	17.84390193	-76.9947774	Eastern
H16	16	3	9 km southwest of Hellshire	17.84889880	-76.93659957	Eastern
H17	17	2	1 km northeast of Hellshire	17.91207349	-76.88734473	Eastern

5.2.1. Western Hotspots

As seen in Table 5.2, there are six hotspots (H1 to H6) designated for the far western end of the southwest coast (Figure 10). This section of coast features several rivers, a large fringing coral reef and long connected sandy beaches. It also features one of the south coast's largest towns, Savanna-la-Mar. Despite the proximity to Savanna-la-Mar, the coastline on either side of the town has the highest density of hotspots in the study region.

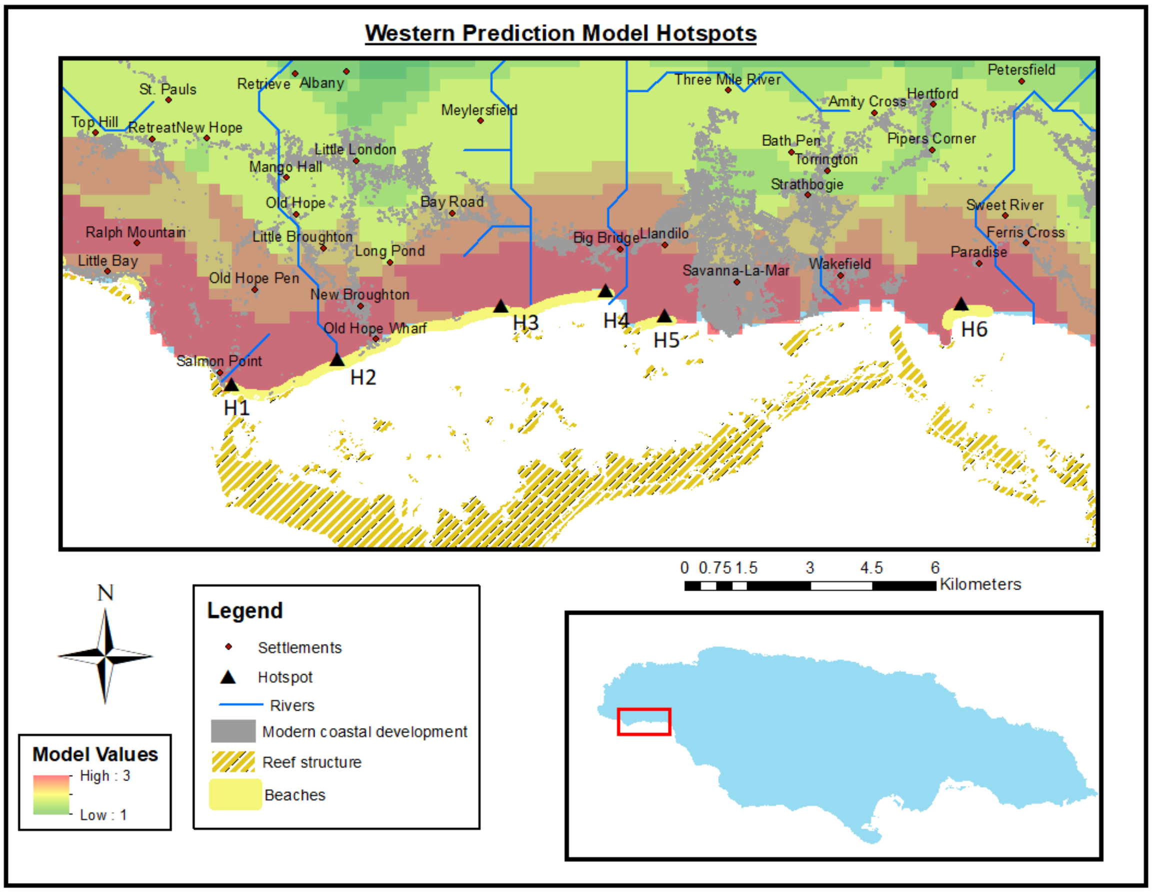

Figure 10: **Western prediction model hotspot locations. (Scale bar relates to top map)**

5.2.2. Southwestern Hotspots

There are three hotspots in the southwestern section of the coast (Figure 11). Moving west to east along the southwestern coast. H7 is located near of Auchindown, H8 is situated near Crawford and H8 is found further east of Crawford. Whitehouse is the largest modern settlement in this area and smaller settlements are consistently found along the coast of the southwestern region. There are several rivers emptying into the sea in this section. Coral reefs are plentiful along this region with a large fringing reef found in the bay south of Crawford.

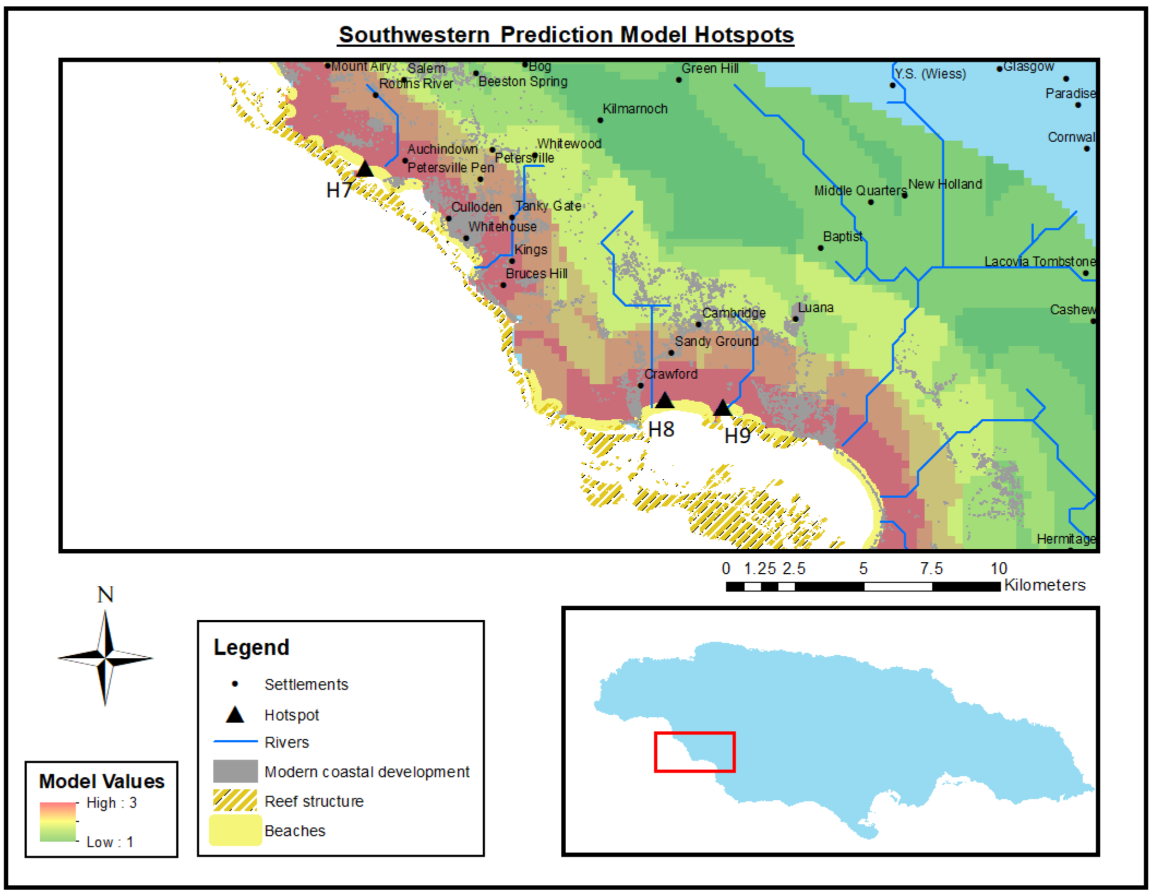

Figure 11: Southwestern prediction model hotspot locations. (Scale bar relates to top map)

5.2.3. Central Hotspots

The central southwest coast has the fewest hotspots due to the lack of coral reefs, except for the small fringing reef off the coast of Hull. Two hotspots occur along the central section of the coast: H10 and H11 (Figure 12). The central section of the south coast is also relatively lightly settled today, perhaps because of the lack of sheltering fringing reefs here with the exception of Alligator Pond which is one of the larger towns along the southwest coast.

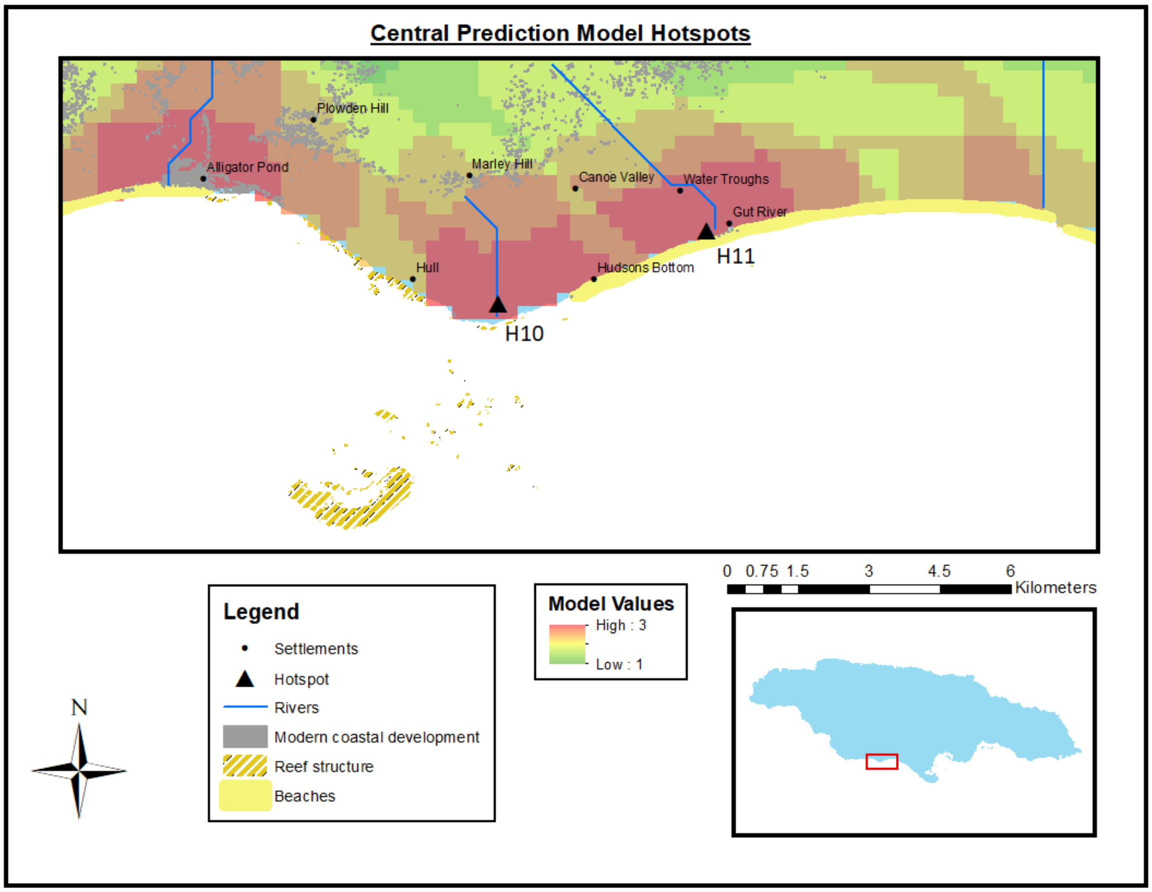

Figure 12 **Central prediction model hotspot locations. (Scale bar relates to top map).**

5.2.4. Central Eastern Hotspots

The central eastern section of the southwest coast contains three hotspots all with a value of four (H12, H13 and H14) due to the presence of loamy soils nearby (Figure 13). Known as Portland Bight, the central eastern section of the coast features rich fringing reefs along the coast and at the mouth of the bay. Much of this area makes up the Portland Bight Protected Area, which is Jamaica's largest protected area. Directly south of Portland Cottage, significant marshy wetlands and mangroves occur (out of frame. See Figure 4); these were excluded from the final model for being unfit for human settlement.

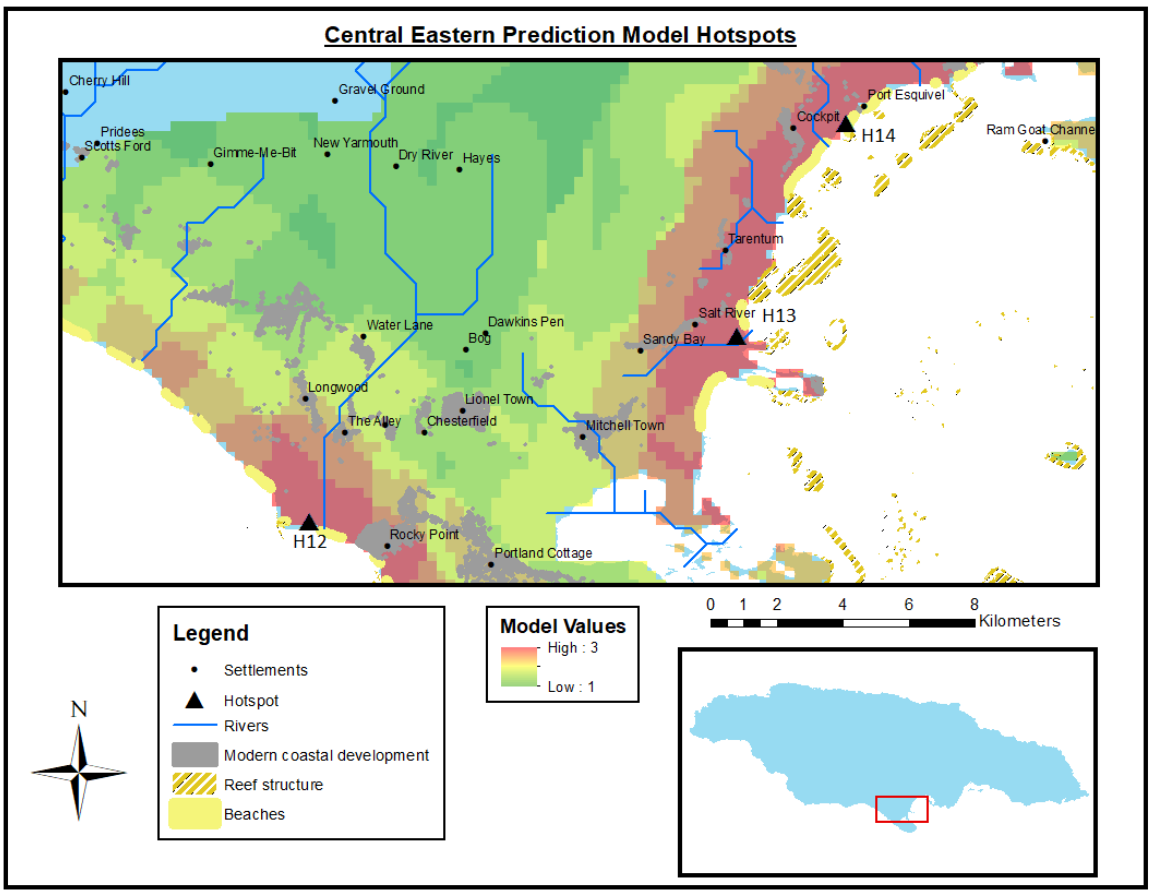

Figure 13: **Central eastern prediction model locations. (Scale bar relates to top map)**

5.2.6. Eastern Hotspots

This eastern section of the study region has three hotspot locations: H15, H16 and H17 (Figure 14). This area, particularly the significant fringing coral reef found off the coast, is also partially included in the Portland Bight Protected Area. Rivers are limited along this section of the coast. Hotspot 17 is the only one with a value of 2 as it is not in close proximity to a sandy beach. While the area of Hotspot 17 is undeveloped much of the surrounding area is highly industrialized, and it is quite likely that a sandy beach was found along this area in the past. Based on this and the fact that H17 is found near a significant river with excellent coral reef resources nearby, I have included it in the list of hotspots.

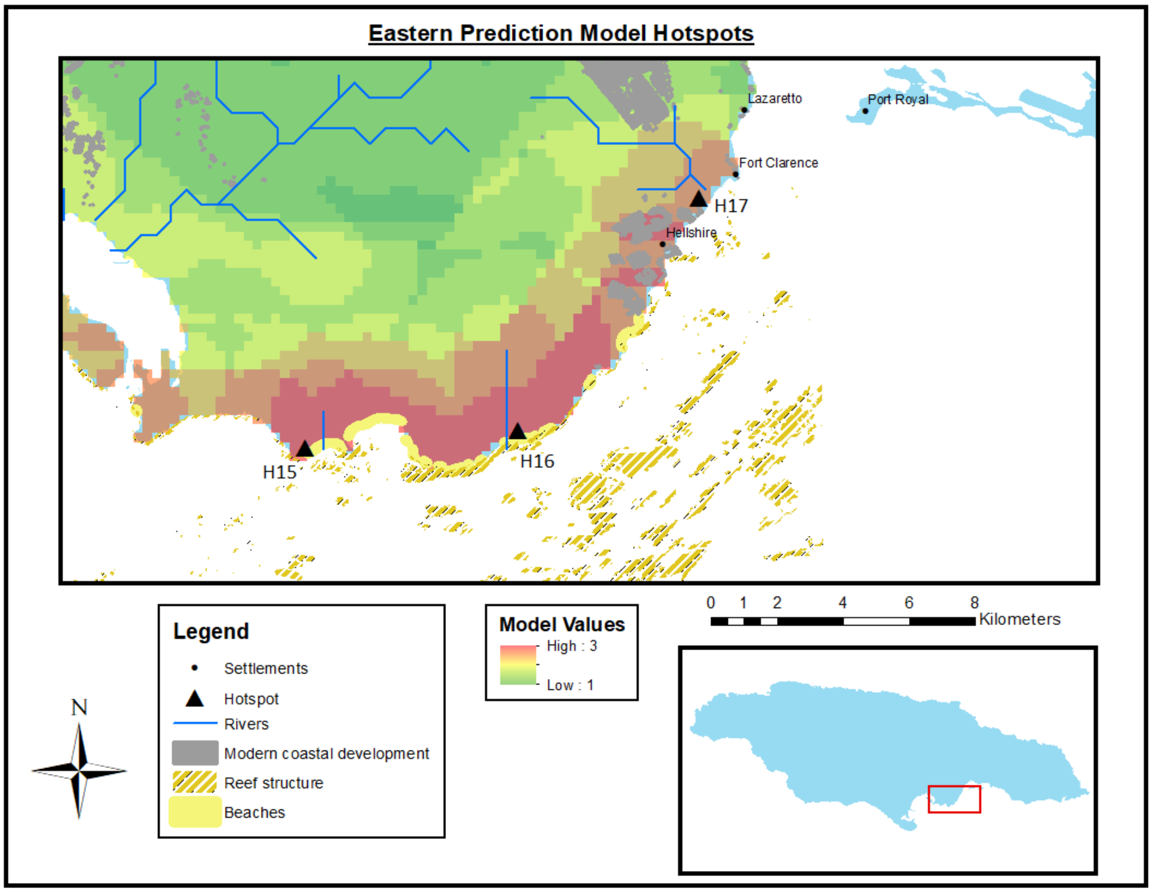

Figure 14: Eastern prediction model hotspot locations. (Scale bar relates to top map)

5.3. Conclusion

Prior to modern commercial and residential development, most of the southwest coast of Jamaica consisted of areas highly suitable for Archaic settlement. Modern development has spread along much of this region, particularly in the most habitable areas such as Savanna-la-Mar, Black River and Old Harbour. Despite the high level of development, seventeen areas with HDV remain largely undisturbed with the western most region of the study area containing the highest number of these hotspots at six. In the following chapter I discuss the implications of the Jamaican predictive model for locating Archaic Age sites in Jamaica.

Chapter 6.

Discussion

The predictive GIS model developed in this thesis, based in the IFD, identified seventeen hotspots that represent undisturbed areas with favourable conditions for Archaic Age settlement along the southwest coast of Jamaica. Here, I highlight the significant impact that modern development of Jamaica's coast has on the potential to find new archaeological sites and discuss other complications to the predictive model such as rising sea levels, and quality and availability of required data. I address development impacts first, since this project hinges on identifying practical areas to field survey for Archaic Age sites and make recommendations for the priority order of hotspot survey. I also discuss the implications of the model for human settlement of Jamaica and compare the model with known Redware sites, which represent the earliest known settlement of the island. Finally, I suggest considerations for future predictive modelling addressing the question of Archaic Age sites in Jamaica.

6.1. Development and site survivorship

The predictive GIS model highlighted areas with a high density of the environmental variables (HDV), including reefs, fresh water, sandy beaches and favourable soil types. I argue that these variables represent locations favourable to Archaic Age settlement. Notably, the areas with HDV are locations of current centres of development along the southwest coast, such as Savanna-La-Mar, Black River and Old Harbour. This suggests that locations favourable to Archaic Age peoples continued to be favourable for successive settlers to the island. Unfortunately, the relationship between areas of HDV and modern settlements indicates that evidence of an Archaic Age settlement of the island may have been erased or obscured underneath these settlements. On the other hand, there are several areas along the southwest coast that have a HDV while remaining largely free of modern development. I define these areas of HDV with limited modern development as hotspots in Chapter 5.

Of the 357 Pre-Columbian archaeological sites in Jamaica known in 2006, 53 have been recorded as destroyed, half of which have been lost through modern development and other types of human ground disturbance (Richards 2006). These site counts are dated and do not speak to unrecorded, unknown or unidentified sites that may have also been destroyed by such activities. Because they are found in highly developed areas and are located extremely close to the coastline, Redware sites are particularly at risk to development, and are susceptible to erosion or submersion (Rampersad 2009; Richards 2006). Many of these Redware sites were discovered in the 1960s and 1970s (Allsworth-Jones 2008; Lee 2006). Since then, significant coastal development has taken place in Jamaica, including areas of the south coast (Richards 2006). Thus, widespread modern coastal development likely represents the largest challenge to finding any undisturbed Archaic Age sites.

6.2. Recommendations for survey

There is limited information on previous archaeological survey of the south coast. James Lee surveyed much of the south coast for all types of archaeological sites, finding the majority of Redware (and Taino) sites known today (Allsworth-Jones 2008). Specific documentation of this survey is limited. Keegan (2019) notes that George Lechler also conducted surveys for Archaic Age sites, but again documentation does not go further than this mention. As discussed below, Redware sites provide interesting comparison to potential Archaic Age sites on the island and there is potential for overlap with Archaic Age sites or misidentification. Thus, reassessment of areas where known Redware sites lie within a hotspot should take priority. There are also several hotspots which lie relatively close to groups of Redware sites yet still some distance away. These hotspots should take second priority for survey.

Furthermore, rising sea levels should be considered when selecting areas for field survey. Ivor Conolley (personal communication, 2020) suggests that Archaic Age sites would likely be submerged by now. Reinforcing this argument is the fact that several Redware sites have become submerged since archaeological discovery, including the type site of Little River and partially the Paradise site near Savanna-la-Mar (Rampersad 2009). Khan et al. (2017) suggest that sea levels could have risen as much as 2.7 m since 4000 BC. Digerfeldt and Hendry (1987) suggest a similar figure of 3 m of sea level rise from 4000 BC. These figures represent a significant inland advance of the coastline. This rise represents a large threat to site survivorship, particularly concerning a material culture that is found close to or directly on beaches. At the same time, there are no known examples of submerged Archaic Age sites in the Caribbean of which I am aware, although there are several submerged Ceramic age sites such as the Taino site of Los Buchillones in Cuba (Peros et al. 2006) . This may represent a gap in our overall knowledge of the Archaic throughout the region, or it may suggest such sites may have been destroyed by wave action rather than submerged.

Based on these considerations, I suggest that the most viable areas for field survey would be hotspots H1 to H7 located on the western south coast (Figure 8). This region represents some of the least developed area of the south coast while including all the variables argued to be favourable to Archaic settlement and therefore the most likely area to have intact sites. Additionally, the hotspot H6 and H7 are located in close proximity to the Redware sites of Paradise (W-13 ASJ designation) and Auchindown (W-10 ASJ designation), respectively, and should be surveyed first. While the closeness of these sites to Paradise and Auchindown in some ways confirms the validity of these locations as suitable settlement sites, the lack of other known Redware sites in this area could signify that insufficient archaeological survey has been conducted in this area.

The central group of two hotspots H10 and H11 should be surveyed next. Apart from nearby Alligator Pond, which has several established Redware sites, these two hotspot locations represent relatively isolated areas of HDV. This isolated area of high density may have limited the settlement location options of Archaic Age people resulting in the settlement of this area.

After the central hotspots, I recommend surveying the central eastern group of hotspots consisting of H12, H13 and H14 (Figure 11). These are hotspots with a value of four, meaning the soil quality in this area is favourable for cultivation as well as already being favourable for the other chosen variables. The Redware site C-5 (Figure 13) is relatively close to this group of hotspots, although it falls outside of the areas with HDV. The marine habitat quality in this area, particularly in the Portland Bight, is excellent, and the natural harbour coupled with significant reef structure protects the coast from severe waves.

The remaining hotspot groups should also be surveyed in respective order: H8,H9, H15, H16 and H17. To account for factors or complications that are not apparent through satellite imagery, I suggest that all seventeen identified hotspots be both pedestrian surveyed and auger tested before other forms of ground disturbing surveying be done. I recommend auger testing, performed using random statistical sampling, to account for any deeply buried materials that may not be evident as artifact scatters encountered on the surface. For example, Armstrong (1980) located several Archaic Age sites buried under volcanic activity on St. Kitts. I also suggest surveying up to the water line in an attempt to account for some amount of sea-level rise over time. After pedestrian surveying and auger testing each hotspot, the suggested order of hotspots may need to be reassessed.

6.3. Archaic Age sites in relation to Jamaican Redware

Examining the Redware site distribution provides further insights on where it would be most suitable to pursue field survey for Archaic Age sites. Redware sites represent the earliest known occupation of the island (appearing from around AD 400 to AD 800) and their location in relation to possible Archaic sites could inform on potential connections between Redware and Archaic Age peoples as proposed by some archaeologists (Keegan 2019; Rampersad 2009). There are three main clusters of Redware sites on the island: a group on the north coast in St. Ann, and two groups along the southwest coast near Black River and then between Treasure Beach and Savanna-la-Mar (Rampersad 2009). Figure 15 shows the distribution of 17 Redware sites found along the south coast of Jamaica along with the hotspots specified by the GIS predictive model. There are 27 known Redware sites on the island, with five sites found in the centre north coast of the island (Rampersad 2009). Location data for five of the sites were unavailable. The vast majority of Redware sites are located along the south coast of the island.

As shown in Figure 15, the distribution of Redware sites largely aligns with the predictive GIS model, with most Redware sites found in areas with a value of 3 or 4. Only two of the seventeen listed Redware sites are found outside of areas with a HDV; namely C-1 and C-5. Notably, two of the three main groups of Redware sites are found in or around the larger modern settlements of Black River, Treasure Beach and Alligator Pond. These are areas that the model specifies as locations with a HDV, but due to the level of modern development, few viable hotspots are identified. As discussed in Chapter 3, Redware sites were occupied by people who settled close to beaches and focused on marine subsistence, a pattern that is similar to known Archaic Age sites on other islands

(Keegan 2019; Lee 2006). Keegan (2019) argues that Redware sites may represent a significantly later settling of Jamaica by Archaic Age groups after developing a *protoagricola* way of life. I suggest Redware sites may have been situated on top of Archaic Age sites.

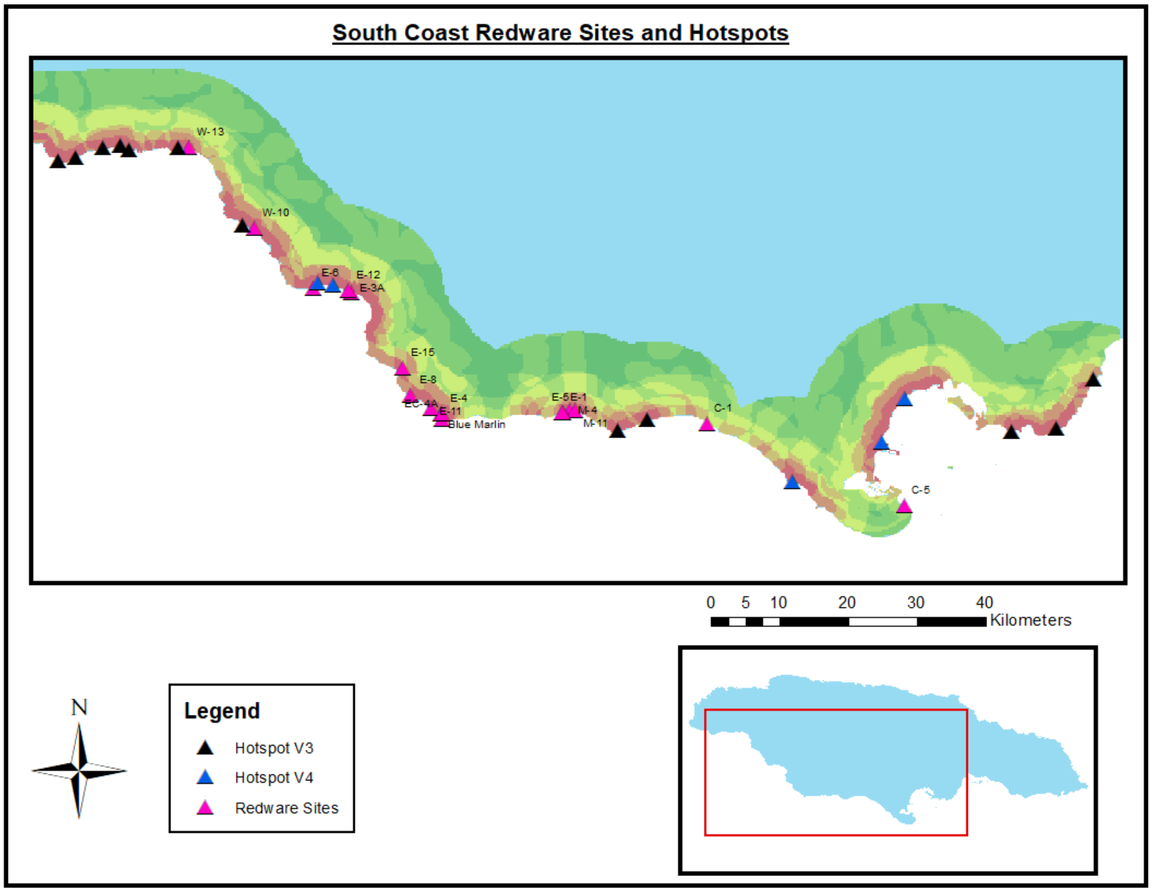

Figure 15: Distribution of Redware sites on the south coast plotted with HDV and areas hotspot locations. Redware site data courtesy of Dr. Lesley-Gail Atkinson. (Scale bar relates to top map)

Similar to Archaic Age sites on other islands, Redware sites deposits are found to be relatively shallow, within 25 cm of the surface (Lee 2006). Consecutive settlements of the same site could easily be mixed into a homogonous layer. There has been limited radiocarbon dating of Redware sites; only the type site of Little River (AD 650 ± 120) and the Blue Marlin site have been dated, but results for the latter have yet to be published (Rampersad 2009; Vanderwal 1968). Thus, identification of Redware sites has relied heavily on relative dating of their distinct ceramic assemblages and site locations, an approach that allows for sites or non-ceramic artifacts to be misidentified.

Furthermore, when comparing known Redware sites with areas of HDV it is clear that Redware peoples likely valued environments highly similar to Archaic settlers. Future research is likely needed to expand on these potential connections.

6.4. Inland Archaic Age sites

A further consideration is that the predictive GIS model does not account for the potential of inland Archaic Age sites. Of the four model variables (modern development excluded), half are oriented towards the coast (beaches and reef data). Thus, while the model does list areas of high density (in other words values of three or four) somewhat inland, the model by default implies that the most desirable of these locations are closest to the coast. Consequently, the hotspots reported in Chapter 5 are all located within 50 m of the coast. As noted in Chapter 3, however, while some Archaic Age sites on other Caribbean islands are found inland, the majority are found closer to the coast, meaning that in its current state the predictive model's focus on the coast represents the more realistic area for field survey (Keegan and Hofman 2017; Rouse 1992).

6.5. Recommendations for future modelling

In addition to improved site location data, I also suggest other additions should be made for future GIS modelling on the question of the Jamaican Archaic Age. A predictive GIS model applied to the entirety of Jamaica may reveal potential undisturbed hotspots elsewhere on the island. Modelling the entire island may give us insights on the impact that coastal erosion due to sea level rise has had on archaeological sites on the north coast of the island where the bathymetry is notably different than on the south. Similar modelling has been done with higher-resolution site location and environmental data on the smaller Caribbean islands of Grenada, the Grenadines and St. Vincent (Hanna and Giovas 2019). Inclusion of more significant bathymetric modelling and considerations for underwater archaeological survey may be enlightening for the purpose of this research. Predictive bathymetric modeling of submerged sites has been undertaken by Davis et al. (2009) in Oregon, USA and by Monteleone et al. (2012) in Alaska, USA. The predictive model of Archaic Age sites in Jamaica could be used to incorporate bathymetric modeling of the island.

Additionally, agricultural or management activities of Archaic Age peoples are relatively understudied and the significance of including such a parameter is ambiguous. Due to constraints with available data, the inclusion of soil quality in the model predicts that Archaic Age peoples valued maximizing yields by choosing the best soils. However, it is currently not known whether they would have in fact been concerned with doing this. More investigation into the extent of agricultural practices of Archaic Age peoples would allow a more refined incorporation of a soil richness data in modelling. Incorporating higher resolution data on soil fertility or environmental richness could advance predictive modelling by better capturing the nuances of potential Archaic Age crop management than soil type data does, if this variable does in fact reliably predict Archaic site locations.

Further investigation of all the environmental variables used in this research, not just soil quality, would likely improve the predictive model. Ideally, these variables should be tested on a sub-sample of Archaic Age sites in the Caribbean to understand how much each variable was valued. Field-testing the highest-ranked areas would likely lead to further refinement. Furthermore, if the predictive model developed here fails to locate Archaic Age sites, higher quality environmental variable data, coupled with in-depth settlement pattern analysis of Archaic Age sites in both the Greater and Lesser Antilles, could produce a more accurate predictive model. Settlement pattern analysis of these sites may identify more predictive environmental variables, such as those mentioned in Section 4.2, that may improve the accuracy of the model.

If, after refining the current model and exploring more specific environmental variables, the IFD theoretical model still fails to locate an Archaic Age settlement on Jamaica, the possibility that the theoretical assumptions of the IFD model are flawed may need to be considered. If so, other models of colonization could be trialed to predict settlement patterning, such as the string of pearls or beachhead models (Keegan and Diamond 1987, Moore 2001). While various models of colonization may be applied to investigate how potential Archaic Age settlements of Jamaica occurred, however, it still seems logically sound to assume that people would settle in viable environments, as suggested by the IFD. Another option might be to investigate commensal models of earlier human introductions of flora and fauna species into Jamaica (Matisoo-Smith 2009; Storey et al. 2013). If future iterations of this model fail, other avenues of investigation such as coring of lakes and wetlands for paleoenvironmental indicators of human settlement could be used (Elliott et al. 2022; Siegel et al. 2015; Siegel 2018). For example, Siegel et al. (2015) and Siegel (2018) have successfully analysed soil cores from several islands in the Lesser Antilles for phytoliths, pollen and charcoal that suggest evidence for human alteration of the landscape prior to the appearance of the first archaeological sites during the Ceramic Age.

6.6. Conclusion

Based on the IFD-informed predictive model developed in this thesis, the southwest coast of Jamaica constituted a largely favourable environment for Archaic Age settlement. Today, much of the Jamaican coast has been developed, mostly through residential and urban construction, resulting in the destruction of many known archaeological sites and likely many that will never be documented. This modern development represents the greatest challenge to finding any undisturbed Archaic Age sites. While the southwest coast is some of the least developed coastline on the island, there are still significant areas of modern development in this region. Despite this, the model identified seventeen hotspots of high potential that were minimally affected by development. Interestingly, the areas of high potential identified in this research show a connection with known Redware sites on the island. The comparisons made between Redware sites and the model hotspots suggest similar settlement patterns and potentially a more significant connection between Redware and Archaic Age peoples. I suggest that all hotspots be pedestrian surveyed before more invasive types of surveying be done, starting with the western most hotspots (H1 to H6) near Savanna-la-Mar. In the final chapter that follows, I outline my final conclusions made through this research.

Chapter 7.

Conclusion

Jamaica’s pre-Columbian history has often been viewed as simpler relative to the settlement history of the greater Caribbean region (Keegan and Atkinson 2006). A significant factor in this portrayal is the fact that Jamaica appears to be settled much later in history compared to neighbouring islands and is thus far lacking evidence of an Archaic Age settlement. While Jamaica has a long history of archaeological investigation, several authors have noted the lack of systematic research and the need for increased scrutiny of the island’s pre-Columbian history (Keegan 2019; Keegan and Hofman 2017; Rampersad 2009). Furthermore, there is limited documentation of investigations into potential Archaic Age settlements of Jamaica and arguments made for the lack of an Archaic Age settlement are not entirely satisfactory (Callaghan 2008; Howard 1965; Keegan 2019). For example, one of the main arguments is that rough seas along the north coast of the island prevented access. However, my personal observations based on 18 years of living in Jamaica indicate that coastal waters on this side of the island, at least, fluctuate greatly in their storminess and are sometimes extremely calm. For these reasons, I have argued that there is a high potential for the discovery of an Archaic Age settlement of Jamaica with increased systematic and informed survey of the island.

The predictive model developed through this research lays a framework for just such a survey of the island, beginning with the southwest coast. In doing so, it addresses the four research objectives: 1) to identify areas with a high likelihood of finding Archaic Age material; 2) to understand how modern development has impacted the chance to locate these sites; 3) to determine how these areas relate to known Redware settlement patterns and 4) in which order these areas should be surveyed.

This research identifies seventeen areas that represent suitable environments for Archaic Age populations to settle based on proposed measures of habitat quality. These areas are located near perennial fresh water. They are in close proximity to a sandy beach that allows access to the nearby marine resources sustained by the fringing reef systems along the southwest coast. Notably, there are many similarities between these chosen environmental variables and the settlement patterns of the earliest known occupation of the island by Redware peoples. In the case of five of the seventeen hotspots there are rich loamy soils suitable for agriculture. Perhaps most importantly, these seventeen areas have remained largely undeveloped throughout the 20th and 21st centuries, during which modern coastal development of Jamaica has seen exponential growth.

The pace of coastal development in Jamaica represents the single largest risk to the survivability of archaeological sites on the island; both known and unknown. Further exacerbating this risk are rising sea levels that have already resulted in the destruction of several known archaeological sites such as Little River and Paradise (Rampersad 2009). Potential Archaic Age sites would be threatened by both actions. Importantly, the likelihood of discovering an Archaic Age settlement of Jamaica is continually diminishing, making it imperative that systematic field survey for these sites begins quickly. Therefore, I recommend field survey of all the hotspots identified, beginning with H1 through H6.

The discovery of an Archaic Age settlement of Jamaica would fill a long-noted gap in Caribbean prehistory and could push back the island's human history significantly (Callaghan 2008; Hofman and Antczak 2019; Keegan and Hofman 2019; Wilson 2007; Keegan 2019; Rouse 1992; Wilson 2007). This predictive model provides the substructure for the systematic survey of the island for Archaic Age sites upon which future studies can build to increase archaeological scrutiny of the entire island. Furthermore, discovery of an Archaic Age site in Jamaica would significantly change the known settlement order of the Caribbean and remove the large voyaging shadow that the absence of Archaic Age settlement assumes (Keegan 2019). Future research would benefit from further validating the model's environmental variables by analyzing Archaic Age settlement patterns on other islands to improve its predictive power. My research was limited by the availability of such data to conduct this analysis on other islands. With access to higher quality data, future predictive models addressing the question of Archaic Age settlements of Jamaica could be refined for accuracy and practicality.

In conclusion, this research has identified seventeen areas along Jamaican's southwest coast that represent high-quality habitat suitable for Archaic Age settlement and at the same time remain largely undisturbed by modern development. The next step to further this research is to ground truth this predictive model through the systematic survey of the hotspots identified.

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Appendix.

Archaic Age Site Data from Haiti and Puerto Rico

? denotes missing standard deviation. Non-bolded site names are Lithic Age sites while bolded site names are Archaic Age sites. Chronometric hygiene requirements as per Fitzpatrick 2006 and Napolitano et al. 2019. Class 1 requirements: dated from short-lived terrestrial material identified to taxon with sufficient provenance. Class 2 requirements: charcoal not identified to taxon or marine shell identified to taxon with sufficient provenance. Classes 3 and 4 did not pass chronometric hygiene (Napolitano et al. 2019, 9).

Site name	Country	Radiocarbon years BP	Calibrated dates (median probability)	Calibrated dates (range)	Material dated	Lab Number	Chronometric Hygiene Y/N	Reference
Vignier III	Haiti	5580 +/- 80 BP	3821 BC	4040 - 3610 BC	marine shell	Beta 26796	N	Moore 1987, Moore and Tremmel 1997
Vignier II	Haiti	5270 +/- 100 BP	3481 BC	3758 - 3221 BC	marine shell	Beta 50944	N	Moore 1987, Moore and Tremmel 1997
Savanne Carree II	Haiti	4610 BP	2660 BC?		marine shell (*Strombus pugilis*)		N	Moore and Tremmel 1997
Nan Michelle III	Haiti	4420 +/- 110 BP	2437 BC	2811 - 2111 BC	marine shell		N	Moore and Tremmel 1997

Site name	Country	Radiocarbon years BP	Calibrated dates (median probability)	Calibrated dates (range)	Material dated	Lab Number	Chronometric Hygiene Y/N	Reference
Source Matelas	Haiti	4370 +/- 90 BP	2370 BC	2659 - 2078 BC		Beta 20473	N	Moore 1987, Moore and Tremmel 1997
Des Cahots	Haiti	4240 +/- 80 BP	2201 BC	2456 - 1941 BC		Beta 30942	N	Moore 1987, Moore and Tremmel 1997
Pradel	Haiti	4200 BP	2250 BC?				N	Moore and Tremmel 1997
Anse a l'Eau	Haiti	3910 BP	1960 BC?				N	Moore and Tremmel 1997
De Ravine	Haiti	3812 BP	1862 BC?				N	Moore and Tremmel 1997
L'Oiseau (S)	Haiti	3720 BP	1770 BC?				N	Moore and Tremmel 1997
Les Cayes	Haiti	3650 BP	1700 BC?				N	Moore and Tremmel 1997
Ca coq I	Haiti	3580 BP	1630 BC?				N	Moore and Tremmel 1997
Ca coq IV	Haiti	3490 BP	1540 BC?				N	Moore and Tremmel 1997
Madame Bernard I	Haiti	3430 BP	1480 BC?				N	Moore and Tremmel 1997
Gillotte I	Haiti	3260 +/- 60BP	1531 BC	1685 - 1417 BC	marine shell	Beta 52888	N	Moore and Tremmel 1997, Napolitano et al. 2019

Site name	Country	Radiocarbon years BP	Calibrated dates (median probability)	Calibrated dates (range)	Material dated	Lab Number	Chronometric Hygiene Y/N	Reference
Source Lagon Paradis	Haiti	3260 BP	1310 BC?				N	Moore and Tremmel 1997
Phaeton	Haiti	3260 +/- 70BP	965 BC	1190 - 774 BC	marine shell	Beta 30943	N	Moore 1987, Moore and Tremmel 1997
Ca coq II	Haiti	3090 +/- 80 BP	768 BC	1001 - 508 BC	marine shell	CaCII	N	Moore 1987, Moore and Tremmel 1997
Source Pascade II	Haiti	3040 BP	1090 BC?				N	Moore and Tremmel 1997
Etang Salé II	Haiti	3030 BP	1080 BC?				N	Moore and Tremmel 1997
Anse Millieu I	Haiti	2930 BP	980 BC?				N	Moore and Tremmel 1997
Anse Millieu II	Haiti	2930 BP	980 BC?				N	Moore and Tremmel 1997
Ca coq III	Haiti	2910 BP	960 BC?				N	Moore and Tremmel 1997
Nan Michelle II	Haiti	2900 +/- 120 BP	540 BC	825 - 198 BC	marine shell		N	Moore and Tremmel 1997
Morne Charbon	Haiti	2580 BP	630 BC?				N	Moore and Tremmel 1997
Bonne Fin	Haiti	2410 BP	460 BC?				N	Moore and Tremmel 1997
Cabaret	Haiti	2280 +/- 80 BP	313 BC	724 - 100 BC	marine shell	Beta 2S933	N	Moore 1987, Moore and Tremmel 1997

Site name	Country	Radiocarbon years BP	Calibrated dates (median probability)	Calibrated dates (range)	Material dated	Lab Number	Chronometric Hygiene Y/N	Reference
Madame Bernard II	Haiti	1825 BP	AD 125?				N	Moore and Tremmel 1997
Dame Marie (La Source)	Haiti	1710 BP	AD 240?				N	Moore and Tremmel 1997
Couri II	Haiti	1710 +/- 70 BP	AD 348	AD 214- 537	marine shell	Beta-41783	N	Moore and Tremmel 1997
Caille Lambi	Haiti	1590 BP	AD 360?				N	Moore and Tremmel 1997
Fou Lachau III	Haiti	1570 BP	AD 380?				N	Moore and Tremmel 1997
Source Philippe	Haiti	1560 BP	AD 390?				N	Moore and Tremmel 1997
Angostura	Puerto Rico	3920 +/- 40 BP	2403 BC	2565 - 2240 BC	charcoal	GX-28807	Y (Class 2)	Rivera-Collazo et al. 2015
Caño Hondo	Puerto Rico	3010 +/- 70 BP			unknown	UGa-995	N	Rouse and Alegria 1990
Puerto Ferro	Puerto Rico	4095 +/- 80 BP	2008 BC	2273 - 1746 BC	marine shell (**Strombus gigas*)	I-18971	Y (Class 2)	Nargannes Storde 2005
Cayo Cofresí	Puerto Rico	2275 +/- 85 BP			unknown	I-7425	N	Rouse and Alegria 1990
Tembladera	Puerto Rico	4160 +/- 30 BP	2090 BC	2271 - 1922 BC	marine shell	UGM-30017	N	Rodríguez Ramos 2017
Ventana	Puerto Rico	4250 +/- 25 BP	2216 BC	2393 - 2038 BC	marine shell (*Phacoides* sp.)	UGM-17566	Y (Class 2)	Rodríguez Ramos 2014

Site name	Country	Radiocarbon years BP	Calibrated dates (median probability)	Calibrated dates (range)	Material dated	Lab Number	Chronometric Hygiene Y/N	Reference
Jobos	Puerto Rico							
María de la Cruz	Puerto Rico	1920 +/- 120 BP	AD 104	195 BC - AD 405	charcoal	Y-1235	Y (Class 2)	Rouse and Alegria 1990
Maruca	Puerto Rico	4160 +/- 50 BP	2091 BC	2294 - 1889 BC	marine shell	Beta-92892	N	Rodríguez Lopez 2004
Paso del Indio	Puerto Rico	4110 +/- 40 BP	2689 BC	2871 - 2501 BC	charcoal	Beta-178680		Walker 2005
*Species now *Aliger gigas*								